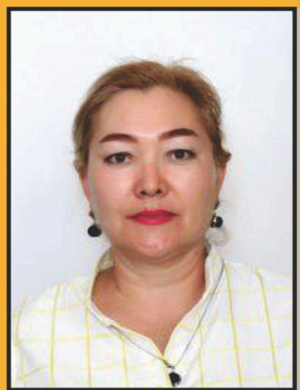

Brief information about the author

Kulmirzaeva Gulrabo Abduganiyevna was born on February 19, 1972 in the Djambay district of the Samarkand region. In 1989, she graduated from school and entered the mechanics and mathematics faculty of the Samarkand State University.

Since 1994, she began working at the Samarkand College of Finance and Economics. She began teaching computer science, then taught statistics. Since 2000, she began teaching Mathematics at the Department of Exact Sciences. Since 2014, she worked as a senior lecturer at the Department of Higher Mathematics at Samarkand State Architectural and Civil Engineering Institute. During her scientific and methodological work at Samarkand State Architectural and Civil Engineering Institute, she published more than 40 scientific articles and theses, more than 8 methodological guidelines and manuals. The book-textbook “Numerical Analysis”, “Differential Equations” and “Differential Equations” was published.

There are 2 patents of Asia, Euro and 4 DGU. She won in the nomination "Best invention and utility model" of the competition "Woman Inventor - 2022" as part of the week "100 women inventors of the region". In 2022, she took part in the competition "100 new faces-2022", held in Kazakhstan, and received a diploma, certificate, first degree badge and chest medals.

On January 20, 2023, she was awarded a diploma and a breast badge of the Scientific Researcher Research Center for achievements in science and innovation. On April 20, 2023, she was awarded a diploma and a breast badge of the Innovative Promoter Research Center in science and innovation in the specialty Innovative Promoter. She took part in the international competition of scientific and pedagogical personnel "Best Researcher - 2023" and was awarded a 2nd degree diploma and a breast badge. In January 2025, she received the international diploma "Best Scientific Article - 2025", in February she received a breast medal, certificate and article "Best Young Scientist - 2025".

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Monograph

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AND INNOVATIONS

SAMARKAND STATE UNIVERSITY OF ARCHITECTURAL AND CIVIL ENGINEERING

NAMED AFTER MIRZO ULUGBEK

DEPARTMENT OF SOCIAL AND NATURAL SCIENCES.

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In the monograph, Mirzo Ulugbek's work "Zizhi Koragoniy" consisted of 4 books. Mirzo Ulugbek wrote the work "Zizhi Koragoniy" as a result of scientific observations conducted at the observatory. Since Ulugbek's "Zizhi" is the most perfect astronomical work of the Middle Ages in terms of the movement of the Sun and Moon, the catalog of stars and the mathematical methods used in it, he made a great contribution to the development of astronomy. primarily in Muslim countries. Readers should learn more about Mirzo Ulugbek, because great scientists of Central Asia spoke out. They should be proud of our scientists and be their followers.

Reviemers:

SamSUAC – PhD, Doctor of Philosophy, Associate Professor Kuldoshev A.T.

TSEU Samarkand branch- Doctor of Philosophy in History (PhD), U.Xudayarov.

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Abstract

The purpose of writing this monograph is that our university is named after Mirzo Ulugbek. By the 630th anniversary of Mirzo Ulugbek's birth, readers should also learn about his contribution to mathematics. "Zij" consists of four works and was translated into Uzbek for the first time. The first book is devoted to chronology and calendars. The book contains information about the Chinese, ancient Turks, Persians, Greeks and Arabs. The second book is about spherical astronomy and mathematical geography, and presents tables of mathematics and geography. The third book is about planetary motion and stellar astronomy - there is a catalog describing the tables of planetary motion and spherical coordinates of 1018 stars. All tables are easily interpreted for a period of two thousand years before and after the creation of "Zij" (1437). The fourth book is devoted to astrology, description of horoscopes.

Ulugbek founded two madrassas in Samarkand: one as part of the Registan ensemble, the other as part of the Gori Amir ensemble. Among other great scholars, Ulugbek himself lectured once a week in each of these madrassas.

The rest of the time was devoted tomore astronomical observations, work on "Zij". Until recently, he was considered only an astronomer and mathematician. But at the end of the 20th century, his activity intensified, and it turned out that he also wrote on history, poetry and music. Ulugbek also wrote poetry.

Ulugh Beg's star map was the rarest and most perfect map of the Middle Ages. "Zij" had a great influence on the work of scholars of its time. Ali Kushchi, Miram Chalabi and Hussein Birjandi wrote a review of Ulugh Beg's "Zij". According to information, there are about 100 Persian and more than 15 Arabic copies of Ulugh Beg's "Zij". No astronomical or mathematical work written in the Middle Ages was so widely distributed.

This translation of Ulugbek's "Zij" is provided with commentaries using medieval information from Nizamiddin al-Birjandi (1523).

In this monograph, the birthplace and life of Ulugbek is taken from volumes 4, 7 and 11 of the Uzbek Encyclopedia. His scientific and cultural heritage was studied. In addition, information was obtained from Ulugbek Muhammad Taragay ibn Shahrukh "Zizhi Jadidi Guragoni" 2nd edition. Not everyone has the opportunity to read this book, so the monograph provides brief information. In this monograph, I wrote about the comparison of data obtained from the roofs and how scientists explain their research. An interested reader can also read information on the Internet to get more information.

Guests of Samarkand should definitely visit the Ulugbek Observatory. Ulugbek's childhood and youth are also covered. One of Ulugbek's contributions to science is one of the madrassas he built in Bukhara and Samarkand. The place he created in Samarkand is the Samarkand Observatory. He taught at the Ulugbek Academy once a week. The events of Ulugbek's reign are also covered.

The appearance of "Zij" is shown in the life of Ulugbek. There is also information about the works of scientists who contributed to "Zij". In addition, information on the roofs of the book "Bases" is also given with brief comments. We use it in schools and universities.

Annotatsiya

Ushbu monografiyani yozishdan maqsad, bizning universitetimiz Mirzo Ulug'bek nomi bilan atalgan. Mirzo Ulug'bek tavalludining 630 yilligiga bag'ishlangan, bundan tashqari u matematikaga qo'shgan hissasini o'quvchilar bilishi kerak. “Zij”i to'rt asardan iborat bo'lib, u birinchi marta o'zbek tilida tarjima qilingan. Birinchi kitobda - xronologiya va taqvimlarga bag'ishlangan. Kitobda xitoylar, qadimgi turklar, forslar, yunonlar va arablarning yil hisobi haqida ma'lumotlar berilgan. Ikkinchi kitobda - sferik astronomiya va matematik geografiyaga bag'ishlangan bo'lib riyoziyot va jug'rofiya jadvallar keltirilgan. Uchinchi kitobda – sayyoralar harakati va yulduzlar astronomiyasi haqida, sayyoralar harakati jadvallari va 1018 yulduzning sferik koordinatalarini tavsiflovchi katalog berilgan. Barcha jadvallar “Zij” yaratilishi vaqtidan (1437) ikki ming yil oldingi va keyingi davr uchun osongina talqin qilinadi. To'rtinchi kitob astrologiyaga, munajjimlar bashoratining tavsifiga bag'ishlangan.

Ulug'bek Samarqandda ikkita madrasa: biri Registon ansambli tarkibidava ikkinchisi Go'ri Amir ansambli tarkibida barpo etgan. Boshqa yirik olimlar qatorida Ulug'bekning o'zi ham bu madrasalarning har birida haftada bir marotaba ma'ruza o'qigan.

Boshqa vaqtni ko'proq astronomik kuzatishlarga, “Zij” ustida ishlashga bag'ishlangan. Yaqin yillargacha u faqat astronom va matematik deb hisoblanardi. Lekin XX asr oxirida uning ijodi serqirra bo'lib, u tarix, she'riyat va musiqa bobida ham qalam tebratgani aniqlandi. Ulug'bek she'rlar ham yozgan.

Ulug'bekning yulduzlar jadvali o'rta asrlar davridagi eng nodir va mukammal jadval bo'lgan. “Zij” o'z zamonasidayoq olimlar ijodiga katta ta'sir ko'rsatgan. Ulug'bek “Zij”iga Ali Qushchi, Miram Chalabiy va Husayn Birjandiylar sharh yozgan. Ma'lumotlarga qaraganda Ulug'bek “Ziji”ning 100 ga yaqin forsiy va 15 dan ortiq arabiy nusxalari mavjud. O'rta asrlarda yozilgan hech bir astronomik yoki matematik asar bunchalik ommaviy keng yoyilmagan.

Ulug'bek “Zij”ining mazkur tarjimasi Nizomiddin al –Birjandiyning (1523) o'rta asr ma'lumotlaridan foydalanilgan holda sharhlar bilan ta'minlangan.

Bu monografiyada Ulug'bekning tug'ilib o'sgan joyi va hayoti haqida O'zbek ensiklopediyasi 4, 7 va 11 tomlardan olingan. Bunda uning ilmiy, madaniy meroslari o'rganilgan. Bundan tashqari Ulug'bek Muhammad Tarag'ay ibn Shohruh “Ziji jadidi Guragoniy” 2 – nashr kirobidan ham ma'lumotlar olingan. Bu kitobni olib o'qishga hammaning ham imkoni yo'q, shuning uchun qisqa ma'lumotni shu monografiyada berilayapti. Bu monografiyada olingan tomlardagi ma'lumotlarni qiyoslashlarni, olimlar o'z izlanishlarini qanday izoh berishini qiziqib yozdim. O'qib qiziqgan o'quvchi yanada ko'proq ma'lumotga ega bo'lishi uchun internetdan ham olib o'qishi mumkin.

Samarqandga kelgan mehmonlar albatta Ulug'bek rasadxonasiga kelib ko'rib ketishlari kerak. Ulug'bekning bolalik va o'smirlik yillari ham yoritilgan. Ulug'bekning ilmga qo'shgan hissalaridan biri Buxorada va Samarqandda qurgan madrasalaridan biridir. Samarqandda o'zi ishlab ijod qilgan joyi – bu Samarqand rasadxonasidir. U haftada bir marta Ulug'bek akademiyasida saboq bergan. Ulug'bekning hukmdorlik davridagi voqealar ham yoritilgan.

Ulug'bekning hayotida “Zij”ning paydo bo'lishi ko'rsatilgan. “Zij”ga hissa qo'shgan allomalarning ishlari haqida ham ma'lumotlar bor. Bundan tashqari “Negizlar” kitobining tomlaridagi ma'lumotlar ham qisqa izohlar berilgan. Unda biz maktabda va oliygohlarda foydalanamiz.

Аннотация

Целью написания данной монографии является то, что наш университет по имени Мирзо Улугбека. К 630-летию со дня рождения Мирзо Улугбека читатели должны узнать и о его вкладе в математику. «Зидж» состоит из четырех произведений и впервые переведен на узбекский язык. Первая книга посвящена хронологии и календарям. В книге собраны сведения о китайцах, древних тюрках, персах, греках и арабах. Во второй книге - сферическая астрономия и математическая география, представлены таблицы математики и географии. В третьей книге - о движении планет и звездной астрономии - есть каталог с описанием таблиц движения планет и сферических координат 1018 звезд. Все таблицы легко интерпретируются на период двух тысяч лет до и после создания «Зиджа» (1437 г.). Четвертая книга посвящена астрологии, описанию гороскопов.

Улугбек основал в Самарканде два медресе: одно в составе ансамбля «Регистан», другое — в составе ансамбля «Гори Амир». Среди других великих ученых Улугбек сам читал лекции раз в неделю в каждом из этих медресе.

Остальное время было посвящено более астрономическим наблюдениям, работе над «Зиджем». До недавнего времени его считали только астрономом и математиком. Но в конце 20 века его деятельность активизировалась, и выяснилось, что он пишет также по истории, поэзии и музыке. Улугбек также писал стихи.

Звездная карта Улугбека была самой редкой и совершенной картой Средневековья. «Зидж» оказал большое влияние на творчество учёных своего времени. Али Кушчи, Мирам Чалаби и Хусейн Бирджанди написали рецензию на Улугбека «Зидж». По информации, существует около 100 персидских и более 15 арабских копий Улугбека «Зиджи». Ни одна астрономическая или математическая работа, написанная в средние века, не была так широко распространена.

Данный перевод Улугбека «Зидж» снабжен комментариями с использованием средневековых сведений Низамиддина аль-Бирджанди (1523 г.).

В данной монографии место рождения и жизни Улугбека взято из томов 4, 7 и 11 Узбекской энциклопедии. При этом изучалось его научное и культурное наследие. Кроме того, информация получена от Улугбека Мухаммада Тарагая ибн Шахруха «Зижи Джадиди Гурагони» 2-е издание. Не у всех есть возможность прочитать эту книгу, поэтому в монографии дана краткая информация. В этой монографии я написал о сопоставлении данных, полученных с крыш, и о том, как ученые объясняют свои исследования. Заинтересованный читатель также может прочитать информацию в Интернете, чтобы получить дополнительную информацию.

Гостям Самарканда обязательно стоит посетить обсерваторию Улугбека. Освещены также детские и юношеские годы Улугбека. Одним из вкладов Улугбека в науку является одно из медресе, построенных им в Бухаре и Самарканде. Место, которое он создал в Самарканде, — Самаркандская обсерватория. Он преподавал в Академии Улугбека один раз в неделю. Освещены также события правления Улугбека.

Облик «Зиджа» показан в жизни Улугбека. Также имеются сведения о трудах ученых, внесших вклад в «Зидж». Кроме того, информация по крышам книги «Основы» также дается с краткими комментариями. Мы используем его в школах и университетах.

"Religion dissipates like fog,

the kingdom is destroyed, but the works
"Scientists remain forever"
(Mirzo Ulugbek)

Mirzo Ulugbek

Ulugbek (pseudonym: real name Muhammad Taragai) [03.22.1394, the city of Sultaniya, Iran Azerbaijan - 10.27.1449. Samarkand] - the great Uzbek astronomer and mathematician, statesman. Son of Shahrukh, grandson of Amir Temur. He was born during the siege of the Mordin fortress in Iraq during the "five-year campaign" of Sahibkiran (1392-96). Sharafuddin Ali Yazdi writes in "Zafarname" that a messenger came to Amir Temur and brought the good news of the birth of Ulugbek and that astrologers predicted that this grandson would become a scientist and ruler in the future. The delighted master ends the siege of the Mordin castle and cancels the tax imposed on his people. The fact that he named his grandson Muhammad Taragay and Ulugbek can be connected with the above predictions of astrologers.

The working process of Mirzo Ulugbek.

Amir Temur paid special attention to Ulugbek's education and involved him in events of national importance. According to Clavihan, Ulugbek participated in the ceremony of receiving foreign ambassadors of his grandfather. In 1404, Amir Temur celebrated the weddings of his six grandchildren (including Ulugbek) in Kenigil. At the wedding, the host presented Ulugbek with Tashkent, Sairam, Yangi (now Taroz), Ashpara and Mugalistan as gifts to China. Ulugbek was there when Amir Temur died in Otror. The struggle for the throne began among the Timurids. The children of Shahrukh, Ulugbek and Ibrahim Sultan, who returned from Otror, were not allowed into the capital Samarkand by the emirs; they took refuge in Bukhara. Khalil Sultan took the throne of Samarkand. Shahrukh Ulugbek, who ruled Khorasan, entrusted him with the governance of Andkhoy and Shibirgan, and then part of Khorasan consisting of Tus, Khabushan, Kalota, Bovard, Naso, Yazir, Sabzavor and Nishapur. In 1410, when Shahrukh took control of Movarunnahr, he handed it over to Ulugbeg along with the Turkestan region and restored the will of Sahibkiran. Since Ulugbek was 15 years old, Amir Shokhmalik was appointed his sponsor. But Shokhmalik's rival - Sheikh Nuriddin in Otrar and the governors of Muhammad Jahangir in Hiros - opposed Ulugbeg and Shokhmalik in the spring of 1410. Shokhmalik and Ulugbek won the battle in the summer of that year with the participation of Shahrukh. In September 1411, Shahrukh came to Samarkand, took Shokhmalik with him to Herat, and later sent him to Khorezm as a governor in 1413. From then on, Ulugbek began to rule Movarunnarkh independently. Shahrukh also transferred property to other Timurid princes in Movarunnarkh. For example, Hisori gave Shodmon to Muhammad Jahangir Mirza, the son of Muhammad Sultan, and the province of Uzgand to Amirak Ahmad, the son of Umarshaikh. However, they were subordinate to Ulugbek. In 1414-15, a conflict broke out between them, and Ulugbek Amirak gathered an army against Ahmad and defeated him. Shahrukh summoned Amirak Ahmad to Khorasan; Kashgar also belonged to Ulugbeg until 1428.

During his reign, Ulugbek made two major military campaigns. In the first of them, in 1425, when the Khan of Velistan, Shermukhammad Oglan (1421-25), declared himself an independent khan, Ulugbek marched against him and won. Ulugbek's second campaign was against the city of Signok.The lower lake of Syr Darya was under the control of Ulugbek. In 1427 Ulugbek encountered Barak oglan, who threatened his possessions near Sighnak, and was defeated. The enemy pursued Ulugbek and reached the threshold of Samarkand. Since Movaunnahr was in danger, Shahrukh would remove the danger by leading a large army from Khorasan.

After Shahrukh's death on March 12, 1447, the Timurid ruler was succeeded by the eldest son of Ulugbek Abullatif. But Shahrukh's strict wife Gawharshad Begum had her own opinion on this matter. He was in favor of placing Aludavla Mirza, the son of Baysungur Mirza, the third son of the deceased, and his favorite grandson, on the throne of Herat, which had become the capital of the Timurids during Shahrukh's reign. The fact that Gawharshad Beg placed Aludavla on the throne of Herat should have been regarded as a rebellion against Ulugbek. Therefore, in the spring of 1448, Ulugbek, together with Abdullatif, came to Khorasan with 90 thousand soldiers and defeated Aludavla in the battle near Herat. Although the victory was achieved thanks to the personal courage and military leadership of Abdullatif, Ulugbek announced the decree in the name of his younger son Abdulaziz. In addition, he will also give Ulugbek Abdulaziz the Ikhtiyoriddin castle in Herat and its wealth, bequeathed to Abdullatif by his grandfather Shahrukh. After this, the relationship between Ulugbek and Abdullatif took the form of open hostility.

Ulugbek leaves Abdulaziz in Samarkand and goes with his army to battle against his eldest son. Abdullatif also came to the banks of the Amu Darya with his army. Both armies stood for a long time on both banks of the river and did not dare to cross the water. Meanwhile, Ulugbek is forced to return to Samarkand, having heard the news that Abdulaziz is persecuting the families of the amirs in the army, and he witnesses the uprising of the city's inhabitants against Abdulaziz. The city was quickly put in order, and he again went into battle against Abdullatif, but was defeated by him near Samarkand. Soon after, Ulugbek Abdullatif was executed by order. His body was buried in the mausoleum of Gori Amir.

During the reign of his father Shahrukh, Ulugbek was somewhat independent as a political ruler in domestic and foreign policy. He conducted direct trade and embassy relations with other countries. During the reign of Ulugbek, the city of Samarkand became more prosperous. Crafts, architecture, literature, and science in general rose in the city, and trade developed. In 1417 in Bukhara, in 1420 in Samarkand, and in 1432-1433, madrasahs and charitable institutions were built in Marv. In the madrasah, along with religious sciences, secular sciences were taught, and greater importance was attached to specific sciences. The construction of the Bibikhanum Mosque and the Amir Mausoleum were completed.Temur, Shahizinda and Registan complexes. In addition, many public buildings (caravanserais), tims, chorsu, baths and other buildings were built in the country. During the time of Ulugbek, he established domestic and foreign policy, ambassadorial relations, monetary reforms, economic and cultural conditions in Movarunnahr.

Ulugbek was interested in medicine and music, and wrote poetry. Alisher Navoi's Majolis un-Nafais and Abu Tahirhoja's Samaria contain examples of his poetry. Ulugbek also created musical pieces performed on large and small drums. During his time, many works were translated from Arabic and Persian into Old Uzbek. The rich library created by Ulugbek contained more than 15 thousand volumes of books on various topics. [6].

Childhood and youth of Ulugbek

By the beginning of the 14th century, the empire built by Genghis Khan and his descendants in the previous century had weakened from a military-political and socio-economic point of view. A similar situation was observed in the three western states, including part of Khorezm. East Turkestan and Khorasan. The same situation was in the Chigatoy ulus, which included. China, which was part of the Great Nation, gained complete independence from the Mongols in 1968. By the middle of this century, all three Western-type Mongols were completely Turkified. Most of yesterday's Mongols adopted Islam, in the Chigatoy method this process was somewhat delayed. The decline of central power led to the rise of local emirs, which led to the growth of separatism. By the middle of the 14th century, Iran was divided into several small estates. The same situation developed in Movarunnahr. However, the 12-year reign of the somewhat stronger Emir Kazagan (1346-1358) and the 36-year reign of Khan Tughlik Temur could not stop this process. The rapid change of khans and the incessant internecine wars of the ulus emirs led to the complete destruction of the country. The high culture of Movarunnahr before the Mongols gave way to depression. There was no need for cultural growth. [3]

XIV By the end of the 1950s, when Temur appeared on the international arena, the country was in complete chaos. Emir Qazagan, who ruled in Movarunnahr at that time, came to power after the murder of Qazhan Khan in 1346. Timur entered the political scene in the last year of Emir Qazagan's reign. Temur's actions determined the life of Movarunnahr in the following years and during the time of Ulugbek. Temur's long-term struggle with the Chigatoy khans and their vassals for viceroyalty in the Chigatoy Khanate ended in 1370 with Temur's complete victory. Already in 1366, Temur, together with his comrade-in-arms Amir Hussein, managed to break and destroy the military power of the last strong khans of the Chigatay clan, Tughlik Temur and his son Ilyas Khoja.

After the removal of the Chigatai Khans from the political scene, Timur's main rival for the throne of Movaraunnahr was his son-in-law, the Chigatai Emir Hussein. A five-year struggle with this Emir ended with Timur's victory: in the early spring of 1370, Emir Hussein was executed in Balkh. In 1370, Timur became the sole ruler of the entire Chigatai Ulus, which included Central Asia, Kazakhstan east of the Aral Sea, East Turkestan and Northeastern Khorasan, that is, the lands south of the Amu Darya, being the Emir of the Khans. Although Timur eliminated his main rivals, he still had to fight with some powerful Emirs, Kaykhusraw Khuttalani, to completely subjugate Khorezm. Another ten years passed.

It was at this time that Temur took the ulus of Jochi into his sphere of influence. Tokhtamysh escapes from the White Horde and comes to Temur, asks him for refuge and remains in his service for two years. In 1378, with the military support of Temur, Tokhtamysh defeated his rival Temur Malik and rose to the khanate of the White Horde and immediately tried to unite the GoldenHorde with the khanate. Timur's patronage of Tokhtamysh continued for a long time after this, he twice in 1391 and 1395 went on campaigns to the lands of the Golden Horde and Rus' to punish Tokhtamysh for attacking his possessions. As a result of these two campaigns, Timur completely broke the power of the Horde khans, and after that, for several decades, they relied on the help of Central Asian rulers in their internal reprisals and were also considered the property of Ulugbek.

1386In 1391, Timur made a “three-year campaign” to the western parts of Iran, and in 1391, a “five-year campaign.” As a result of these military expeditions, Timur annexed Iran, India, Iraq, Syria, Eastern Anatolia, and the entire Caucasus, both North and South, to his empire.

"While Timur's forces were in East Asia, that is, in Western Iran and Iraq, during the "Five Years' Campaign", on Friday, 19,796 AH / March 22, 1394, his 17-year-old son Shahrukh wife Gavharshadbegim before Asia he was in the Sultanate (Southern Azerbaijan) with Okurug, his eyes cleared up and a son was born. On April 17, a herald brought this good news to Timur when he was in the newly fortified city of Mardin in Upper Mesopotamia. The newborn prince will be called Muhammad Taragai. But it is replaced by the term Ulugbek, his main name, and this term remains his main name.

On August 14 of the same year, Shahrukh's second wife also gave birth to a son, who was named Ibrahim. However, the name of this prince's mother is not recorded in any source. Ulugbek was raised by Timur's main wife, Lady Sarai Mulk. And Ibrahimin, his second wife, was raised by Tuman Ago. Judging by this distribution of grandchildren, it can be said that Ulugbek had a special affection for his grandfather before. In May 1394The princesses and their grandchildren were recalled to Ibrahim's homeland in Armenia and Azerbaijan, where Timur had arrived earlier. In September, they returned to the Sultanate, but after some time they were again summoned to Timur. In the spring of 1395, the princesses were sent to Samarkand with the princes; the princes' father, Shahrukh, had been waiting for them there since the autumn of 1394. In 1396, Shahrukh, along with his children and wives, greeted Timur, who was returning from a "five-year" campaign to Guzor in Kashkadarya.

During the campaign to India, Sarai Mulk accompanied Timur to Kabul together with Ulugbek, which testifies to the special love of the great commander for this grandson. In August 1398, Timur returned his wife and grandson to Samarkand from the outskirts of Kabul. Ghiyasuddin Ali explains this as follows: Timur, although he did not want to send his beloved grandson back, could not take him with him, as he was afraid that the hot climate of India would negatively affect the child's health. On Sunday, March 30, 1399, five-year-old Ulugbek was among those who greeted Timur on the banks of the Amu Darya, returning from a campaign in India.

During Timur's 1399-1404 campaign in Ancient Asia, known as the "Seven Years' Campaign", Ulugbek gave birth together with his grandmothers. In those years, Timur's favorite place to spend the winter was Karabakh; here he spent the winters of 1389/1400, 1401/1402, 1402/1403 together withillness. In 1400/1401, 1402/1403, the princesses and princes live in Ulugh Beg's hometown of Sultania. In 1403, Ulugbek, Ibrahim Sultan, and other princes welcomed Timur to Arzirum. In mid-May 1404, Timur captures the fortress of Feruzko on Mount Demovand in Northern Iran. Then, on 11 Zulqada 806 AH/21 May 1404 AD, the queens Sarai Mulk and Tuman Agoni went to Samarkand with the princes Ulugbek, Ibrahim Sultan, Ijil, and Sadvakkos.

Timur returned to Samarkand from the "seven-year campaign" on 16 Muharram 807 AH/19 July 1404 AD. On the occasion of his return from the victorious campaign, he organized ceremonial weddings.

Rabi al 807 Hijri - one of the first, that is, "the year of bichin", on September 7, 1404 CE. held a congress and held a huge wedding - the daughter of Muhammad Sultan, the son of Jahangir Mirza, Oga Begumni. Ulugbek passed; he also marriedIbrahim Sultan, son of Mirunshah Ijil, sons of Umarshah Pir Muhammad, Sayyid Ahmad and Boykar. The kings and princes of all the states subordinate to Amir Timur took part in the wedding. Of the sons and grandsons, only the youngest son Shahrukh, the father of Ulugbek, then the governor of

Khorasan, and his grandson Pir Muhammad, son of Jahangir, then of India and the governor of Kandahar, were absent on the wedding day. The wedding lasted almost two months, and a man was sent to Pir Muhammad to participate. According to Timur's will, Shahrukh was not present at the wedding. Sahibkiran explained this as follows: "Therefore, those who are in Iraq and Azerbaijan feel great strength." Among the Genghis Khans present at the wedding was Taizi Oglan, as well as the "ambassadors of the farangs", among whom was Ruy González de Clavijo, ambassador and spy of Castile and Leon.

The wedding ceremonies lasted up to two months. After the wedding ceremony, Amir Timur began preparing for the campaign to China. Before leaving, he divided the eastern lands of his empire between his two favorite grandsons, the sons of Shahrukh. Then the lands of Tashkent, Sairam, Yangi, Ashpara and Jeta reached Ulugbek to China, and Andijan, Akhchikent, Topoz and Koshgar with the adjacent lands to Khotan - reachedIbrahim-Sultan. Amir Temur announced this on a special tablet and put his seal on it. Therefore, Ulugbek and Ibrahim Sultan were together with their grandfathers in the main camp.

The right wing of the army of Amir Temur, led by the son of Khalil Sultan Mironshah, the son of Ahmad Umarsheikh, as well as the emirs Khudoidad Hosseini, Shamsiddin Abbas and the heads of other districts and thousands will spend the winter in Tashkent, Shahrukhiya and Sairam, part of the left wing of the army and let them spend the winter in Yassy and Sabron under the leadership of Sultan Hussein, the grandson of the daughter of the owner, he said.

ArmyHaving entrusted the rear and defense of Samarkand to Amir Arghunshah, and the state treasury to Sheikh Chura, on Friday 23, 807 AH / November 27, 1404 AD, Amir Temur left Samarkand for his last military unit - the Chinese unit.

Sharafuddin, the palace astrologer Maulana Badriddin, quoted the horoscope for the day of his departure from Samarkand: “The Sun was in the middle of Romi’s horoscope with Mushtari in hexagonal aspect and Mushtari in trigonal aspect.”

Amir TemurAt first he stopped when he reached the village of Aksultan in the Kara-Bulak district and stayed there for 28 days. Then, on December 25, 1404, he passed along the Ilon-Otti road and came to the Tomlik region. After landing there, a lot of snow fell and it was very cold. After that, he moved from there and came to the village of Aksultan near Otror, where he decided to spend the winter, since the ground was sandy and there was a lot of grass. Here he assembled the divan, examined the military leaders and received Kara-khoja, the ambassador of Tokhtamysh. At the reception ceremony, Taizi O'glan and Toshtemir O'glan from the Ogday kaon clan and Zharka O'glan from the Jo'chi clan were sitting on his right, and on his left was his grandson Ulugbek, Ibrahim Sultan and Idjil were sitting. After the reception ceremony, Amir Temur took the princesses back to Samarkand along with their grandchildren.

Due to severe cold and a lot of snow, the winter in Aksulot was difficult. On February 11, Sahibkiran suddenly developed a high fever. His condition worsened every day, he did not receive any treatment, and on February 18, 1405, Sahibgiron Amir Temur died. According to the will of the owner, the successor to the Samarkand throne was to be Pir Muhammad, the son of Mirza Jahangir, who was in Kandahar at the time. Perhaps this appointment was a mistake by Amir Temur, who was on the verge of death, since his will shows that he was not aware of the situation in his country and the actions of his descendants. After the death of all the commanders of Sahibkiran, such as Berdibek Sari Buga, Sheikh Nuriddin, Shah Malik, Haji Yusuf and others, took the Koran into their hands and were faithful to the will of the great commander, the emirs and princes died, they swear that they will not allow conflict among themselves and continue the Chinese campaign started by the master. In addition, they decided to keep Timur's deathsecretly from others until the successor Pir Muhammad arrives in Samarkand. But this ominous news is quickly revealed by the cries of his wives, and the relations between his descendants and the emirs quickly deteriorate. Contrary to the will of Amir Temur, on March 18, 1405, Mirunshah's son Khalil Sultan came to power in Samarkand. Further developments showed that he did not lay claim to any lands other than Movarunnahr. Around the same time, Timur's youngest son Shahrukh "sat on the throne of Khorasan", and his "kingdom and rule in Iran and Iraq" began.

At the beginning of the Time of Troubles, it was impossible to talk about continuing the campaign, so the entire army, together with the emirs and generals, moved towards Samarkand. Ulugbek remained on the right wing of the army, which was commanded by Amir Shah Malik. After this, Shah Malik's father Ulugbek became his guardian until he reached adulthood.I, that is, until 1411. When the lashkar approached Samarkand, Amir Arghunshah was allowed to enter the city only by Sarai Mulk along with other princesses and princes. Amirs Shah Malik and Sheikh Nuriddin march towards Bukhara along with princes Ulugbek and Ibrahim Sultan.

Khalil Sultan's actions were completely contrary to the will of Amir Temur, and in this case he was a threat to Khorasan, which he ruled. In addition, Shahrukh Khalil may have thought that by taking the throne of Samarkand and becoming stronger, he would be able to lay claim to all of Amir Temur's property. Moreover, Shahrukh found himself between father and son - Mironshah, who ruled Azerbaijan, and his son Khalil Sultan. In addition, his brothers Abu Bakr and

Mirza Umar began to threaten the northwestern regions of Shahrukh's estate from Tabriz. Therefore, Shahrukh, without waiting, correctly assessed the situation and decided to attackKhalil Sultan, who was approaching the Amu Darya, pushed his warriors back towards Shibirgan. In such a difficult situation, it was safer for Shahrukh's younger sons, Ulugbek and Ibrahim Sultan, to go to Herat with their father. The emirs Sheikh Nuriddin and Shah Malik went to this city with the princes.

Shahrukh promises to hand over the riches in Samarkand to him on condition that he stays in the village of Duqa on the Amu Darya River and does not go to Movarunnahr. After this, the construction of the bridge will be stopped. Shahrukh returned to Herat.

Upon arrival in Herat, Ulugbek took an active part in the military and political life of Khorasan. In early 1406, he took part in the war againstKhalil Sultan, who, together with his father Shah Malik, attacked Balkh and Shibirgan. Unfortunately, the sources do not indicate how Ulugbek acquired worldly knowledge during these years. Although in his Zij he called Kazizada Rumi his teacher, the sources do not indicate when and where he received his education from him. It is known that in Kazizada Rumi came to Movarunnahr in the 80s of the 13th century. When Ulugbek met Jamshid Koshii, he was summoned to Samarkand after becoming the sultan of Movarunnahr, appointed him governor of the cities of Samalkon, Mashhad, Jarmughan and Kalot. This year, Ulugbek spends the winter with Shah Malik in Astrobad - southeast of the Caspian. In the spring of 1407, Shahrukh annexed Mozandaran, the province of Astrobad, to Ulugbeg's possessions. At the end of the same year, Pir Podshahni, who invaded the lands of Ulugbek at the request of Shahrukh Ulugbek, went to Mazandaran for the sake of the fetish.

Khalil Sultan's fears about the situation in Mazandaran were soon allayed. On March 30, 1409, Khalil Sultan was arrested near Samarkand by Khudoidad Hosseini, allegedly acting on the orders of Shahrukh. At that time, this man was ready on the banks of the Amu Darya with a large army, which included Shah Malik and Ulugbek. Knowing aboutKhalil Sultan's condition, he crossed the river with Shahrukh Ulugbek and Shah Malik and entered Samarkand on May 13, 1409. Shahrukh, who was busy improving the military and political situation in Movarunnahr, remained in Samarkand until the end of the same year. He then appointed Ulugbek as the king of Movarunnahr and Turkestan, and Shah Malik as his protector and adviser. Shahrukh would return to Herat at the end of the year. After this, the full name of the Ulugbek sultanate became Abul Fath Muhammad Taragai Ulugbek.

1410 In the early spring of 1915, Amir Temur's former general, Sheikh Nuriddin, Otrar's deputy, rebelled and marched against Ulugbek along with his former comrade Shah Malik. The rebel gathered a large army, approached Samarkand, and on April 20, 1410, began a war with Shah Malik. Ulugbek and Shah Malik were defeated and retreated to Kalif on the banks of the Amu Darya. Shahrukh was prepared for such events and on June 20, he crossed the Amu Darya with his army in two places: Kalifde and Termez. Ulugbek went with Shah Malik in the second group, which was lightly armed and advanced. Hearing that the enemy had crossed the river, Sheikh Nuriddin headed towards them. In the ensuing battle, Shah Malik was again defeated and retreated to Samarkand. Then Shahrukh arrived with the main force and on July 12, 1410, fought with Sheikh Nuriddin, defeated him and forced him to flee. He retreated to O'tror. Shahrukh sent Shah Malik to O'tror to completely suppress the rebel and Amir Mizrab to Hissar to punish his partner Hamza Sulduz, and he himself left Samarkand on July 23 and reached Herat on August 3.

Amirxon January 11, 1411, Shah Malik marched against Sheikh Nuriddin. The soldiers of both commanders stood opposite each other in Sarbonyakin, but there was no battle. Shah Malik used a trick: while the soldiers were lining up, he asked Sheikh Nuriddin to go out on foot alone, distracted him with memories of past battles in the field and cut off his head with a dagger. Thus, the dangerous enemy of Ulugbek was finished. In September 1411, worried about the situation in Movarunnahr, Shahrukh returned to Herat in November of the same year. He took with him Ulugbek's patron Shah Malik. And in October 1411, that is, in the 18th year of his life, Ulugbek became an independent ruler of Movarunnahr and Turkestan.

Scientific and cultural heritage

Ulugbek brought the science and culture of the peoples of Central Asia to the highest level of world science in the Middle Ages. The greatest thing he did was to found the Samarkand Scientific School, the academy of that time. More than 200 scientists worked in this scientific school.The most prominent among them were Kazizade Rumi, Giyosiddin Jamshid Koshi. The scientific school of Ulugbek, which included famous Central Asian scientists Muhammad Khorezmi, Ahmad al-Farghani, Abul Abbas al-Jawahari, Ibn Turk al-Khuttali, Khalid al-Marwarrudi, Ahmed al-Marvazi, Abu Nasr Farabi, Abu Rayhan, was based on the scientific tradition started by the Berunis. Ulugbek built an observatory near Samarkand. [4]

Ali Kushchi, a major scholar of the Ulugbek Academy, in the preface to "Ziji" says "farzandi arjumand", that is, "my dear child". In fact, he was a faithful student of Ulugbek and helped his teacher until the work on "Ziji" was completed.

Ulugbek founded two madrassas in Samarkand: one in the Registan complex and the other in the Gori Amir complex. Among other great scholars, Ulugbek himself lectured once a week in each of these madrassas. The rest of the time was devoted to astronomical observations, work on the Zij and state affairs. Ulugbek is known to the world as an astronomer and scientist for his work Zij Koragony.

Historian Haydar Mirzo wrote in his book “History of Rashidi”: “Mirzo Ulugbek was a wise historian and wrote down the history of the “Four Nations”. But the original of the “Four Nations” has not reached us. Two copiesare kept in Istanbul, and an abridged copy is kept in the library of the India Office in London and the British Museum.

Another mathematical work by Ulugbek is called "Risolai of Ulugh Beg", a copy of which is kept in the Aligarh Unti library in India and has not been studied to date.It may also have something to do with computational mathematics.

Studying the Legacy of Ulugbeg

The scientific legacy of Ulugbek, which left an indelible mark on the history of culture, is his "Zij". This work attracted the attention of scholars in Muslim countries, since it was the most perfect medieval astronomical work in terms of the interpretation of the planets, the movement of the Sun and Moon, the star catalog and the mathematical methods used in it. The first commentary on "Zij" was written by Ulugbeg's student Ali Kushchi under the name "Sharkhi Ziji Ulugbek". [4]

In the same 15th century, the Cairo astrologer Shamsiddin Muhammad al-Sufi al-Misri wrote a work entitled "Tashil Ziji Ulugbek" ("Easy "Zij" of Ulugbeg"), in which he adapted Ulugbeg's tables to the latitude of Cairo. Al-Mirsi in his "Taqwim al-Kabaqib al-Saba" ("Calendars of the Seven Planets") and "Jodawil al-Mahlul assani ala". Ulugh Beg refers to "Zij" in two more works entitled "Usul Ulugh Beg" (The Second Table of Solutions by Ulugh Beg's Method).

The Syrian scholar Zayniddin al-Jawhari al-Salihi (15th century) reworked the ZijUlugbek in his work entitled “Ad-Durr an-nozil fi tashil at-taqvim” (“Revealed Durs in the Simplification of the Calendar”).

The most perfect commentary writtenon Ulugbek "Zij" is "Sharkhi Ziji Ulugbek", written in 1523 and completed in 1523 by Nizamiddin Abdul Ali ibn Muhammad ibn Hussein Birjandi (1525), the last representative of the Samarkand scientific school. Birjandi reveals the secrets of "Zij" in his "Sharkh" in detail and with precise figures. He explained and proved many of Ulugbek's sayings with drawings.

Miram Chalabi (1525), the grandson of two great Samarkand scholars, Kazizade Rumi and Ali Kushchi, wrote a commentary on Zij and called it“Dastur al-amal wa tashih al-jadwal” (“Program of action and correction of tables”).

The Iranian scholar Ghiyoseddin Mansur al-Husaini al-Shirazi (1542) wrote a commentary on Zij entitled Risala dar tanik Zij Ulugek (Ab Treatise on the Explanation of Ulugbeg's Zij).

The 16th century saw a number of Muslim scholars in the second half of the 17th and 18th centuries write commentaries on the Zij and adapt it to their time and place. Among them are the Syrian Taqiyiddin al-Shami (1526-85), Majariddin al-Qari (16th century), the Egyptian Abdul Qadir al-Manufi al-Shafi'i (16th century), the Iranian Shah Fathullah Shirazi (1589) and Muhammad Baqir al-Yazdi (1637), the Indian Fariduddin Dehlavi (1629), and the Turk Muhammad Damadon al from Dagestan. - Among them are commentaries by scholars such as Mukhiy (1718).

Among them, the work of the Indian statesman and scientist Sawai Jai Singh occupies a special place. By order of Babur Sultan Muhammad Shah (1719-48) from India, he founded observatories in Delhi, Banoras, Jaipur, Ujjain and Muttra in accordance with the specifications of the equipment of the observatory of Ulugbek. Then he wrote the work "Ziji Muhammadshahi" on behalf of the Sultan, whom he patronized, and in it he adopted some of Ulugbek's schemes. T.N.Kori-Niyazi and G.Sobirov from Dushanbe showed in their works the connection between the work of Sawai Jai Singh and Ulugbek "Zij".

The name of Ulugbek was known in Europe and Western countries in general due to the fame of his great-grandfather Amir Temur. Europe first heard about Amir Temur and his family members from the Spanish ambassador Ruy González de Clavijo, who traveled to Samarkand in 1403-05. After Clavijo's Diaries were published in Seville in 1582 and in Paris in 1607, Europeans immediately became interested in Amir Temur and his family members. The name of Ulugbek is mentioned in dramatic works dedicated to Amir Temur from the beginning of the 17th century (since 1601).

The first European publication directly dedicated to Ulugbek was written by the English astronomer John Greaves (1602-52). His work, published in 1648, included a portion of Ulugbeg's star chart (98 stars). In 1665, another English scholar, Thomas Hyde (1636-1703), published a Persian and Latin translation of the star chart in Zij, which had no relation to Greaves.

1690 g.In two engravings in the "Atlas of the Starry Sky", published by the Polish astronomer Jan Hevely in Gdansk, Ulugbek is given a place of honor among the famous astronomers of that time, in which Ulugbek's star map was compared with Ptolemy, Tycho Brahe, Riccioli, William IV and compared it with the tables. In 1711, Ulugbek's geographical table was published 3 times in Oxford. In 1807, this table was also published in Modern Greek. In 1725, the English astronomer D. Flemetides (1646-1719) published Ulugbek's star map together with Ptolemy, Tycho Brahe, Riccioli, William IV, Jan Hevely and his own maps. In 1767, the Englishman G. Sharpe republished Ulugbek's star map in the edition of T. Hyde. In 1843, the Englishman F. Bailey (1774 - 1844) improved this edition and published the 3rd edition. The French orientalist L. A. Sedio (1808-76) published in 1839 part of the astronomical tables of Ulugh Beg "Zij". In 1917, the American scientist E. B. Noble Ulugh Beg published a critical text of the table of stars "Zij" based on 27 manuscripts, and in 1927 K. Shoy published a trigonometric table "Zij". Ulugh Beg "Zij" had a special history in Russia and the former Soviet Union. In the first half of the 18th century, "Zij" of Ulugbek was under special consideration at the St. Petersburg Academy, and scientists Yu. N. Delil (1688-1768), G. Ya. Ker began to translate it, but the work was not completed.

1908-09 years after V.L. Vyatkin excavated the ruins of the Ulugbek observatory and its main instrument, the quaffrant, a new interest in the activities of Samarkand scientists began. As a result, in 1918, V.V. Bartold's work "Ulugbek and His Era" was published.

During the Soviet period TN.Kori-Niyazi made a lot of efforts to familiarize the public of the country with the life and work of Ulugbek. In the propaganda of Ulugbek's work, the publications of F. Jalolov and V.P. Shcheglov are also worthy of attention. By the beginning of the 80s of the twentieth century, A. Akhmedov completed and published in 1994 a complete and perfect translation of Ulugbek's "Zij" with scientific annotations.

Until recently, Ulugbek was considered only an astronomer and mathematician. But at the end of the 20th century, his activity intensified, and it turned out that he also wrote on history, poetry and music.

Historian Mirza Muhammad Haidar wrote in his book “History of Rashidi” that “Mirza Ulugbek was a wise historian (and) wrote down (history)"Four Nations". Written in Turkish, Ulugbek's work "Tarihi arbaulus" ("History of the Four Nations") is an important source for studying the political life of the countries conquered by Genghis Khan in the first half of the 13th-14th centuries.

MashhadIn one of the buildings, the following verse written by Ulugbek was found:

It is a beautiful piece of gold though.
Don't look at the toast in the fireplace.

Meaning:

Although your husband's property is at your disposal,
Don't be arrogant because you are in front of him.

Examples of his poems are also included in Navoi's Majolis un-Nafais and Abu Tahirhoja's Samaria. During his time, many works were translated from Arabic and Persian into Old Uzbek. The rich library created by Ulugbek contained more than 15 thousand volumes of books on various topics.

Alisher Navoi praised Ulugbek in his work “Khamsa” and wrote:

Mirzo Ulugbek from the family of Temur Khan,
The world has never seen a sultan like you.
People of that era have an indelible memory.
His distressed jeans are ruined.
Valek ul found his way to science,
The sky is low before his eyes.
My vision is a beautiful world.
To know this kind of knowledge is heavenly,
Zizhi Koragoniy wrote about this.

Authors of the distant and recent past (Darvishali Changiy, Fitrat, etc.) say that Ulugbek took music lessons from his youth, among other subjects, created a number of tunes and methods, and wrote a treatise on this topic.

The 600th anniversary of Ulugbek's birth was solemnly celebrated in April 1994 in Paris, and international conferences were held in Tashkent and Samarkand in October. A monument to Ulugbek was erected in Tashkent that same year.

PersonalityUlugbek is among the portraits of world-famous scientists in the conference halls of the Pulkovo Observatory and Moscow University. A memorial museum of Ulugbek has been created in Samarkand. In Tashkent, the National University of Uzbekistan, a district, a planetarium, a street, a block, a metro station, a park and a city are named after Ulugbek. The Fergana Pedagogical University, the Samarkand University of Architecture and Construction, the Kitab International Latitude Station, a village, a school and others are named after Ulugbek.

A play about the life and work of Ulugbek (M. Shaikhzoda, "The Tragedy of Mirzo Ulugbek"), a novel (O. Yagubov, "Treasures of Ulugbek"; S. Borodin, "Stars in the Sky of Samarkand"), an opera (A. Kozlovsky, "Ulugbek"), a poem (M. Boboev, "Ulugbek"), a ballet (M. Bafoev, "Ulugbek Burji"), a film (directed by Latif Fayziev, "The Star of Ulugbek", 1965) and others were created.

Ulugbek Madrasah in Bukhara.

An architectural monument in Bukhara (1417). This is the oldest of the three madrasahs built by Ulugbek. During the reign of Abdullah Khan II, major repairs were carried out (1586). The main style is a majestic pediment, two-story rooms in two wings and flower bouquets in the corners. The top of the bouquets has a dome shape. The main decoration of the madrasah is on the pediment, which in addition to syrkop bricks, uses multi-colored rivets and tiles. From Ravokli Peshtoq it goes through the miyan - the palace to the courtyard. The inner dome of the Mion Palace consists of 12 faces made of brick mesh, between which blue and airy tiles are laid. The site $(26 \times 25\ m)$It is surrounded by a row of two-story rooms and two verandas with a roof. The northern and southern sides of the courtyard have a shorter appearance, and the walls, arches and pediments are finished with white, turquoise and purple glazed bricks. The interior of the chambers is plastered. The madrasah is not very large $(53 \times 41{,}6\ m)$, the premises are remarkable, harmonious, the internal and external arrangement is unique. The mosque $(15{,}5 \times 5{,}5\ m)$ and the classroom $(5{,}5 \times 5{,}5\ m)$ are located on two sides of the dome. [4]

Ulugbek Madrasah in Bukhara.

On the 2nd floor of Mion Palace there is a library. Khoja Saad Joybori renovated the outer facade and side rooms (1586). The name of the master of the repairs, Ismail ibn Tahir ibn Mukhmud Isfahani, has been preserved among the ganchkori decorations at the top of the room in the west of the courtyard. According to Abdurazzok Samarkandi, Ulugbek (November 28, 1419) distributed gifts to students who came to the madrasah. The Ulugbek Madrasah has reached us in a greatly altered form. It was renovated in the 16th-17th centuries, in 1950-70 and 1990-96. The patterns contain many stars. The porch pillars are gilded. The phrase "Education is obligatory for every Muslim man and woman" is engraved in Arabic on the door panels.

Ulugbek Madrasah in Gijduvan

The architectural monument of the Ulugbek Madrasah in Gijduvan dates back to 1433. Ulugbek is the smallest and simplest of the madrasahs built in Samarkand and Bukhara. The madrasah consists of a one-story room-murabba $(33 \times 30\ m)$, a mosque, a classroom and a dormitory. The roof is deeply arched. In the middle is a mosque, a mosque and a classroom next to it $(8 \times 4{,}6\ m)$, and in the corners is a bouquet of flowers. The entrance to the courtyard is through a door in the Mionsarai network. On 2 sides of the courtyard there are 5 rooms $(15 \times 13\ m)$, 4 of which are in the form of a murabba, with domed roofs. The main building of the Ulugbek Madrasah of the 15th century, the adjoining porch and minaret have been preserved. In 1933, V. Shishkin, V. Nielsen and I. Notkin determined the dimensions. The name of Ulugbek and the date of construction are written in the main font. To the west of the madrasah is the grave of Sheikh Abdukholik Gijduvani. By the 890th anniversary of Gijduvan (1993), the Ulugbek madrasah was renovated. Next to the pointed pediment, a porch with columns and a flat roof, decorated with tiles, was built, doors to the rooms on the sides of the pediment. The entrance is made in a pointed style, ganchkori claws are installed on the pediments. The ornament of Serkhasham was restored. In 2003, a porch covered with a wooden carved dome was built on the roof of Gijduvani. The decorations of the Dakhma were restored. The territory in front of the madrasah, dakhma and the newly built mosque is landscaped in accordance with modern requirements.

Ulugbek Madrasah in Samarkand.

An architectural monument in Samarkand (1417-22). It is located in the west of the Registan ensemble. 2-storey, $(56 \times 81\ m)$Rectangular. The main style facing the square is in the form of a majestic pediment, with a wide arched arch (height 16.5 m) and flower bouquets (height 32 m) on both its sides. The decoration of the kanos, reflecting the starry sky above the porch, is unique. The top of the bouquet is decorated with muqarnas, honors. The edge of the peshtok has the shape of a morpech, and the elements of the shelf are decorated in a unique style. Various unique examples of the girih pattern are presented on the facade, flowerbed and outer walls. Light enters the room through the ganchkori lattice. The surface of the wall, decorated with geometric patterns using blue-light blue tiles and ceramic bricks, harmonizes with the inscriptions and stands out clearly. Through the peshtok, the chorsi goes out into the courtyard
$(30 \times 30\ m)$. [4]

Ulugbek Madrasah. Registan Square. Samarkand.

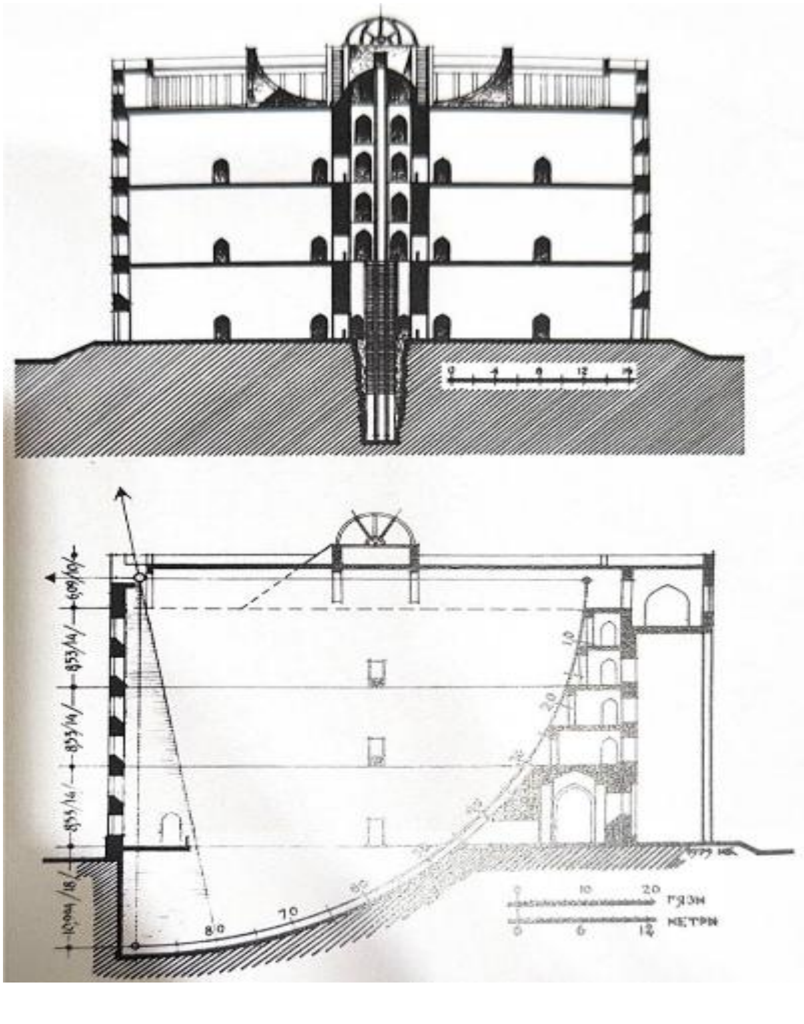
The courtyard is surrounded by 48 two-storey rooms, each of which consists of a kitchen, a bedroom and a common room. Between the northern and southern aisles of the madrasah there are separate porticoes outside. The four sides of the madrasah are occupied by a classroom and a porch. The mosque extends to the southeast. There are 4 high towers at the outer four corners. The interior of the hall $(22 \times 8\ m)$ and some rooms is decorated with decorative ornaments. Among the decorations there are Kufic and Sul inscriptions. The destroyed 2 floors, the crooked flowerbed, the displaced decorations on the walls were restored in 1936, the north-eastern tower was repaired in 1932 according to the design of V. Shukhov and M. Mauer. E. Gendel restored the leaning tower in 1965. A. Umarov, Sh. Such masters as Gafurov, G. Dzhalilov, I. Shermukhammedov, A. Kuliev participated. The Ulugbek Madrasah, in its architectural form and structure, is the most perfect example of high art among buildings of this type in the architecture of Central Asia.

Ulugbek Observatory

One of the rare examples of 15th century architecture in Samarkand, an ancient astronomical observatory.It was built in the form of a huge cylinder on the Kokhak (Choponota) hill in 1428-29 by order of Ulugbek some manuscripts are built in 3 floors with a height of 30.4 m according to (Boburnoma). It contained more than ten different astronomical devices and instruments. The most important of them is a quadrant (or near-sextant) device consisting of a double arc with a radius of 40.2 m. The southern part of the quadrant is underground, and the rest is located on the northern side, about 30 m above ground level. One degree of arc corresponds to 701.85 mm, and 1 arc minute corresponds to 11.53 mm. In the Middle Ages, the observatory was equipped with equipment. The device made it possible to determine the main constants of astronomy - measuring the angle between the equator and the ecliptic, the constant of annual precession, the length of the tropical year and other fundamental astronomical constants. The observatory had small instruments: an armillary sphere, measuring devices with 2, 4 and 7 rings, a triangular, a sun and star clock, an astrolob and others. With the help of this scientific equipment, the Sun, Moon, planets and individual stars were observed. The largest astronomical work of Mirzo Ulugbek, Zizhi Koragani, was created in the observatory. Its construction and subsequent scientific activity are associated with a number of famous scientists, Giyosiddin Koshi, Kazizoda Rumi, Ali Kushchi and others, who gathered at the invitation of Ulugbek. [9]

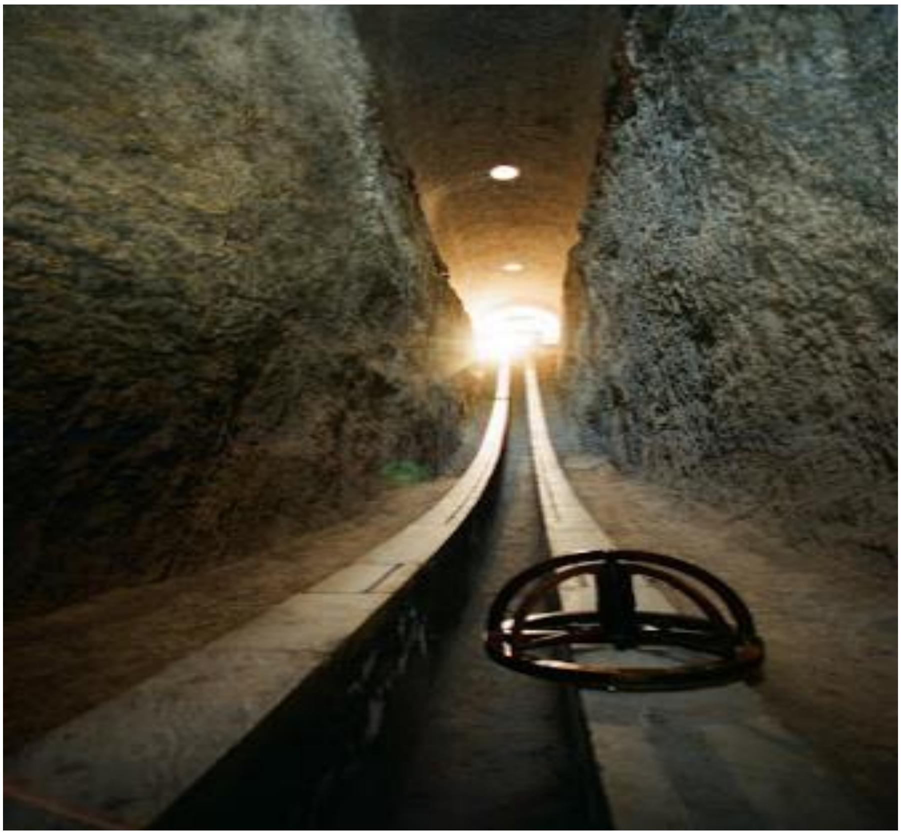
Ulugbek Observatory

The archaeological remains of the Ulugbek observatory were discovered in 1908 as a result of excavations conducted under the direction of V. L. Vyatkin. In particular, a wall with a diameter of 48 m and a thickness of one brick was discovered here, as well as the remains of a huge main structure consisting of a double arch in its center. It had large halls, various large and small rooms. According to Bobir, the surface of the Ulugbek observatory is decorated with tiles and mysterious rivets. The sun, moon, planets and stars are recorded with great accuracy by a very large device installed inside the observatory. The observatory also had a library. On the inner wall there is an image of the sky, a map of the stars, an image of a globe with mountains, seas and countries. Later it was abandoned and destroyed in the 16th century. Now the large instrument in the Ulugbek observatory - part of the area stored underground - reaches a height of 11 meters. In 1964, the Ulugbek Museum was opened next to the Ulugbek Observatory. Uzbek and foreign scientists are conducting research into the original appearance, interior structure, and main equipment of the Ulugbek Observatory.



Sections of the Ulugbek observatory building. Reconstruction by M. Bulatov.

Zijs(from Persian - astronomical table) - ancient astronomical tables. Initially, it consisted of tables of arcsines, i.e. vataras, later it included tables of trigonometric functions, as well as star catalogs and the basics of theoretical astronomy. The Indians called Ziji "Siddhanta". It is known that the early Indian "Siddhantas" were compiled under the influence of ancient Greek astronomers, in particular Alexandrian. Early Ziji - "Sindhins", belonging to the Arabian East, are translations of these "Siddhantas", which have almost not survived. At the same time, in the middle of the 9th century, after Claudius Ptomey (2nd century) translated the astronomical work "Almagest" (al-Majisti) into Arabic, he influenced the development of Eastern astronomy, including improving Ziji.



Underground part of the quadrant of the Samarkand Observatory.

VIII - IX centuries - it is known that over the centuries about 100 Ziji were compiled. About 20 of them were compiled on the basis of direct astronomical observations of their authors, most of them were compiled in Central Asia, more precisely, in Movarunnarra or with the participation of Movarunnarra scientists. Many Ziji are dedicated to statesmen who patronized the scientists who compiled them.

Armed sphere. In the Samarkand observatory.

The most famous Ziji in the East arethe following. "Ziji al-Ma'muni", compiled by Muhammad ibn Musa al-Khwarizmi (c. 780-850) and Abbas ibn Said al-Jawhari (9th century) and dedicated to the Abbasid Caliph Ma'mun ar-Rashid (813-833), "Ziji as-Sabi", compiled by Muhammad al-Battani (850-929) from the Sabian group, the Moorish Ahmad ibn "Ziji al-Habashi", compiled by Abdullah Habash al-Hasib (9th century), "Ziji Malikshahi", compiled by Omar Khayyam (1048 - 1131) and dedicated to the Seljuk Sultan Malikshah ibn Alp Arslon (1072 - 1092), Moorish Abdulfattah Abdurrahman. al-Khazini", dedicated to the Sultan of Ghazna Abu Rayhan Beruni Masud Ghaznavi. "Kanuni Masudi" was compiled under the guidance of the Azerbaijani astronomer Nasiriddin Tusi (1201 - 1274), and "Zija Ilkhani", dedicated to the Mongol Khan Khalok, was compiled by Giyosiddin Jamshik al-Koshi (circa 14th - 15th centuries). "Zizhi Khokaniy", dedicated to Ulughbek, "Zizhi Koragoniy", composed by Ulughbek and his students. ("Zizhi Ulughbeg").

Ulugbek Observatory. Southern Front. Reconstruction by B. Zasypkin.

The original Zij was as accurate as Ptolemy's table, but the later Zij achieved much greater accuracy.Because in al-Khwarizmi zij, in the sixty-year number system, the table of sines is given in the interval $1°$ with an accuracy of up to three digits, and the table of cotangents $1°$ is given with an accuracy of one digit. The table of sines, sine dependencies, tangents, cotangents and cosecants of Habash al-Khasib is given in the interval with an accuracy of up to three digits. In Beruni's work "Kanuni Masudi" the table $15'$ of sines is given with intervals, and the table of tangents $1°$- with an interval. Beruni, in particular, calculated with an accuracy of up $sin 1°$ to 10^{-8} One of the most accurate zijs is "Zizhi Koragoniy" by Ulugbek, which indicates the position of 1018 stars in the ecliptic coordinate system, as well as a table of sines with an $1'$ interval, tables of tangents with 45° an $1'$ accuracy of $46°$ to $90°$ an $5'$ accuracy of is given. The values of trigonometric functions 10^{-10} can be calculated using Ulugh Beg's zijs with an accuracy of about . Zijs compiled in the countries of the East had a great influence on the development of trigonometry and astronomy in Western Europe. In particular, the tables of al-Khwarizmi, al-Battani, al-Khazini, Beruni, Nasiriddin Tusi and Ulugbeg were known to Western European scholars of the 11th-17th centuries, were translated into Western languages and played an important role in the development of science and culture in Europe.

Ulugbek Academy

Ulugbek was familiar with the classical works of Greek scholars Plato, Aristotle, Hipparchus and Ptolemy, and had studied well the works of his compatriots Ahmad Farghani, Beruni, Ibn Sina and Khorezmi. Ulugbek Madrasah (1420) in Samarkand was not only a higher educational institution, but also an academy of that time, together with an observatory. The arithmetic of decimal fractions was created by Giyosiddin Koshiy at Ulugbek Academy. The method for determining the sine of an 1° arc was developed by Ulugbek and Koshiy (using the method $ax^2 + bx + c = 0$ for solving a three-dimensional algebraic equation of the form). The value of the Cauchy number π is calculated with an accuracy of up to 17 digits, i.e. [7]

$$\pi = 3{,}14159265358927932$$

Astronomers led by Ulugbek built an observatory with relatively precise instruments and equipment to study the secrets of the universe more deeply and widely, as well as to carry out important scientific work. In the observatory, Ulugbek determined the latitude of Samarkand for the first time with great accuracy and derived a value for it $= 39°37'33''$. Indicates that this value is acceptable. Despite the lack of $\varphi = 39°40'37'' \pm 1''0$ advanced observation and measuring instruments, Ulugbek correctly calculated the movement of the Sun and the Moon, his calculations were not much different from modern calculations. This can be found out by comparing Ulugbek's calculation with the estimate of the deviation of the ecliptic plane from the equator by astronomers of different times:

in Eratosthenes	$23°51'20''$	error	$+7'35''$
in Hipparchus	$23°51'20''$	error	$+8'23''$
In Ptolemy	$23°51'20''$	error	$+10'10''$
In Battonia	$23°35'$	error	$-0'17''$
Abulwafada	$23°35'$	error	$+0'35''$
On Kohi	$23°51'01''$	error	$+16'36''$
In Tusi	$23°\ 30'$	error	$-2'9''$
In Ulugbek	$23°30'17''$	error	$-0'32''$

Ulugh Beg's reports on the stellar year are also very close to the current accounting books:

365 days 6 hours 10 minutes 8 seconds in Ulugbek
In fact, 365 days 6 hours 9 minutes 6 seconds.

"Zizhi Koragony"

"Zidzhi zhadidi" Koragoniy" ("New Astronomical Table of Koragoniy"), "Ulugbek Ziji" is a scientific work created in the observatory near Samarkand under the direction of Mirzo Ulugbek (1437). It consists of two sections. The introduction is divided into four parts. [4]

Part I. The chronology describes the methods of calculating the year of the peoples of the East. The Arabic, Greek, Iranian, Chinese and Uighur calendars are described, as well as the methods of transition from one to another and the methods of counting individual national holidays of these peoples.

Part II. Dedicated to the issues of practical astronomy. In this case, the issues of determining the angle between the ecliptic and the equator, methods of finding the coordinates of celestial bodies, transferring the meridian line, determining the azimuth of the qibla, finding geographic coordinates, determining the length of the year and conducting differential measurements in the celestial sphere are considered.

In **Part III.** The apparent movements of the planets are interpreted on the basis of the geocentric system.

In **Part IV**. Information on the horoscope is provided. The table of stars presented in "Zizhi Koragoniy" is compiled on the basis of observations made in Samarkand. The map corresponds to the Hipparchus-Ptolemy map in the history of astronomy in terms of the number of stars and the originality of the observations.$(2 - century)$ranks second among zijs made before the invention of optical instruments."Zizhi Koragony" is the most perfect. It was used to determine time and measure geographical coordinates, as well as to solve various astronomical problems in the East and Europe until the 17th century.

There are other tables in the work. The table containingI have geographic coordinates of 683 points, compiled mainly using various sources. Trigonometric tables of sines and tangents were calculated using new methods developed by Samarkand scientists, which are significantly more accurate than the tables calculated up to that time$(\pm 10^{-9})$.

"Ziji Koragony" was written in Persian; later it was translated into Arabic and Turkish. Ali Kushchi, a student of Ulugh Beg, made a great contribution to the wide dissemination of Ziji manuscripts.

"Ziji Koragoniy" was first published in Europe in 1648 (England); it was later translated into many European languages. Handwritten copies of "Ziji Koragoniy" are kept in libraries in England, France, Turkey and India, and one of the oldest copies, written in Persian, is kept in the Institute of Oriental Studies of the USSR Academy of Sciences.

"Ziji» (from Persian - astronomical table) - ancient astronomical tables. Initially, it consisted of tables of arcsines, i.e. vatars, later it included tables of trigonometric functions, as well as star catalogs and the basics of theoretical astronomy. The Indians called "Zij" "Sindhanta". It is known that the early Indian "Sindhanta" was compiled under the influence of ancient Greek astronomers, in particular Alexandrian astronomers. The first "Zij" - "Sindhinds", belonging to the Arab East, are translations of these "Sindhanta", almost not preserved), after his astronomical works were translated into Arabic, he influenced the development of Eastern astronomy, including the improvement of "Zij". [5]

VIII-IX century it is known that about 100 "Zij" were created over the centuries. About 20 of them were compiled on the basis of direct astronomical observations of their authors, more precisely, most of them in Central Asia. Compiled in Movarunnahr or with the participation of Movarunnahr scientists. Many "Zij" are dedicated to statesmen who patronized the scientists who composed them.

The most famous "zijs" in the East arethe following. "Ziji al-Ma'muni", compiled by Muhammad ibn Musa al-Khwarizmi (c. 780-850) and Abbas ibn Said al-Jawhari (9th century) and dedicated to the Abbasid caliph Ma'mun ar-Rashid (813-833), "Ziji as-Sabi", compiled by Muhammad al-Battani (850-929) from the ranks of the Sabians of Ahmad ibn Abdullah Marw. "Habash al-Habashiy", compiled by Umar Khayyom (1048-1131) and dedicated to the Seljuk Sultan Malikshah ibn Alp Arslon (1072-1092) "Ziji Malikshahi", "Ziji", compiled by the Moorish Abulfat Abdurrahman al-Khazini (12th century) al-Khazini", "Law" of Abu Rayhan Beruni, dedicated to Masud of Ghazni, the Sultan of Ghazna. Mas'udi" was built under the guidance of the Azerbaijani astronomer Nasiriddin Tusi (1201-1274), and "Ziji Ilkhani", dedicated to the Mongol Khan Khalok, was built by Giyosiddin Jamshid al-Koshi (c. 14th-15th centuries) "Ziji Khoganiy". ", "Zizhi Koragoniy" works of Ulugbek and his students, etc.

The original Ziz had the same precision, but the later Ziz had much higher precision. For example, in the Zizi of al-Khwarizmi, the table of sines in hexadecimal notation is given to three digits of precision, and the table of cotangents is given to one digit of precision. Table of sine, sine-opposite, tangent, cotangent, and cosecant in the Zizi of Habash al-Hasib $1°$ three rooms between them are given with accuracy. In Beruni's work "Kanuni Masudi" the table of sines is $15'$ given with intervals, and the table of tangents $1°$- with an interval. Beruni, $sin 1°$ in particular, calculated with an accuracy of 10^{-8}. One of the most accurate zijs is "Zij Koragons" of Ulugbek, which shows the position of 1018 stars in the ecliptic coordinate system, as well as a table of sines $15'$ with an interval, a table of tangents with $45°$ an accuracy $1'$ of $46°$ to $90°$ an interval $5'$. The values of trigonometric functions according 10^{-10} to Ulugbek zij were calculated with an accuracy of . "Zij", created in the countries of the East, had a great influence on the development of trigonometry and astronomy in Western Europe. In particular, the tables of al-Khwarizmi, al-Battani, al-Khazini, Beruni, Nasiriddin Tusi and Ulugbek were known to Western European scholars of the 11th-17th centuries and were translated into Western languages and became the basis of science and culture in Europe and played an important role in its development.

The Great is the ruler

Ulugbek became the ruler of a huge state at such a young age and ruled the state for 39 years – until his tragic death.[3]

Ulugbek's childhood years, especially during the life of his grandfather, can be called the years of courage. Because these years were the years of great victories and the greatness of Amir Temur. Ulugbek and by that time he was respected and brought up, and his father and grandfather were preparing him for the royal rank. The situation and conditions 6 years after the death of the owner require exactly this. The first 10-15 years of Ulugbek's reign passed without flaws, and Ulugbek established himself as a sultan.

At the beginning of Ulugbeg's reign, there were still conflicts between the Timurids. In the autumn of 1413, Mirza Iskandar's son Umarshaikh, the then governor of Western Iran, rebelled. Shahrukh personally went with his troops to suppress the rebellion. Ulugbek sent only his elephants on this campaign. He himself declared that he would not be able to participate in his father's military campaign and would not be able to send soldiers, since the situation in Movarunnahr was not very good at that time. Mirza Amirak Ahmad, another son of Umarshaikh, the governor of Fergana, did not submit to Ulugbek. When Ulugbeg's attempts to make peace failed, he went to Fergana with his warriors. Ahmad first fled to the mountains, then moved to Koshgar. Ulugbek annexed Koshgar only in 1416, placing a governor there: Shahrukh summoned Ahmad to Herat.

In the summer of 1419, when several Uzbek princes were fighting for the throne in the Golden Horde, Ulugbek moved towards Tashkent. Then one of the warring nomadic Uzbek clans would be close to Ulugbek. Then Ulugbek used

Baroq, the grandson of Orushan Khan of the Golden Horde, whose grandfather had once fought with Sahibgiron. This ensured the safety of his property on the northern side. Now he could turn hisattention to Mughalistan, the main population of which was the desert Uzbek class, which, according to the position of Amir Temur, belonged to the possessions of Ulugbek. From 1416 to 1420, there was a struggle for power. As an interested party, Ulugbek intervened in this dispute. By the end of 1421, Ulugbek managed to transfer his man, Sher-Muhammad, to the throne of Mughalistan.

However, soon after this, Sher Muhammad treated Ulugbek unfairly and began to demonstrate invisibility and disobedience. Because of his actions, Ulugbek was forced to go to Mughalistan to punish his rebellious subject. He began his campaign in the second half of February 1425 and reached Issyk-Kul in the first ten days of March. There was no major battle between the armies of Ulugbek and Sher Muhammad. Only minor skirmishes occurred between small groups. In all the minor skirmishes, Ulugbek's troops won, since they had the advantage. WhenThey finally reached Ketmontepa, a battle took place between the two armies, in which Ulugbek was victorious.

Ulugbek verreturned to Samarkand from the campaign against Yetisu on June 27, 1425, and celebrated his victory. The celebrations on this occasion continued in the autumn in Herat, where Ulugbek arrived at the end of October, and returned to Samarkand in mid-November.

A former subject of Ulugbek began to claim that the lands in the middle and lower reaches of the Syr Darya belonged to his grandfather Orushan. This was reported by his deputy Arslanhoja Tarkhan. Ulugbek wanted to act against the nomadic Uzbeks and sent a message to his father about this. Shahrukh sent warriors to help Ulugbek, led by his youngest son Joki. He left Herat in mid-February 1427 and joined Ulugbek at Signog on the Syr Darya, one of the main places claimed by Barak: here lived the Uzbek khan of the Golden Horde of the early fourteenth century Erzone, the son of Sassig Buga, an ancestor of Barak, was buried.

After the two groups of warriors united, Ulugbek and Joki completely forgot about their vigilance, the Uzbeks immediately took advantage of this and attacked the combined forces of Ulugbek and Joki with their inferior warriors, forcing them to flee, and they barely escaped. It was a complete defeat. The Uzbeks of Barak Khan achieved victory and began to plunder the cities and villages of Movarunnahr and Turkestan, but in any case did not dare to enter the main cities of Movarunnahr - Samarkand and Bukhara.

The defeat left an alarming impression on the inhabitants of Movarunnahr and on Ulugbek himself. As Barthold said, the humiliation of 1427 seemed to have cemented the entire kingdom of Ulugbek. This defeat greatly undermined the reputation of Sultan Ulugbek. In fact, after this defeat, the Uzbeks of the Golden Horde began to grow, and later the Uzbek nation. In the 40sIn the 15th century, during the reign of the Uzbek Khan Abulkhair, the border between the Uzbek state and the Timurid state of Movarunnahr ran along the middle course of the Sirdari. After these 10 years, the nomadic Uzbeks had completely settled in Khorezm and were constantly attacking the Caspian lands of the Timurids in Iran.

Ulugbeg's power in Movarunnahr was preserved during Shahrukh's life, in many ways for the better,giving him authority. After Shahrukh's death on March 12, 1447, Ulugbeg's reign gradually began to decline.

During Shahrukh's lifetime, his wife Gawharshad Begim had a great influence on state affairs. In the matterthe succession throne in Herat, this woman paid more attention to her favorite grandson Aluddavla, the son of Shahrukh's third son Boysungur Mirza. Shahrukh himself considered his fourth son Joki to be his heir, although he did not speak about it openly. But the eldest son of Ulugbek, Abdullatif, could not be taken into account, since he always lived in Herat and defended his father's interests here. However, at the end of 1444, Joki died, and only his eldest son Ulugbek remained alive until Shahrukh's death.

Shahrukh died on his way west to suppress his rebellious grandson, Sultan Muhammad, son of Baysungur. With him were Gavharshadbegim and Abdullatif. Aloudavla remained in the capital, and at the suggestion of Gavharshadbegim, Abdullatif took command of the soldiers. Meanwhile, this same Gavharshadbegim secretly warns Aloudavla of this march. As soon as Ulugh Beg heard of what was happening, he gathered his warriors and immediately moved to the Amu Darya, moved to the left bank of the river and occupied Balkh. Abu Bakr Joki, the ruler of Balkh and the surrounding lands, captured his son Ulugh Beg and sent him to Samarkand, where he was executed on his orders.

Abdullatif Having become the commander of Shahrukh's entire army, he now had to fight against the rebellious field commanders - his relatives. They were Abul Qasim Babur, the son of Baysungur, and Khalil Sultan, the son of Muhammad Jahangir. They separated from the army, plundered Oghruk and fled to Khorasan. Abdullatif realized that Gawharshadbegim was involved in this rebellion and arrested him, while he himself moved east with his army and reached Nishapur. Hearing what had happened to Gawharshadbegim, Aluddavla distributed Shahrukh's treasures to the soldiers who were with him and moved towards Nishapur. In April 1447, Aluddavla's troops suddenly attacked Abdullatif's army, defeated it and captured Abdullatif himself. After this, Abdullatif was imprisoned in the castle of Ikhtiyoriddin in Herat. Then Aluddavla goes to Balkh against Ulugbek.

In this case, Ulugbek will allow himself to lack enthusiasm and make a mistake in the following tactics. He made peace with Aloudavla, his position was very difficult, since Herat was threatened from the west by his brother Abul Qasim, who even defeated Aloudavla's bodyguards. In fact, he was pressured from both sides, and if Ulugbek had been bolder, he would have defeated Aloudavla. Peace was very close to him, and he took the opportunity to make peace with Ulugbek. According to the treaty, the border between the lands of Ulugbek and Aloudavla passed along the oasis of the Murghab River. Aloudavla and Abul Qasim also made peace. The border point between their lands was recognized as the city of Quchan in the north of Khorasan. Thus, as a result of Ulugbek's mistake, the state built by Timur in forty years was divided into several small states.

Under the terms of the agreement, Abdullatif was released and Ulugbek appointed him governor of Balkh and the provinces on both sides of the Amu Darya. The terms of the agreement do not seem to have satisfied Abdullatif, and he began military operations against Aloudawla as early as the end of 1447. Moreover, contrary to the agreement, Aluddawla did not release his servants who were in captivity with him, and appointed Mirza Salih, an enemy of Abdullatif, as emir of Chechaktu, a border place. Abdullatif first marched against Mirza Salih and defeated his troops. Salih himself fled to Herat. This forced Aluddawla to move to Balkh, but due to severe frosts in early 1448 he had to stop before Chechaktu.

In the spring of the same year, Ulugbek Abdullatif gathered an army of 90 thousand people and marched against Alouddavla. The battle between the armies of Movarunnahr and Khorasan took place a few 10 km from Herat; Ulugbek and Abdullatif won a complete victory, Alouddavla fled to Kuchang, his brother Abulkasim Babur. Having heard that Alouddavla was defeated, the courtiers fled from the capital together with Gavharshadbegim. Father and son now moved west, took Herat and Mashhad. Babur's ambassadors came to Ulugbek in Radkond and said that he agreed to recognize Ulugbek as his king, included his name in the sermon and agreed to mint money. Nevertheless, Ulugbek continued the campaign and reached Isfarain, where he stayed for 3 weeks, and sent Abdullatif to Bistoma and Astrobad. After this, Ulugbek reached the bridge over the Ibrisham River, did not dare to cross it and returned to Mashhad, although Babur fled even further, to Damgan, Ulugbek's return to Mashhad was his next military mistake, because if he wanted, he could catch up with his remaining enemies, and they considered Ulugbek's return from the bridge a retreat and they became more courageous.

In this campaign, Ulugbek made another, but very big mistake. This mistake was connected with his eldest son Abdullatif. In the battle with Aloudavla, Ulugbek entrusted the leadership of the left wing of his army to Abdullatif, and the right to his younger son Abdulaziz. Although the course of this campaign and the victory achieved were due to the actions and personal heroism of Abdullatif, the decrees sent to the cities and provinces did not show the victory in this battle or in any other place, by any action, but his beloved father named his youngest son Abdulaziz. During Shahrukh's life, the castle of Ikhtiyoriddin in Herat was considered the personal property of Abdullatif, and he kept all his wealth in the castle, including the gold and silver given to him by his grandfather. In addition, Abdullatif did not allow anyone else to take the fortress. Barthold says that Ulugbek belittled Abdullatif so much that now the people of Herat and Khorasan -Abdullatif was from Khorasan - they will be in second place, as it was in the time of Timur. This fukru cannot be joined. If Ulugbek sympathized with Abdullatif, would he have been so ambitious and humiliated his own child, the eldest son? Since he was not from politics, various palace officials and corrupt officials of the fiksu gathered around Ulugbek and began to set him against his eldest son. Ulugbek fell for their tricks and once again demonstrated his political cunning. Our assumption is confirmed by the fact that when Abdullatif retreated from Bistom to Nishapur before the invasion of Babur's troops, when he fell ill, these people called Ulugbek's sick son a swindler. Ulugbek sees with his own eyes that there is no fraud in this.

Ulugbek's campaign against Khorason showed that, unlike his grandfather and father, he was not a skilled diplomat and military strategist: he always suffered failures in this direction. The fact that he first made peace with Aluddavla and went to war against him a year later was considered treason by the priests of Khorasan, and he was deeply insulted by Bahauddin Ulugbek, the sheikh of Khorasan. In addition, Ulugbek's soldiers also plundered the sheikh's property.

Be that as it may, by the spring of 1448 an insurmountable feud had arisen between Ulugbek and his son Abdullatif, which ultimately led to the fall of both of them, and perhaps to the fall of the Timurid state as a whole.

In November 1448, Ulugbek accused the people of Herat of having a common language with the rebels and handed over their houses to his soldiers for three days to plunder. By doing so, he aroused the hatred of the entire population of Khorasan. And when Ulugbek heard about the next attacks of the Uzbeks led by Abulkhair Khan in the vicinity of Movarunnahr and Samarkand and left Herat in a hurry, the Khorasanians led by Babur and led by Hinduka caught up with him on the wayto the Amu Darya. A group of Khunduki leaders inflicts heavy losses on Ulugbek's army. While crossing the river, Ulugbek's army was attacked by

Uzbeks, who took away his army. This indicated that Ulugbek had made another mistake in not being prepared to cross the river this time, since the guards and yak team should have been sent earlier; in fact, he seems to have fled from the pursuing Babur without looking back.

Abdullatif at first he remained in Herat, but after Babur expelled him from the city, he moved to his estate at Balkh.

According to the historian, as a result of the events of 1448, Ulugbek lostattention of both soldiers and the population. Meanwhile, the drama of the father-son relationship grew. In the spring of 1449, Abdullatif suppressed the rebellion of a certain Mironshah named Timurid and killed him. Among the belongings of the murdered man, a letter was found, according to the meaning of which Ulugbek called on Mironshah to rebel. After this, Abdullatif completely turned away from his father.

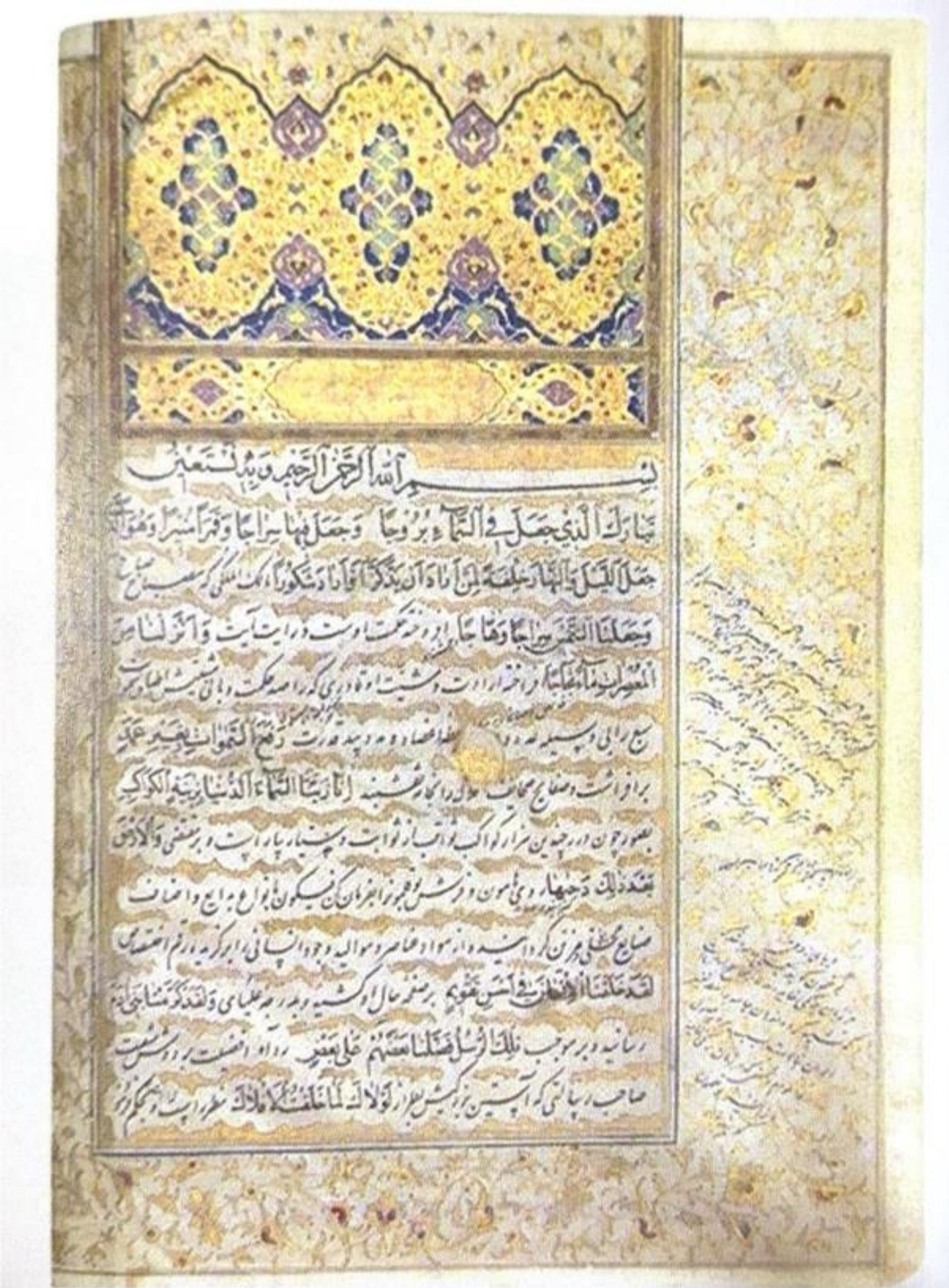
Ulugbek leaves the capital Samarkand to his younger son Abdulaziz and goes to war with his warriors against his eldest son. Both armies stood for a long time on both banks of the river and did not dare to cross the water and start a battle. However, events that happened behind Ulugbek forced him to return to the capital. Abdulaziz was his father's favorite son and was not prepared for an independent life, much less for public affairs. According to information received by Ulugbek, Abdulaziz Ulugbek oppresses the families of the amirs in Ulugbek's army and mocks their wives. This news immediately caused discontent among the soldiers, which forced Ulugbek to return to Samarkand. When Ulugbek returned to the capital, a rebellion against Abdulaziz actually occurred.

Ulugbek managed to improve the situation in the city. Taking Abdulaziz with him and appointing Mironshah Kavchin as the governor of Samarkand, he again went into battle against Abdullatif. The latter had managed to cross the Amu Darya, was approaching Samarkand and was preparing for battle. The two armies met each other in the village of Damascus near Samarkand, where the battle took place. Ulugbek suffered a complete defeat. When he tried to hide in the Samarkand fortress, Mironshah Kavchin, whom he had appointed, did not let him in. Then he went to Shahrukhiya, where they threatened not to let him in, but to arrest him and hand him over to Abdullatif. After that, he decided to voluntarily surrender to Abdullatif and came to Samarkand, taking Abdulaziz and some servants with him. It is surprising that in the events and developments of the last two years, which were very much connected with the fate of his father, Abdulaziz did not show any initiative on his part, did not stand out in any way and, like the shadow of his father, he followed him and followed what he said, although he was no longer a little boy.

Ulugbek was allowed to make a pilgrimage to Mecca, and then, without Ulugbek being present, a trial was held against him, at which several people spoke out and demanded revenge for their relatives. Sharia vengeance was given to a man named Abbas, whose father had been executed by order of Ulugbek. The court issued a fatwa, which was signed by all the religious leaders of Samarkand, except Kazi Miskin.The fatwa was issued by Abbas on 8 (or 10) Ramadan 853 AH/25 (or 27) October 1449 AD. Abbas killed Ulugh Beg, but he also killed a great scholar of the Middle Ages.

In the work of Davlatshah Samarkandi "Tazkirat ush-shuaro" Mirzo writes about Ulugbek: "Ulugbek rose to a high level of science. Since the time of the two kings, Alexander the Great, at the beginning of the current government, there was no such king and scientist as Ulugbek. He founded an observatory, completed the construction of the observatory togetherwith other scholars, including Kazizad Rumi and Maulana Ghiyaziddin Jamshid Koshi, and completed the writing of Sultan Zij. "Previously, Mirzo Ulugh Beg carried out the affairs of state administration and the court."

The appearance of "Zij" in the life of Ulugbek



Page of the manuscript "Ziji Ulugbek". Iran. Late 17th century.

Science in the Life of Ulugbek. "Zij"

Movarunnahr Ulugbeg's activities as an organizer and leader of science caused a congress of scholars from almost all corners of the Islamic world to come to Samarkand. This is exactly what happened to Kazizada Rumi. He was born in the city of Bursa (south of the Sea of Marmara) in Asia Minor in 755-765 AH/1354-1364 AD. He received his primary education in his hometown, then Mullah Shams al-Din Fanari taught him mathematics and astronomy and instilled in him a great love for the exact sciences. Young Kazizada heard from Mullah Fanari about the glory of the mathematicians and astronomers of Khorasan and Movarunnahr, and when he was twenty years old (early 80s of the 14th century), he left his hometown completely and went to the East.[3]

In and The sources do not report when Kazizade Rumi met Ulugh Beg, but Ulugh Beg called Kazizade Rumi his teacher in the preface to his Ziji. The Turkish historian of science Salih Zaki (died 1914) also wrote that he was Ulugh Beg's teacher, stating that he received this information from the works Shakoyi Numaniya and Taj at Tavorikh. Since Ulugbek lived in Khorasan from the death of his grandfather Amir Temur until his accession to the throne in 1411, it can be said that Ulugbek met Kazizade Rumi there and received an education from him.

Appointed Sultan of Movarunnahr, Ulugbek brought his teacher to Samarkand in 1413, where he remained until the end of his life. With his direct participation, the Ulugbek madrasahs will be builtand the observatory on the hill of Kohak. Kazizada Rumi also participates in the beginning of the work on the Zij. But Kaziza died in 1430, long before the completion of the work on the Zij.

Kazizada Rumi apparently had moregreat reputation in Samarkand as a teacher of Ulugbek, and as one of the greatest scholars of his time, with whom Ulugbek had to reckon as the ruler of Movarunnahr and Turkestan. The following scene from the life of the scholar testifies to this.

To Kazizade appointed Rumi as the "chairman of the teachers" (raisul-mu'allimin). Usually, four teachers taught in the four classrooms of the madrasah. Once a week, Kazizade Rumi himself gave a lecture to all the students, and Ulugbek also participated in it. At some point, Ulugbek, for some reason, suspended one of the teachers from teaching. Objecting to this, Kazizade Rumi does not come to the madrasah. Hearing about this, Ulugbek thought that Rumi might get sick in Kaziza, so he personally went to see him. But seeing him completely healthy, Ulugbek asked him why he did not attend classes. Kazizade Rumi gave him the following answer: "We thought that the position of a teacher was inviolable and would not be punished." Now we see that this position belongs to the Sultan himself. That is why we have refused to teach."

After this, Ulugbek returns the expelled teacher to the madrasah, apologizes to Kazizade Rumi and asks him to begin lessons, and also promises that he will never interfere in the affairs of the madrasah again.

Jamshid Koshi, another great scientist Samarkand, first worked in Herat in the palace of Shahrukh. Then Ulugbek called him to Samarkand on the advice of Rumi in Kaziza. Jamshid Koshi was one of the greatest scholars of the medieval Islamic world. In his works "The Key to Arithmetic" and "Treatise on the Circle", mathematics in Islamic countries reached its peak in the Middle Ages. He wrote an astronomical work called "Ziji Khaqani" for the library of Ulugbek. The preface to the work says: "There are many khans and khans in Movarunnahr and Turkestan. I have named the work so that they will like it." Although Ulugbeg's preface to his "Ziji" says that "Koshy died at the beginning of the work on "Ziji", Ulugbeg's Arabic translation of the theoretical part of "Ziji" is his. At the end of these translations, Koshi said: The Zij of Maulana Sultan Ulugbek, son of Amir Temur Kuragon, son of Sultan Shahrukh Sultan, is finished. He finished it in Samarkand. It is said that its editing in Arabic was done by Maulana Sheikh of scholars, the most learned Ghiyasiddin Jamshid. Therefore, it can be concluded that "the theoretical text of Zij was written before his observations began, and Koshi Arabized it before his death. Below, in explaining some parts of Ulugbeg's Zij, we see that he implemented some of the ideas expressed by Koshi in his Zij. In fact, Koshi's Zij Khaqani was dedicated to improving the Zij Elkhani of Nasriddin Tusi (1201-1274), who already knew many things in the Zij, and he told the young scholar that Ulugbek may have given many useful tips. Since Cauchy was well aware of the working principle of the observatory in Marogh and the scientists who worked there, he was the main owner of the engineering idea in the construction of the madrasah and observatory in Samarkand. The Ulugbek observatory was designed with his direct participation. As the Pakistani scientist Abbas Razvi said, “Cauchy’s familiarity with astronomy and astronomical instruments, his awareness of the works of ancient astronomers, and his acquaintance with the scientists of the recent past, especially with the scientists of the observatories in Marogh and Shiraz, made him a unique scientist for his time.”

Koshi left a valuable relic - a letter he wrote to his father in Kachon in the 20s of the 14th century. In this letter, he praised Ulugbeg's intellect.

The third great scholar mentioned by Ulugbek in the preface to his Ziji was Alovuddin Ali ibn Muhammad Qushchi (b. 1402). Ulugbek remembers him with very warm words and says "farzandi arjumand", that is, "my precious son", although he was the son of the keeper (kashi) of the palace falcons. Alovuddin was a diligent and trusted student of Ulugbek and was loyal to him towards his sons. Later, he became a great expert in Movarunnahr. Gradually, he became a link between eastern and western science.

1449After the tragic events of autumn 2008, the political situation in Movarunnahr became complicated. The Timurid rulers of Samarkand after Ulugbek showed no interest in secular sciences. Therefore, in the early 60s of the 14th century, Ali Kushchi left Samarkand and went first to Khorasan, and from there he moved to Kermon, where he lived until 1465. In those same years, he moved to the city of Tabriz, lost by the Timurids and now under the control of the Turkmen dynasty. Ali Kushchi lived in Tabriz for eight years, in early 1473 he moved to Istanbul, the new capital of Ottoman Turkey, and died there in December 1477.

Ali Koshchi arrived in Istanbul, and by the decision of the Sultan he founded a madrasah in the Hagia Sophia mosque, where he gathered scholars and conducted research in the fields of mathematics and astronomy.

Turkish Science Historian Salih Zaki admits that no one in Turkey seriously studied mathematics and astronomy until Ali Kuschi came to Istanbul; Ali Kuschi was one of the first to begin astronomical research here.

Weonly the names of the scientists who formed the core of Ulugbek's astronomical scientific school in Samarkand were mentioned. Undoubtedly, it was Ulugbek who organized and laid the foundation for science. On his initiative, in 1417, madrassas were built not only in Samarkand, but also in Bukhara and Gijduvan. The construction of the madrassas in Samarkand was completed in 1420, and the construction of the observatory began and was completed in the same year.

But in Samarkand there is another madrasah of Ulugbek, which is part of the Gori Amir ensemble. If you enter the courtyard of the ensemble from the porch, the madrasah is on the left. On the right side of the courtyard, in front of the Ulugbek madrasah, there is a madrasah built by another grandson of Amir Temur - Mirza Muhammad Sultan. Students studied in these madrasahs in 1625, when this place was visited by Mutribi Asam from Bukhara, the author of the "History of Jahangiri". It is not known when these madrasahs were built and why they were destroyed. Ulugbek himself checked the teachers of the madrasah and determined their qualifications. He himself lectured in the madrasah.

As for Ulugbek’s creative work, it is known that in addition to “Zi"ji" he wrote three more works. First of all, "Treatise on Determining the Sine of a Degree" (Risala fi istihraj jaib degree wahid). At first it was believed that Kazizada Rumi wrote a treatise with this title, and it was found in Mirim Chalabi's treatise "Rule of Actions and Correction of Tables", which was translated into Russian by B.A. Rosenfeld and presented in this volume by Jamshid Koshi. This treatise on Kaziza was written by Ulugh Beg, not Rumi. While Ulugh Beg was working on "Ziji", a more complete version of this treatise was published in "Zijiga" in Birjandi, and a Russian translation of it was also published. Now it turns out that there are two separate copies of this brochure and they are kept in Berlin and Cairo.

It turned out that the scientist has another mathematical work called “Ulugbek’s Risolai”, which is kept in Aligarh (India) and has not yet been studied.

Until recently, Ulugbek was considered only an astronomer and mathematician in science, although medieval authors considered him well versed in classical Arabic and Persian literature, music and history. B.A. Akhmedov was the first in science to learn that Ulugbek wrote the work "Tarihi arbaulus" ("History of the Four Nations") about the history of the Mongolian state. The only, incomplete copy of this work is kept in the British Museum (London).

The works of Ulugbek, which brought him worldwide fame, are known under the titles “Ziji Ulugbek", "Ziji Sultani" and "Ziji Jadidi Koragoniy". But the first of these names is more common, so it is called "Ulugbek ziji". Ulugbek's "Ziji" ranks second (108 copies) among the surviving manuscript monuments of astronomical and mathematical nature of the Middle Ages. This shows that this work was very popular in the Islamic world.

a) The purpose and objectives of writing "Zij".

Medieval Muslim zijs, that is, astronomical works with star catalogs inside, are divided into two types: the first - written by their authors based on personal observations, and the second type - theoretical summaries of several zijs and treatises, only in the opinion of the author. observations of planets and stars, some explanations will be included. Most of the works of Muslim astronomers belong to the second type. Among them are "Kanuni Masudi" by Beruni, "Ziji Elkhani" by Nasriddin Tusi, dedicated to Khulog Khan (1256 - 1265), and "Ziji Khaqani" by Jamshid Koshi. [3]

Among the first works written before Ulugh Beg is “The Image of Fixed Stars” by Abdurrahman Sufi (901-986) (Suwar al-kawokib as-sobita). This book is the result of many years of observations by the Sufi at the court of Sultan Buwayhi Azud ad-Daula Fanna Khusrau in the Persian region. In it, the Sufi gave a catalogue of 1017 stars, which he observed for the first time since the time of Ptolemy. Scholars before Ulugbek mainly used the Sufi’s catalogue.

Biruni, however, sharply criticizes the Sufi, accusing him of irresponsibility and lack of scientific criticism, and in his "Kanuni Masudi", a more complete (1029 stars) catalog of the Middle Ages, contains more data based on Ptolemy's "Almagest". Only 60 of the brightest stars are listed in the "Ziji Elkhani" catalog, compiled during the Mongol rule in Iran and considered correct.

At the beginning of the 15th century, there was a need to create a science with great precision and on the basis of complete information. In addition, the lack of a complete star catalog had its own objective reasons. The main phenomenon is that one complete revolution of Saturn in its orbit takes 29.5 years. According to this phenomenon, it would be necessary to observe the planets and fixed stars continuously for about thirty years in a place with a known longitude and latitude, because only then would it be possible to create a complete picture of the movement of the luminaries. This is why astronomers have long accepted the 30-year "Saturn cycle". All astronomical tables are compiled on this basis. According to this principle, tables of planetary motion were compiled for the 30th anniversary of the calendar year and every 30 years in the following year. The results of the previous 30 years of observations were generalized for the 30 years of the past and future centuries.

Due to various wars, political imbalances, lack of patronage and other reasons, few astronomers had the opportunity to stay in one place for 30 years and conduct astronomical observations. Observations over such a long period required large "royal" financial expenses. Ptolemy and the Sufis were patronized by kings. As for Ulugbek - being both a king and a scholar, this opportunity was doubly provided, because as a scholar he could pose the questions he wanted to, and as a king he opened the doors of the state for royal expenses.

According to Ulugbek's observation, Samarkand $39°37'27''$ in latitude and lies far north of Alexandria and Shiraz, the basis of the works of Ptolemy and the Sufis. The shortcomings of the Sufi catalogue were also pointed out by Ulugbek, who said the following about the work of the Sufi: “Abdurrahman Sufi wrote a special book on the knowledge of the fixed stars, to which all scholars refer and which he accepts. Abd ar-Rahman referred to a book written by a Sufi, and according to this book it was accepted that the stars are located on a sphere, although this contradicts what they see. When Allah helped us to observe these stars through rasad, and when we observed these stars, we saw that these stars do not correspond to the story that [Abdur Rahman] showed in his book. Ulugh Beg’s task was to clarify the catalogues of his predecessors [astronomers], taking into account the latitudes of Samarkand.

As for the time of writing of Ulugbeg's "Ziji", this question is not easy, since the date of writing of this work is not indicated in any other manuscript No.

1041, belonging to the Salor Jung Library in Patna (India). At the end of this manuscript the following chronology is given: "Ulugbek, son of Temur Kuragoni, son of Shahrukh, who wrote it and arranged it in the year of Hijra."

This graph does not correspond to some facts. First of all, it says that "Temur is the son of Koragon"; Temur was not the son of Kuragon, but "Kuragon" himself, that is, the son-in-law of the Mongolian Khan. His father Taragaybek was not a Kuragon. This must be a copyist's error.

As for the time of writing of Zij, the abjad number in the above chronology can be read as 843 and 848, the first number corresponds to 1439, and the second to 1444/1445. But it is wrong to accept the first Hijri number, since it points to 1439 CE, in which Ulugbeg's first observations in Samarkand correspond to 1409, but Samarkand was not Ulugbeg's permanent place of residence in that year. But the second date is correct, since the beginning of the "Zuhal cycle" coincides with 1411, which means that Ulugbek became the ruler of Movaraunnahr in 1411 and began active scientific work with Rumi in Kaziza, the bey's observations in Samarkand began long before that. the construction of the observatory - around 1414.

Starting with L. Sediyo, all the authors, when they had some reaction to Ulugbeg's "Ziji", erroneously indicated the date of completion of its writing - 841 AH/1437 AD. In this case, they follow from the fact that in this work, 2 Muharram 841 AH was adopted as the date in all the travel tables, which is the first day of the year of the Hijra, which corresponds to July 4, 1437 AD. The reason why Ulugbek took this day as a date is the following. In this work, the lunar years of the Hijra are taken as a measure of time. The lunar year consists of 12 lunar months. The lunar month is a synodic month, that is, the period between two new moons (crescents), equal to 29.53059 days. But in the Hijri calendar, all odd days are 30 days long and all even days are 29 days long, except for a leap year, in which the last month is 30 days long. Since ancient times, Muslim scholars have accepted a 30-year lunar cycle, consisting of 19 ordinary years of 354 days each and 11 leap years of 355 days each. Then comes the number of days $354 \times 19 + 355 \times 11 = 10631354,$, which differs from the actual days in that period by only 0.0124 days $36708 \times 30 = 10631{,}0124.$

This 30-year period is counted from the first year of the Hijra, which was not a leap year. The leap years are the 2nd, 5th, 7th, 10th, 13th, 15th, 18th, 21st, 24th, 26th, 29th years of this period. During the life of Ulugbek, the beginning of the next such period corresponds to 1 Muharram 841 AH/4th July 1437 AD (if we consider the beginning of the Hijra, as in Ulugbek, to be 15th July 622). Ulugbek is the date of "Zij", it is not the date of completion of "Zij", which was approximately in the middle of the work.

Thus, the reading of the chronogram is exactly 848 AH, which corresponds to 1444/45 AD.

b) Brief summary of "Zij".

Ulugh Beg's Zij consists of a general introduction and four articles (books). At the beginning of his introduction, Ulugh Beg justifies the necessity of astronomy with science, citing chapters and hadiths from the Quran. The next paragraph begins with the phrase "Then" and leaves no doubt that the author of Zij was Ulugh Beg himself. But below he tells how Kazizade Rumi, Jamshid Koshi and Ali Kushchi participated in this matter. From this part of the prologue we know that Jamshid Koshi died before the work on Zij began. It is known that Koshi's work "Miftah al-lisb" ("The Key to Arithmetic"), written for Ulugh Beg's library, was written on Friday 3rd 830 AH / March 2, 1427 AD. According to some sources, al-Koshi died on June 22, 1429. It is possible that at that time the main part of Zij had not yet been launched and information was being collected for it.[3]

The first article of Ziji consists of an introduction and seven chapters. In the introduction, Ulugbek defines the types of days (real and mean) and the beginning of days among different peoples; defines equal and seasonal (curved) hours. It is noteworthy that Ulugbek reported on the Turkish-Uyghur method of measuring time; they took this style from the Ziji Khaqani of Jamshid Koshi, and from the Ziji Elkhani of Nasir al-Din Tusi. These are very old names, such as keshku (mouse), ut (cow), lu (dragon), yunad (horse), bichin (monkey), dakuk (chicken), perhaps this indicates that it corresponds to the beginning.

Chapter 1. The article "Zij" is devoted to determining the beginning of years and months in the Hijri calendar. However, Ulugh Beg took Thursday, July 15, 622, as the first day of the first year of the Hijra, and not Friday, July 16, as in the current synchronistic tables, i.e. 1 - Muharram. Therefore, in order for the data in "Zij" to correspond to the current synchronistic charts, it is necessary to add one to the result obtained.

Chapter 2. The article is devoted to determining the beginning of the years and months of the era of the "Romans", that is, the Seleucid era of the Greeks, which began on October 1, 312 BC - the day of the ascension of Alexander III Seleucus to the throne and is called the Era of Alexander.

Chapter 3. Is dedicated to determining the beginning of the years and months of the "Persian era", that is, the era of Yazdgard III ibn Shahriyar, the last Sassanid king of Iran.

Chapter 4. Is devoted to the determination of the date given to one of the three eras by the other two eras, and a corresponding table is presented.

The previous four chapters of the article "Zij" are in many ways similar to the materials of the second book "Kanuni Masudi" written by Beruni, and Jamshid Koshii in a letter to his father said that the Samarkand scholars had books on fragments. In particular, this table of Ulugbek practically repeats such a table of Beruni.

Chapter 5. Is dedicated to the definition of the Maliki era (or Jalali), named after the Seljuk Sultan Jalaluddin Malikshah ibn Alp Arslan (1072-1092), at whose court a group of astronomers headed by the famous Umar Khayyam (1048-1131) created a calendar (calendar) reform. March 16 was chosen as the true equinox of 1079 as the beginning of the Maliki era. The Maliki calendar was widely used during the Seljuk period, used in the state of Anushtegini-Khorezmshahs and even in the state of the Timurid. But after the 15th century, this calendar was forgotten.

Chapter 6. This article makes up almost half of it and consists of ten chapters, it examines the periodic calendars of China and Turkestan and Central China, that is, the homeland of the ancient Uyghurs, because the names of the muchals and chogs that he gives are ancient Uyghur urcha, but not Central Asian. Ulugbek dwells in great detail on animal cycles and calendars in Chinese measurements of time. As we said above, referring to Hussein Birjandi in this matter, Ulugbek borrowed much in this matter from Koshi's "Ziji Khakani" and Nasiriddin Tusi's "Ziji Elkhani".

The last 7 chapters of the article are devoted to famous days and holidays in these calendars.

The largest part of Ulugbek's "Ziji" is his II article, consisting of 22 chapters. The issues of plane and spherical trigonometry, spherical astronomy are described.

Chapter 1. Called "On the Equation between Two Straight Lines", it describes the generalrules of linear interpolation of a function $f(x)$ and its argument x, when x_0 and h are known, that is, this

$$f(x) = f(x_0) + (x - x_0) \cdot \frac{f(x_0 + h) - f(x_0)}{h}$$

$$x = x_0 + h \cdot \frac{f(x) - f(x_0)}{f(x_0 + h) - f(x_0)}$$

dedicated to the definition of formulas.

Ethat is an element of higher mathematics, and Europe at that time was far from this.

It should be noted that the same rules were in"Masudi's Law" by Beruni, but in it, $h = 15$ and $h = 1$ in Ulugbek, that is, the accuracy is the same as in modern sine tables.

In Chapter 2. Definitions of sines (cosines) and their arcs are given: the same rules of linear interpolation are interpolated for sines, cosines and their "axes", i.e. the complements of the sines lines to the diameter. It should also be said that Ulugbek works with a circle equal $R = 60$ to units, and his trigonometric tables are also based on it.

That's all at the end of the chapter he writes that Ulugbek wrote a separate book on the definition of the arcsine of one degree, and all trigonometric and astronomical tables are based on it. We described this brochure in explanation - 12.

Chapters 3. Ttangents (first shadow, reflected shadow), cotangents (second shadow, direct shadow) and the rules for their comparison and the rules of linear interpolation.

ThisThe table of tangents presented in the chapter has the accuracy: the values of tangents in it are accurate to fifths, and the difference in arguments is equal to 10.

Chapter 4. Ecliptic dedicated to determining the deviations of levels. Ulugbek gives two types of "deviations": the first is the true deviation - the equatorial coordinate of light, and the second - the southern latitude of light, that is, the ecliptic coordinate. Ulugbek found the angle of deviation of the ecliptic to the equator, equal to $23^{\circ}30'17''$, which is quite accurate for the latitude of $39^{\circ}37'23''$ Samarkand he found.

Ulugbek does not set forth any particular rule of spherical astronomy or describe how he found it; there is not a single figure in the entire work. He voices all the rules in the form of ready-made formulas. In this chapter we find the deviation τ of the light source from β its southern ecliptic latitude , ecliptic longitude and maximum deviation ε , using the rules of strong sin , equal to the theorem of sines $sin\delta = sin\lambda \times sin\varepsilon$ and the tangent theorem

$$tg\beta = sin\lambda \times tg\varepsilon.$$

That's allthe largest deviation ε known in the chapter itself δ^* , according to the inverted deviation, the expansion of the β ecliptic – Ulugbek β

$$\cos \underline{\beta} = \frac{cos\varepsilon}{cos\delta_*}$$

formula, i.e. it is determined by a strong rule equal to the spherical $cos\delta^*$ Pythagorean theorem.

This the table of first and second deflections of light found for the Samarkand expansion in the chapter is relevant.

These rules of spherical astronomy in the following chapters are written in the symbolism of modern formulas and require explanation from the point of view of their accuracy and correctness. Since there is no such concept in the Zij itself, we turn to the commentary of Hussein Birjandi on"Zij" of Ulugbek, because it contains answers to all questions that arise when reading "Zij". That is why their commentaries contain drawings that explain this or that rule, but they are not in Ulugbek's work.

"Zij" Chapter 5 of the book under consideration is devoted to the definition of the deviation of light. Ulugbek called it the distance of the light source to the celestial equator. Unlike the previous chapter, which described only points on the ecliptic, here an arbitrary point of the celestial sphere is considered. In this chapter, Ulugbek introduces the concept of "distance argument" (hissay bu'd), by which he means the sum or difference of the northern and southern latitudes of the porthole, that is $\Delta\beta = \beta \pm \underline{\beta}$. Then the deviation of illumination is determined by the function of this argument, namely $\delta = \delta(\Delta\beta)$.

Then, using the known distance argument: $\Delta\beta$, overturning deviation δ^* , maximum deviation ε and southern latitude β Ulugbek determines the deviation of the porthole using δ the following formulas

$$sin\delta = sin\Delta\beta \cdot cos\delta\ , \ \ sin\delta = \frac{sin\Delta\beta \cdot cos\varepsilon}{cos\underline{\beta}}.$$

If the length l is used, the formula takes the following form:

$$sin\delta = \frac{sin\lambda \cdot sin\Delta\beta \cdot sin\varepsilon}{sin\underline{\beta}}.$$

In Chapter 6. The heights of light in different places of the celestial sphere are determined by very well-known formulas from astronomy textbooks.

In Chapter 7- deviation α of the light δ web in the chapter, the greatest deviation ε and longitudinal λ. According to the spherical Pythagorean theorem, spherical sines and tangents are determined by the following formulas:

$$sin\alpha = \frac{cos\lambda}{cos\delta}, \qquad \sin\alpha = \frac{sin\lambda \cdot cos\varepsilon}{cos\delta}, \quad \sin\alpha = \frac{tg\delta}{tg\varepsilon}.$$

Chapter 8 is devoted to the definition of the daylight equation:$\Delta\alpha$. Ulugbek defines this parameter α through the width , deviation φ, area extension, maximum width and rules $\Delta\alpha max$

$$sin\Delta\alpha = tg\delta \cdot tg\varphi, \quad cos\Delta\alpha = \frac{cos\theta}{cos\delta},$$

$$\sin\Delta\alpha = \frac{sin\theta \cdot cos\varphi}{cos\delta}, \qquad \sin\Delta\alpha = \sin\alpha \cdot \sin\Delta\alpha_{max},$$

they have an east azimuth θ at altitude

$$cos\theta = \frac{cos\delta}{cos\varphi}$$

is determined by the rule.

This **Chapter 9** includes many tables of elliptical degrees in different geographic regions. First comes a table of ecliptic $39^{\circ}37'23''$ degrees for the latitude of Samarkand. Then comes a table of materials from the latitude of the earth's equator, that is, zero latitude. Then for each level of expansion, there are tables $1°\ to\ 50°$.

Chapter 10 deals with the opposite problem to the one stated above, that is α, to find its degree , in other words λ_{α}, the full degree of the ecliptic. This question is closely related to astrology, since the degree or degree of the ecliptic, which Ptolemy used to call a horoscope. The rules described here by Ulugbek are as strong as the following formulas:

$$sin\lambda_{\alpha} = cos\alpha \cdot cos\beta, \quad sin\lambda_{\alpha} = \frac{sin\alpha}{cos\delta}.$$

That's all, in the chapter itself, Ulugbek draws attention to some issues related to determining the level of the horoscope. The first is to determine the height of the tenth astrological house, that is, to determine the height of the ecliptic level that intersects the celestial meridian at a given latitude. Then, according to this height,rule $sin\beta_z = \cos h_{10} \times \cos\delta\beta_z$ and finds the "climatic latitude of observation", that is, the ecliptic latitude of the zenith β_z , according to the rule, and then, using these two parameters, finds the degree of the horoscope according to the rule

$$\sin\lambda_H = \frac{\sin h_{10}}{cos\beta_E}.$$

Chapter 11 is devoted to the definition of the material of transition and the degree of transition of light, that is, a question of an astrological nature.

In Chapter 12 2 the properties of the points of rise and fall of light are determined, which is a special case of the operations considered in Chapters 9 and 11.

Chapter 13 dedicated to determining the azimuth of the illuminator depending on its height and depth. For this, Ulugbek introduces an auxiliary concept - the azimuth equation (with corrected samt). This parameter

$$\Delta A = sin\theta \ \pm sinh \cdot tg\varphi,$$

is found according to a strict rule equal to the formula, and the azimuth itself

$$sinA = \frac{sin\theta \ \pm sinh \cdot tg\varphi}{cosh}$$

finds according to the formula rule.

Another rule of Ulugbek for determining the azimuth A

$$sinA = \frac{sin\delta \ \pm cosh \cdot cos\varphi}{sinhsin\varphi}$$

as strong as the formula.

Ulugbek also gives a third rule for determining azimuth, but this time with the participation of the hour angle *t* according to this formula:

$$cosA = \frac{sint \cdot cos\delta}{cosh}$$

In Chapter 14 Ulugbek determines the height h of light from the known azimuth A and latitude φ according to strict rules equal to the following formulas:

$$sinh = \frac{sin\varphi}{\sqrt{1-cos^2A \cdot cos^2\varphi}}\ , \ \ sinh = \frac{sin\delta}{sin\varphi}.$$

Chapters 15-16 are devoted to mathematical geography – determining the latitude and longitude of cities. At the end of Chapter 16, a table of latitude and longitude of 699 cities and addresses is given.

Ulugbek calculates the longitude of the cities of the Jaziratul Khalidot islands. According to Birjandi, they are located to the west of 10° coast of Africa.

In Chapter 17 Ulugbek goes on to a special definition of "observation of the expansion of climate", in Chapter 10 he partially approached this issue. When the height of h_{10} the tenth house, the difference in longitude of the tenth $\Delta\lambda$ and the whole degree, as well as the ecliptic latitude are known, he determines the "observation climatic latitude", that is, the ecliptic latitude of β_z the zenith, according to the following rules: strong, as the following formulas:

$$cos\beta_z = \frac{sinh_{10}}{sin\Delta\lambda}\ ,\ \ sin\beta_z = cosh_{10} \cdot cos\beta.$$

"In his commentary on this chapter, Zija Hussein Birjandi himself came up with a rule for determining this parameter.

$$cos\beta_z = \frac{sin\alpha \cdot cos\varphi}{sin\lambda_\gamma}$$

gives where λ_γ the longitude of the vernal equinox is Tali.

Chapter 18 The article is devoted to the great problem of spherical astronomy – determining the spherical distances between lights. Ulugbek observes the different positions of pairs of lights and determines their distance from the celestial sphere in relation to the main great circles – the ecliptic, the celestial equator, the celestial meridian and others. In this regard, he gives various rules.

The following formulas for determining distance are ρ noteworthy between two fires:

$$\rho = 90° \pm \arcsin(cos\beta \cdot cos\Delta\lambda)\ ,\quad cos\rho = cos\beta \cdot cos\Delta\lambda,$$

$$\rho = 90° \pm arcsin\left[sin\left(90° - \beta_1 \pm arcsin\frac{sin\beta_1}{\sqrt{1-cos^2\beta_2 \cdot sin^2\Delta\lambda}}\right) \cdot \frac{sin\beta_1}{\sqrt{1-cos^2\beta_2 \cdot sin^2\Delta\lambda}}\right].$$

Chapter 19. Traditional question for medieval Muslims is about determining the azimuth of the qibla, that is, the direction of Mecca in an arbitrary city. Ulugbek gives the rules for determining the azimuth of the qibla by the latitude A_q and deviation A_q of Mecca, the latitude δ_L and deviation φ_E of a certain city δ_E, the difference in their $\lambda_E - \lambda_M$ longitudes, which are expressed by the following formulas:

$$sinA_K = \frac{cos\varphi_M}{\sqrt{1-sin^2\varphi_M \cdot sin^2\varphi_E}}\ ,\ sinA_K = \frac{cos\delta_M}{\sqrt{1-sin^2\delta_M \cdot sin^2\delta_E}}.$$

In Chapter 20 Ulugbek returns to the question of determining the fabric, but by the height of the light. Articles 21-22 of Book II are devoted to astrological questions, determining the height and declination, and determining the toli by the hour.

In Chapter 1 Ulugbek presented the “equation of night and day”, that is, the equation of time is equal to the formula

$$\eta = \frac{\Delta\bar{\lambda} - \Delta\alpha_{\odot}}{15°2'27''50'''49^{IV}} ,$$

is determined by a strict rule, here – if $\Delta\bar{\lambda} = \bar{\lambda}_2 - \bar{\lambda}_1$ the longitudes of the Sun at the beginning and end of this time interval are separated;
;$\Delta\alpha_{\odot} = \Delta\alpha_{\odot 2} - \Delta\alpha_{\odot 1}$ - if you subtract the longitude of the Sun at this end;
$\Delta\alpha_{\odot} = \Delta\alpha_{\odot 2} - \Delta\alpha_{\odot 1}$- this is the difference between the real fabric of the sun of that time.

Thisthe degrees and their fractions given here in the denominator are the fractions of one mean hour, "determined by his observations," which now correspond exactly to one hour of stellar time $1^h0^m9^s$, as found by the most accurate 856 Newcomb's formula.

Ulugbek does not say by what rule he determined the equation of time, true and mean solar time, etc., we will explain them below based on Birjandi's commentary.

This oneThe chapter includes several tables, the most important of which are: "The Basic Table of the Equation of the Day", "The Table of Arguments of the Equation of the Day Added to the Center", "The Argument of the Equation of the Day Found by the True Longitude of the Sun" and others, which are not explained in "Zij". Therefore, we will dwell on all these issues in our comments.

"Zij» Chapter 2 of the article is devoted to determining the average states of the planets. In fact, it describes the rule for using the "table of the average motion of the center of the Sun in the years and months of the Hijra". One of the important main features of this table and Ulugbek "Ziji" and the system of tables as a whole, if we also take into account the planets, is the following. Before Ulugbek, such tables of planetary motion allowed astronomers to determine the average positions of the planets several centuries before or after the history of the planets adopted for this work. Ulugbek's graph is not limited by any time. It allows, for example, to find the average position of the planets with great accuracy for 4121 years before or after the Hijra. For example, according to Ulugbek's chart, on April 5, 1991 at 9:55, the average geocentricity was on the Sun $39°30'33''1'''$.

Chapter 3 is devoted to determining the real states of the walkers "Head" and "Tail", but without the theoretical part.

Chapter 4. The Moon and is devoted to determining the latitude of the planets; for this chapter, tables of the declinations of the Moon and planets are given, for which the northern and southern halves of the Moon's orbit are divided. Muslim scholars were particularly concerned with the motion of the Moon because of its complexity. But in constructing the expansion tables, Ulugh Beg used strict rules, equivalent to the following formulas:

$$sin\beta_L = \frac{sin5° \cdot sin\tilde{\lambda}_L}{R}, \qquad tg\beta_L = \frac{tg5° \cdot sin(\lambda_E - \lambda_A)}{R}$$

Birjandi in this formula gives a strict rule for the greatest expansion of the Moon βmax.

$$sin\beta_{max} = \frac{\sqrt{1+p'^2 \pm 2p' \cdot cos\pi} \cdot sin\left(\varepsilon + arcsin\frac{sin\pi}{\sqrt{1+p'^2 \pm 2p' \cdot cos\pi}}\right)}{\sqrt{1+p'^2 \pm 2p' \cdot cos\pi + cos^2\alpha}},$$

In Chapter 5. Determines the distances from the center of the Universe, from the center of the Earth to the centers of the Sun and the Moon. This includes the "Table of Minutes of the Ratio of Distances of the Moon" and the "Table of the Farthest Distances of the Moon from the Center of the Universe".

Chapter 6. Is devoted to explaining the zones and stops of the planets - concepts used to explain the stops and return movements of the planets.

In Chapter 7. Definitions of planetary ephemerides by longitude and latitude are given. Here, Ulugbek uses the Indian concept of bukhta, which entered Muslim astronomy in the 8th-9th centuries, to explain the movement of planets.

Chapter 8 is devoted to determining the time of approach of the planets to each other, their exchange, conjunction and opposition, i.e. questions connected with astrology. Three tables belong to this chapter: "Determination of the hours of the Moon's movement and its approach to the planets", "Table of the approach of the planets with gulf and distance" and "Table of the movement of the Sun in gulf minutes". , in which the degrees and hours of distance are determined."

Chapter 9 is devoted to the issues of lunar eclipses. Like Muslim astronomers before him, Ulugh Beg recommends three phases of the eclipse: the "fall" before the eclipse (sukut), the "rise" (max) and the "opening" (injil) of the eclipse. Ulugh Beg gives the hours of eclipses during partial eclipses:

$$t_1 = \frac{\sqrt{(r^0 - r_1^0)^2 - r^{0^2}}}{\delta\bar{\lambda}}$$

is determined by a strict rule equal to the formula.

The formula during a total and continuous eclipse is as follows.

$$t_1 = \frac{\sqrt{(r_1^0 - r^0)^2 - r^{0^2}}}{\delta\bar{\lambda}}$$

takes the form , where $r^0, r_1^0, \rho^0 -$ are the angular radii of the Moon and the shadow, respectively, and is the angular distance from the center of the shadow to the orbit of the Moon;

$\delta\bar{\lambda}$- Progress of the Moon, that is, the increase in the movement of the Moon in one hour over the movement of the Sun in one hour.

After a series of operations, Ulugbek determines the surface of the eclipsed part of the Moon using a strict rule equal to the following formula:

$$t_1 = \begin{bmatrix} \frac{y}{3}\pi r_1^{0^2} + \frac{x}{3}\pi r^{0^2} \\ yoki \\ \frac{y}{3}\pi r_1^{0^2} + \left(1 - \frac{x}{3}\right)\pi r^{0^2} \end{bmatrix} - \rho^0 \sqrt{\frac{(r_1^0 + r^0 + \rho^0)(r_1^0 - r^0 + \rho^0)}{2\rho^0} \cdot (r_1^0 - r^0 + \rho^0)}$$

where the "lunar arc" is x and the "shadow arc" is as follows:

$$sinx = \frac{\sqrt{\frac{(r_1^0 + r^0 - \rho^0)(r_1^0 - r^0 + \rho^0)}{2\rho^0} \cdot (r_1^0 - r^0 + \rho^0)}}{\frac{r^0}{60}}$$

$$siny = \frac{\sqrt{\frac{(r_1^0 + r^0 + \rho^0)(r_1^0 - r^0 + \rho^0)}{2\rho^0} \cdot (r_1^0 - r^0 - \rho^0)}}{\frac{r_1^0}{60}}$$

determines from relations.

10 – chapter is devoted to the determination of solar eclipses. Ulugbek sees tabular and practical methods for determining eclipses, that is, the "method of the ancients" and the "methods of modern scientists". The tabular method of determination uses the "Table of parallaxes by longitude and latitude of the most distant Moon", which 5^0 are given for each latitude up $25°$ to $50°$.

In considering the “practical method” of solar eclipses, Ulugbek returns to the questionam determining the height and width of light, that is, to the questions of the second article of "Zij", which are described in articles 10 and 21 of the same article. The horizontal parallax of the Sun π_s , the equidistant parallax of the Moon π_L and the zenith distance of the apparent position of the Moon use strict z_L rules equivalent to the following formulas:

$$sin\pi_L = \frac{cos(h-\pi)}{\rho_s}\ , \quad \bar{\pi}_L = \pi_L - \pi_S\ ,\ z_L = 90° - h + \pi_L,$$

here $\rho_s -$ is the distance from the center of the Sun to the center of the Universe; π_L −horizontal parallax of the Moon.

"This section of Zij includes the 'table of equalized parallax and the equation of the moon at its greatest distance in the circle of altitudes'.

"Describing the "method of the ancients", Ulugbek criticized Ptolemy on the issue of solar eclipses, and also explained the parallax of the Moon in latitude and longitude.

$$\pi_\beta = \bar{\pi}_L \cdot \frac{sin\beta'}{cosh}\ , \qquad \pi_\lambda = \bar{\pi}_L \cdot \sqrt{1 - \frac{sin^2\beta'}{cos^2h}}$$

He says that he made a mistake by using an equilateral triangle instead of a spherical triangle when determining according to the rules. Indeed, Ptolemy made such a mistake in Chapter 19 of Book V of Almagesti. If, like Ulugbek, he had worked with a spherical triangle instead of a right triangle, the formula would have been as follows:

$$sin\pi_\beta = \frac{sin\bar{\pi}_L \cdot sin\beta'}{cosh}\ , \qquad cos\pi_\lambda = cos\bar{\pi}_L \cdot \sqrt{1 - \frac{sin^2\beta'}{cos^2h}}$$

will take the correct form.

When determining solar eclipses “according to the method of modern scientists,” Ulugbek does not name them, but gives strict rules for determining the visible latitude. β_v Moon, apparent longitude λ_{vh} of the horoscope and apparent longitude of λ_{v7} the seventh house, equal to these formulas, results in:

$$sin\beta_v = \frac{sin\beta \cdot sinz_L}{cosh}\ , \qquad sin\lambda_{vh} = \frac{cosz_L \cdot R}{cos\beta_L}\ , \qquad sin\lambda_{v7} = \frac{cosz_L \cdot R}{cos\beta_v}$$

Based on the parameters found, Ulugbek determines the longitudinal parallax π_β and the latitudinal parallax π_λ.

Commenting on this part of Ulugbek's work, Birjandi gives his rule for finding the longitudinal parallax. First, the latitude of the Moon is β This is its apparent latitude according to the zenith z_L distance and altitude h.

$$sin\beta_v = \frac{sin\beta \cdot sinz_L}{cosh}$$

is determined by a strict rule equal to the formula. Then the apparent longitude of the zenith according to this extension *h*

$$sin\lambda_{vz} = \frac{tg\beta_v \cdot \sqrt{cos^2h - sin^2\beta}}{R \cdot sin\beta}$$

as a rule, it determines the longitudinal parallax in the form $\pi_\lambda = \lambda_{vz} - \lambda_v$.

Ulugbek gives another way to determine the visible width βv Moons. First, it is in the 21st chapter of the article "Zij" II.

$$cosx = cos\beta \cdot cos\Delta\lambda\ , \quad siny = \frac{sin\beta}{cos\beta \cdot cos\Delta\lambda}\ ,$$

arcs *x* and *y* found by rules and "first to mind"

$$sinU = \frac{sinz_L \cdot \sqrt{1 - cos^2\beta \cdot sin^2\Delta\lambda}}{cosh}$$

and "second memory"

$$sinw = \frac{cosz_L}{cosu}$$

and in their opinion, expanding the searchable view is β_v

$$sin\beta_v = cosu \cdot sin[w \pm (90° - \beta')] ,$$

finds according to the rule, where β' is the ecliptic continuation of the zenith point.

Chapter 11 is devoted to the definition of the new moon - the crescent, which is a cardinal question in Islam, since the crescent in the year of the Hijra is determined by the appearance of the new moon. Ulugbek solves this problem in two ways:

the first - on spherical astronomy and the second - on stellar astronomy. Using the first method, Ulugbek first calculated the equation $\Delta\lambda_L^w$ moonset.

$$sin\Delta\lambda_L^w = \frac{tg\beta_L}{ctg\beta'}$$

determines its appearance. Then

$$sin\Delta\lambda_E = \frac{sinh}{ctg\beta'}$$

From the relation the equation of the expression $\Delta\lambda_E$ determines .

$$sinx = \frac{tg\beta}{ctg\beta'}$$

And from the relation - the auxiliary arc determines x. With the help of the last two arcs, the new Moon is a visible arc sickle or $\partial\lambda_v = \Delta\lambda_E \pm x$

$$\partial\lambda_v = arcsin\frac{sinh}{ctg\beta'} \pm arcsin\frac{tg\beta}{ctg\beta'}$$

finds by appearance. The second method is devoted to determining the boundaries of the sets of stars passing through the Moon during the positions of the Moon, that is, determining the boundaries of the sets of stars passing through the positions of the Moon during the month, and determining the results for these positions.

Chapter 12 is devoted to the astrological question - the alignment of houses, that is, the method of determining the ecliptic longitudes of the twelve astrological houses. Ulugbek solves several mathematical problems at once.

The last chapter – 13 – of this article is devoted to stellar astronomy. It contains Ulugbek's star catalogue "Ziji", that is, the coordinates of 1014 stars that he himself "observed with his own eyes".

The fourth article of Ulugbek "Zij" is devoted to astrology. It consists of two chapters. Chapter 1 is devoted to birth charts, that is, horoscopes, and consists of seven sections. The first section is devoted to the identification of samples, that is, approximate samples. Ulugbek gives three ancient examples: Ptolemy, Hermes and Zarathustra. He defines the astrological ideas of the owner of the house. In the second part of this chapter, he defines the concept of illumination as a continuation of phenomena. Here with the deviation of the event horizon δ_E. Powerful methods of determination, equivalent to the following formulas, deserve attention:

$$cos\delta' = \frac{R\cdot sinh}{cos\delta A}\ ,\ \ sin\delta' = \frac{R\cdot tg\Delta A}{tgA}\ \ ,\ \ sin\delta' = \frac{R\cdot sinx}{cosz}.$$

The last arcs *x* and *z* of these formulas

$$sinx = \frac{cos\delta \cdot sin\left(\alpha_\lambda - \alpha_{10/4}\right)}{R}\ ,\ \ sinz = \frac{cosx \cdot sin(y \pm \varphi)}{R}$$

Formulas can be found here

$$siny = \frac{sin\delta\cdot R}{\sqrt{R^2 - \left[\frac{sin\left(\alpha_\lambda - \alpha_{10/4}\right)\cdot cos\delta}{R}\right]^2}};$$

in this case α_λ - transitional material; $\alpha_{10/4}$ –matolii of the tenth and fourth houses.

Below is the corrected text for the coverage in section three.$\partial\alpha$this chapter.

$$\delta\alpha = \begin{cases} \alpha_H \pm \Delta\alpha' \\ \alpha_7 \pm \Delta\alpha' \end{cases}$$

the relationship is determined by equally strong rules, in which α_H , α_7 - tole' and matoli' of the seventh house;

$\Delta\alpha'$ –event horizon equation, this is

$$sin\Delta\alpha' = \frac{R \cdot cos\varphi'}{cos\delta'}$$

is determined by the formula.

Section Four of the Chapteris devoted to the problem of the projection of rays of light, that is, the replacement of degrees of the ecliptic or celestial equator. The fifth section is devoted to directions, that is, the direction of rays of light, the sixth section is devoted to the passage of the period of births, and the seventh section is devoted to births and years of upbringing.

Chapter IV 2 articles are devoted to evidence related to the fate of the Universe.

At first, the attitude towards astrology in our country was negative. That is why researchers who had a certain relationship with Ulugbek "Ziji", were forced to remain silent about the scientist's attitude to this teaching. The study of the IV article of "Zij" shows that Ulugbek knew astrology at a high level. He even mathematized it a little.

Since Ulugh Beg is very shy, he does not remember the works of previous authors, except for Ptolemy, Beruni and Abdurrahman Sufi in the Zij. He mentions Ptolemy's Almajisti, Kitab al-Samara, the latter in a revised version by Nasir ad-Din Tusin, as well as Beruni's Qanuni Masudi and KItab Kawakibi as-Sobit" by Abdurrahman Sufi ("Book of Fixed Stars"). According to Birjandi, Ulugbek also used the work "Ziji Khaqani" by Jamshid Koshi in the chronological part.

The high level of mathematics of Ulugbek "Ziji" shows that he used in this area the highest achievements of his predecessors and contemporaries in the Samarkand scientific school.

In the field of astronomy, in addition to Beruni's "Kanuni Masudi", Ulugbek used the works of scientists from the Marogh Observatory - the works of Nasiriddin Tusi and Kutbiddin Shirozi, as well as "Ziji" Koshii. According to E.S. Kennedy, Ulughbek rethought the achievements of his predecessors and used them. In particular, Ulughbeg's table of lunar parallaxes is more accurate than Cauchy's tables. However, at the same time, it is surprising that the Syrian astronomer Ibn al-Shatir (1304-1375) did not have any influence on Ulughbek. "Ziji was much closer to the theory of Copernicus than medieval scientists." Perhaps the reason for this is that he trusted Cauchy more and did not know about the work of Ibn al-Shatir.

On the definition of sine and axis

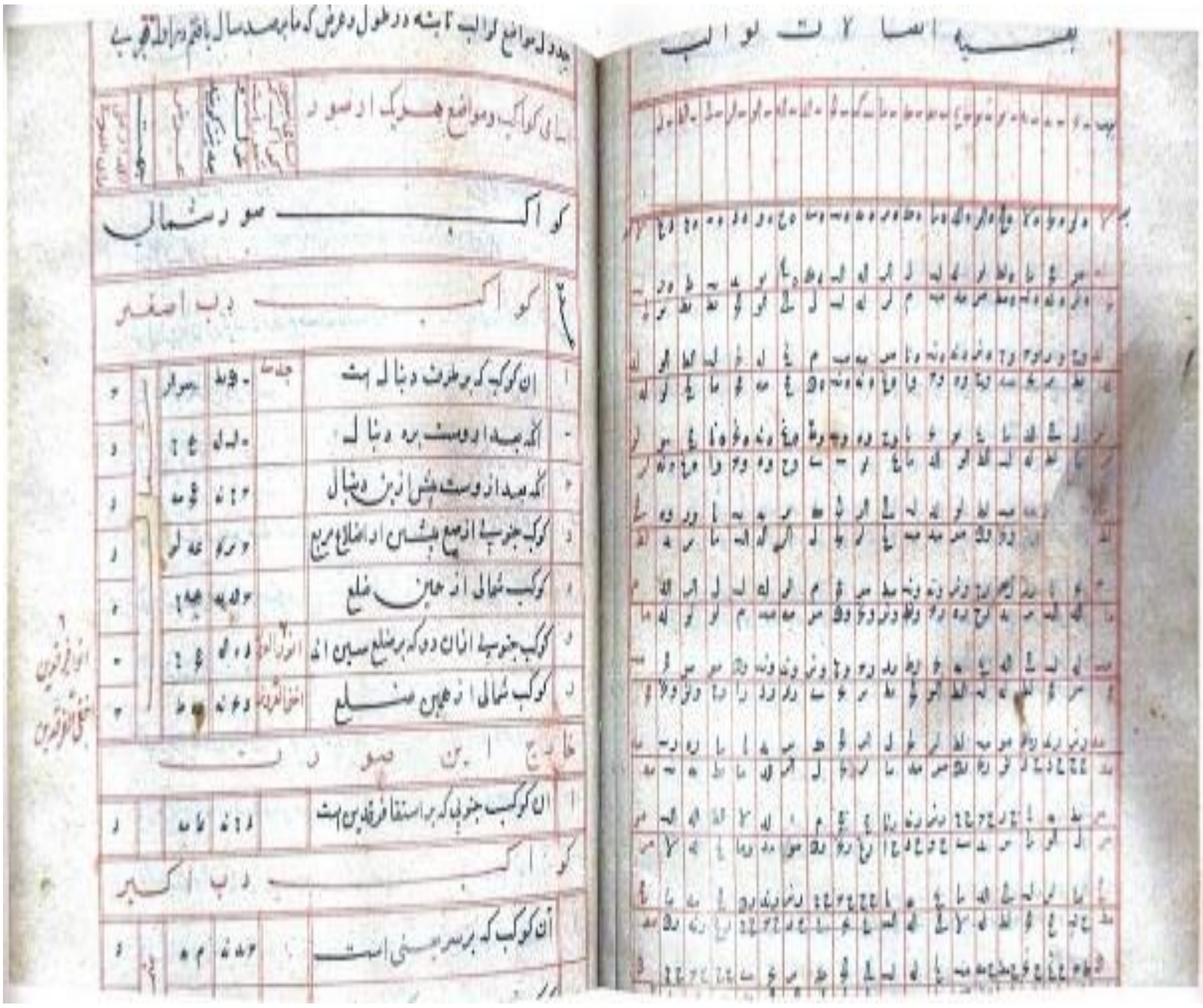
The sine is so perpendicular that it is drawn from one side of the arc to the diameter, and [the diameter] is adjacent to the other side of the arc. A semicircle and a full circle must not have a sine. Therefore, the sine of any four arcs must be equal to one, two of which [arcs] are smaller than the semicircle, and each is the complement of the other to the semicircle; the other two are multiples of the semicircle, each of which is the complement of each of the two arcs smaller than the preceding semicircle, to the full circle. For this reason, in the table of sines, [arcs] are reduced to degrees of the quadrant of the circle. [3]

If we subtract the quadrant of the arcsine from the quadrant of the semi-diameter, the root of the remainder will be the sine of the complement of this arc to the quadrant. The perpendicular drawn from the middle of the arc to the middle of its center is the axis of half of this arc. If we subtract from the semi-diameter the sine of the complement of an arc smaller than any quadrant, then the axis of this arc remains in the difference. If it [the arc] is larger than the quadrant, then we add to half the diameter the sine of its excess over the quadrant, and the axis of this arc is formed.

Ifthe axis is known, if we want to determine its arc, we take the difference between it [the axis] and the semi-diameter and determine its arc from the table [of sines]. Then, if the semi-diameter is greater [than the axis], this arc is subtracted from the quadrant, and if the axis is greater, they are added; the subtraction or sum will be the arc of this axis.

Since the arrow is of little use in astronomical works, and the axis of the arc and the arc of the arrow can be determined from the table of sines, we have not given a table of axes. In the table [Sines] we have placed the sines opposite each arc at one minute [with a difference]. If it is necessary to determine the seconds, solis andand so on down the table, this is defined by [action] between two lines.

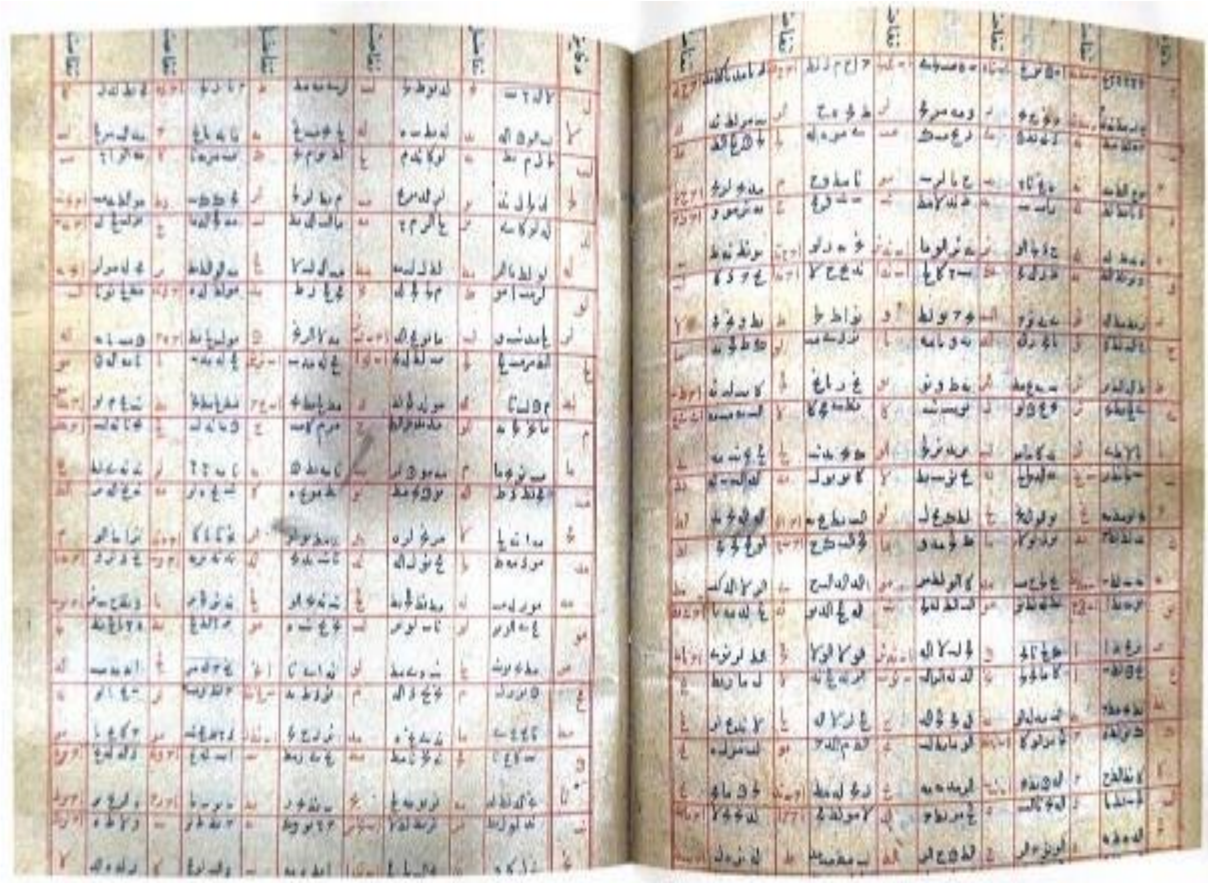
No one has yet succeeded in proving the sine of a degree, which is the basis for constructing tables of sines and shadows. All rulers have said that they cannot find a practical way to find it and only use tricks to determine it approximately.



Pages of "Ziji Ulugbek". Manuscript No. 2214 of the Institute of Oriental Studies. 1525

Pages of the astronomical treatise of Mahmud al-Shaghmini. 1383

Astronomical tables of Kurogon, 1779. Beinecke Rare Book and Manuscript Library



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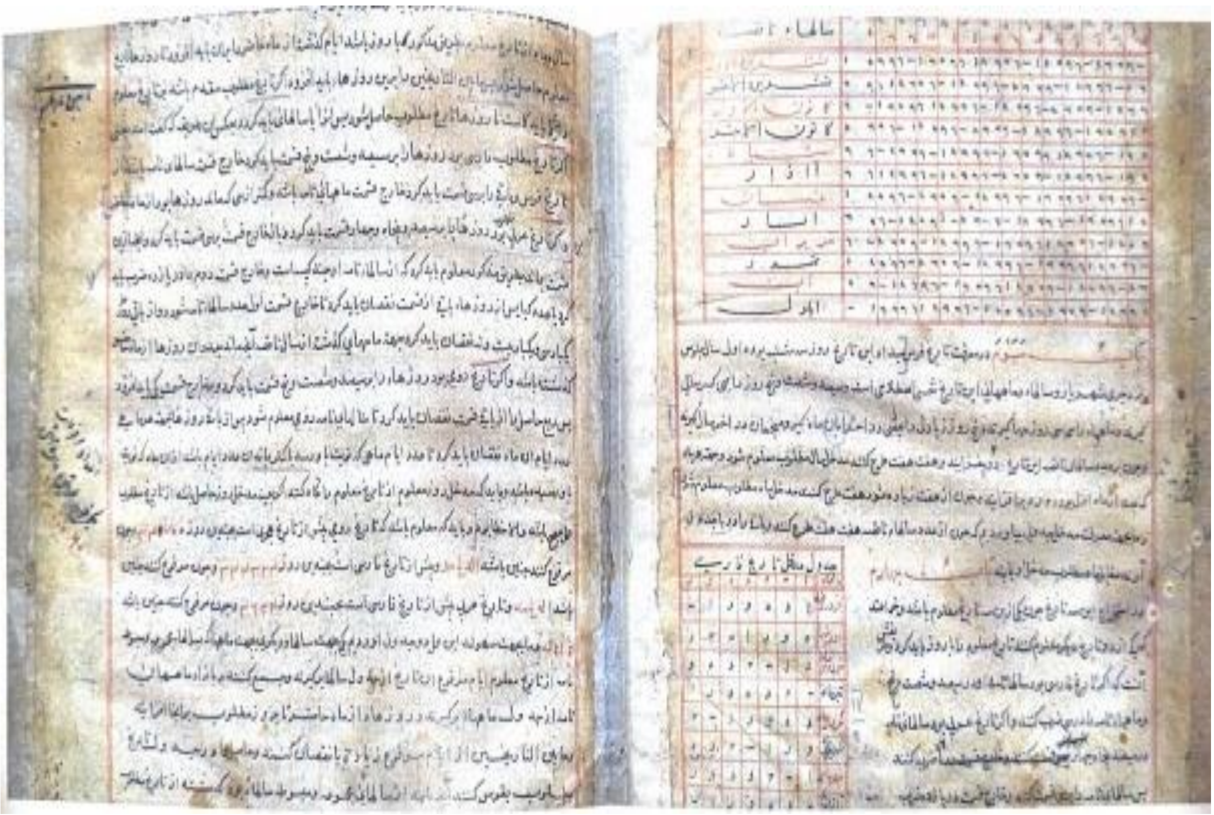

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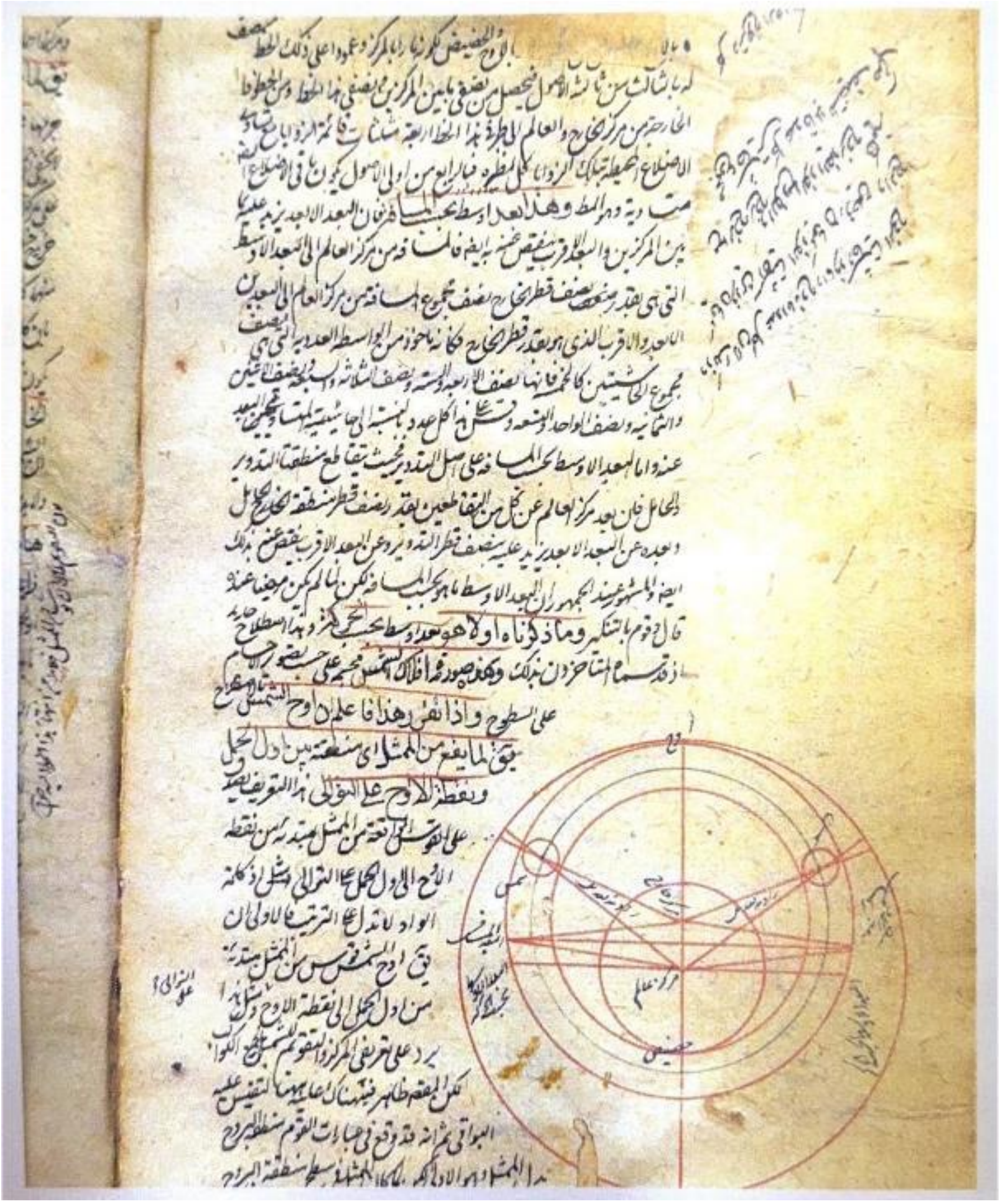

A page from a treatise by Nizamuddin Birjandi. Manuscript from the early 17th century.

جداول مواضع ثوابت در طول وعرض که

برصد یافته است الغ بیک بن شاهرخ بن تیمور

SIVE

TABVLÆ

LONG. AC LAT. STELLARUM FIXARVM,
EX OBSERVATIONE

ULUGH BEIGHI,

TAMERLANIS Magni Nepotis, Regionum ultra citráque *GJIHUN* (i. *Oxum*) Principis potentissimi.

Ex tribus invicèm collatis MSS Persicis jam primùm Luce ac Latio donavit, & Commentariis illustravit,
THOMAS HYDE *A. M. è Coll. Reginæ Oxon.*

In Calce Libri accesserunt *MOHAMMEDIS TIZINI* TABULÆ Declinationum & Rectarum Ascensionum.
Additur demum ELENCHUS Nominum Stellarum.

OXONII,
Typis *Henrici Hall* Academiæ Typographi, Sumptibus Authoris. Venales prostant apud *Richardum Davis* Bibliopolam. CIↃIↃCLXV.

The title of the edition is "Ziji Ulugbek", published by Thomas Hyde. Oxford. 1665.

СИНУСЛАР ЖАДВАЛИ[153]

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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	6									7									8									9									10									11								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	12									13									14									15									16									17								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дак.	18									19									20									21									22									23								
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	24									25									26									27									28									29								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дак.	30									31									32									33									34									35								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дак.	36									37									38									39									40									41								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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58	36	4	51	39	48	0	50	11	47	39	54	43	49	54	0	49	31	45	37	43	55	31	21	0	48	50	48	38	32	25	50	10	0	48	8	59	39	20	13	53	12	0	47	26	16	40	7	18	48	0	0	46	42	42
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	42									43									44									45									46									47								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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53	40	49	49	40	28	0	46	[illegible]	0	41	35	29	30	54	0	45	16	48	42	20	23	44	47	0	44	30	46	43	4	31	32	54	0	43	43	55	43	47	52	6	50	0	42	56	17	44	30	24	39	3	0	42	7	52
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	48 Синуслар					48 Фарқи				49 Синуслар					49 Фарқи			
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43	45	5	14	30	54	0	41	26	55	45	46	16	59	28	0	40	37	6
44	45	5	55	57	49	0	41	26	5	45	46	57	36	34	0	40	36	15
45	45	6	37	23	54	0	41	25	16	45	47	38	12	49	0	40	35	25
46	45	7	48	49	10	0	41	24	26	45	48	18	48	14	0	40	34	34
47	45	8	0	13	36	0	41	23	37	45	48	59	22	48	0	40	33	44
48	45	8	41	37	13	0	41	22	47	45	49	39	56	32	0	40	32	54
49	45	9	25	0	0	0	41	21	58	45	50	20	29	26	0	40	32	4
50	45	10	4	21	58	0	41	21	8	45	51	1	1	30	0	40	31	13
51	45	10	45	43	6	0	41	20	19	45	51	41	32	43	0	40	30	23
52	45	11	27	3	25	0	41	19	29	45	52	22	3	6	0	40	29	33
53	45	12	8	22	54	0	41	18	40	45	53	2	32	39	0	40	28	43
54	45	12	49	41	34	0	41	17	50	45	53	43	1	22	0	40	27	52
55	45	13	30	59	24	0	41	17	0	45	54	23	29	14	0	40	27	2
56	45	14	12	16	24	0	41	16	11	45	55	3	16	16	0	40	26	11
57	45	14	53	32	35	0	41	15	19	45	55	44	22	27	0	40	25	21
58	45	15	34	47	58	0	41	14	34	45	56	24	47	48	0	40	24	31
59	45	16	16	2	28	0	41	13	42	45	57	5	12	19	0	40	23	40

Дақ.	50 Синуслар					50 Фарқи				51 Синуслар					51 Фарқи			
0	45	57	45	35	59	0	40	22	50	46	37	43	31	40	0	39	32	4
1	45	58	25	58	49	0	40	21	59	46	38	23	3	44	0	39	31	42
2	45	59	6	20	48	0	40	21	9	46	39	2	34	56	0	39	30	20
3	45	59	46	41	57	0	40	20	19	46	39	42	5	16	0	39	29	30
4	46	0	27	2	16	0	40	19	28	46	40	21	34	47	0	39	28	38
5	46	1	7	21	44	0	40	18	38	46	41	1	3	25	0	39	27	47
6	46	1	47	40	22	0	40	13	47	46	41	40	31	12	0	39	26	56
7	46	2	27	58	9	0	40	16	57	46	42	19	58	8	0	39	26	5
8	46	3	8	15	6	0	40	16	6	46	42	39	24	13	0	39	25	14
9	46	3	48	31	12	0	40	15	16	46	43	38	49	27	0	39	24	23
10	46	4	28	46	28	0	40	14	25	46	44	18	13	50	0	39	23	31
11	46	5	9	0	53	0	40	13	35	46	44	57	37	21	0	39	22	40
12	46	5	49	14	28	0	40	12	44	46	45	37	0	1	0	39	21	49
13	46	6	29	27	12	0	40	11	54	46	46	16	21	50	0	39	20	58
14	46	7	9	39	6	0	40	11	1	46	46	55	42	48	0	39	20	6
15	46	7	49	50	9	0	40	10	12	46	47	35	2	54	0	39	19	13
16	46	8	20	0	21	0	40	9	22	46	48	14	22	9	0	39	18	23
17	46	9	10	9	43	0	40	8	31	46	48	53	40	32	0	39	17	32
18	46	9	50	18	14	0	40	7	40	46	49	32	58	4	0	39	16	41
19	46	10	30	25	54	0	40	6	50	46	50	12	14	45	0	39	15	50
20	46	11	10	32	44	0	40	5	59	46	50	51	30	35	0	39	14	58
21	46	11	50	38	43	0	40	5	9	46	51	30	45	33	0	39	14	7
22	46	12	30	43	52	0	40	4	18	46	52	9	59	40	0	39	13	15
23	46	13	10	48	10	0	40	3	26	46	52	49	12	55	0	39	12	24
24	46	13	50	51	36	0	40	2	35	46	53	28	25	19	0	39	11	33
25	46	14	30	54	13	0	40	1	40	46	54	7	36	52	0	39	10	41
26	46	15	10	56	0	0	40	0	55	46	54	46	47	33	0	39	9	50
27	46	15	50	56	55	0	40	0	4	46	55	25	57	33	0	39	8	58
28	46	16	30	56	59	0	39	59	54	46	56	5	6	21	0	39	8	7
29	46	17	10	56	53	0	39	58	23	46	56	44	14	28	0	39	7	15
30	46	17	50	54	36	0	39	57	32	45	57	23	21	43	0	39	6	24
31	46	18	30	52	8	0	39	56	41	46	58	2	28	7	0	39	5	32
32	46	19	10	48	49	0	39	55	51	46	58	41	33	39	0	39	4	41
33	46	19	50	44	40	0	39	55	0	46	59	20	38	20	0	39	3	49
34	46	20	30	39	40	0	39	54	9	46	59	59	42	9	0	39	2	57
35	46	21	10	33	49	0	39	53	18	47	0	38	45	6	0	39	2	6
36	46	21	50	27	7	0	39	52	27	47	1	16	47	12	0	39	1	14
37	46	22	30	19	34	0	39	51	37	47	1	56	48	26	0	39	0	23
38	46	23	10	11	1	0	39	50	45	47	2	35	48	49	0	38	59	32
39	46	23	50	1	56	0	39	49	55	47	3	14	48	21	0	38	58	40
40	46	24	29	51	51	0	39	49	4	47	3	53	47	1	0	38	57	48
41	46	25	9	40	55	0	39	48	13	47	4	32	44	49	0	38	56	57
42	46	25	49	29	8	0	39	47	21	47	5	41	41	46	0	38	56	5
43	46	26	29	16	29	0	39	46	31	47	5	50	37	51	0	38	55	13
44	46	27	9	3	0	0	39	45	40	47	6	29	33	4	0	38	54	21
45	46	27	48	48	40	0	39	44	49	47	7	8	27	25	0	38	53	30
46	46	28	28	33	29	0	39	43	58	47	7	47	20	55	0	38	52	38
47	46	29	8	17	27	0	39	43	7	47	8	27	13	33	0	38	51	47
48	46	29	48	0	34	0	39	42	16	47	9	5	5	20	0	38	50	55
49	46	30	27	42	50	0	39	41	26	47	9	43	56	15	0	38	50	3
50	46	31	7	24	16	0	39	40	34	47	10	22	46	18	0	38	49	12
51	46	31	47	4	50	0	39	39	43	47	11	1	35	30	0	38	48	19
52	46	32	26	44	33	0	39	38	52	47	11	40	23	49	0	38	47	28
53	46	33	6	23	25	0	39	38	1	47	12	19	11	17	0	38	46	36
54	46	33	46	1	26	0	39	37	10	47	12	57	57	53	0	38	45	44
55	46	34	25	38	36	0	39	36	19	47	13	36	43	37	0	38	44	52
56	46	35	5	14	55	0	39	35	28	47	14	15	28	29	0	38	44	1
57	46	35	44	50	23	0	39	34	36	47	14	54	12	30	0	38	43	9
58	46	36	24	24	59	0	39	33	46	47	15	32	55	39	0	38	42	17
59	46	37	3	58	45	0	39	32	55	47	16	11	37	56	0	38	41	26

Дақ.	52 Синуслар					52 Фарқи				53 Синуслар					53 Фарқи			
0	47	16	55	19	22	0	38	49	14	47	55	5	16	13	0	37	48	21
1	47	17	28	59	56	0	38	39	41	47	55	43	4	34	0	37	47	29
2	47	18	7	39	37	0	38	38	59	47	56	20	52	3	0	37	46	36
3	47	18	46	18	27	0	38	37	52	47	56	58	33	39	0	37	45	43
4	47	19	24	56	24	0	38	37	6	47	57	36	24	22	0	37	44	59
5	47	20	3	33	30	0	38	36	14	47	58	14	9	12	0	37	43	58
6	47	20	42	9	44	0	38	35	28	47	58	51	53	16	0	37	43	5
7	47	21	20	45	6	0	38	34	30	47	59	29	36	15	0	37	42	13
8	47	21	59	19	36	0	38	33	38	48	0	7	18	28	0	37	41	21
9	47	22	36	53	14	0	38	32	47	48	0	44	59	49	0	32	40	28
10	47	23	16	26	1	0	38	31	55	48	1	22	40	17	0	37	39	35
11	47	23	54	57	56	0	38	31	2	48	2	0	19	52	0	37	38	43
12	47	24	33	38	58	0	38	30	10	48	2	37	58	35	0	37	37	49
13	47	25	11	59	8	0	38	29	19	48	3	15	36	24	0	37	36	57
14	47	25	50	28	27	0	38	28	26	48	3	53	13	21	0	37	36	5
15	47	26	28	56	53	0	38	27	34	48	4	30	49	26	0	37	35	20
16	47	27	7	24	27	0	38	26	42	48	5	8	24	36	0	37	34	15
17	47	27	45	51	9	0	38	25	50	48	5	45	59	51	0	37	33	30
18	47	28	24	16	59	0	38	24	58	48	6	23	32	21	0	37	32	33
19	47	29	2	41	57	0	38	24	6	48	7	1	4	54	0	37	31	41
20	47	29	41	6	3	0	38	23	14	48	7	38	36	35	0	37	30	48
21	47	30	19	29	17	0	38	22	22	48	8	16	7	23	0	37	29	55
22	47	30	57	51	39	0	38	21	29	48	8	53	37	18	0	37	29	2
23	47	31	36	13	8	0	38	20	38	48	9	31	6	20	0	37	28	9
24	46	32	14	33	46	9	38	19	46	48	10	8	34	29	0	37	27	16
25	47	32	52	53	32	0	38	18	54	48	10	46	11	45	0	37	26	23
26	47	33	31	13	26	0	38	18	1	48	11	23	28	8	0	37	25	31
27	47	34	9	30	27	0	38	17	9	48	12	0	53	39	0	37	24	38
28	47	34	47	47	36	0	38	16	17	48	12	38	18	17	0	37	23	45
29	47	35	26	3	53	0	38	15	24	48	13	15	42	1	0	37	22	53
30	47	36	4	19	17	0	38	14	32	48	13	53	4	55	0	37	21	59
31	47	36	42	33	49	0	38	13	41	48	14	30	26	54	0	37	21	7
32	47	37	20	47	30	0	38	12	48	48	15	7	48	1	0	37	20	13
33	47	37	59	0	18	0	38	11	56	48	15	45	8	14	0	37	19	21
34	47	38	37	12	14	0	38	11	4	48	16	22	27	35	0	37	18	27
35	47	39	15	23	18	0	38	10	12	48	16	59	56	2	0	37	17	34
36	47	39	53	33	30	0	38	9	19	48	17	37	3	36	0	37	16	42
37	47	40	31	42	49	0	38	8	26	48	18	14	20	18	0	37	15	49
38	47	41	9	51	15	0	38	7	34	48	18	51	36	7	0	37	14	56
39	47	41	47	58	49	0	38	6	42	48	19	28	51	3	0	37	14	3
40	47	42	26	5	31	0	38	5	50	48	20	6	5	6	0	37	13	10
41	47	43	4	11	21	0	38	4	57	48	20	43	18	6	0	37	12	27
42	47	43	42	26	18	0	38	4	5	48	21	20	50	33	0	37	11	24
43	47	44	20	20	23	0	38	3	13	48	21	57	41	57	0	37	10	30
44	47	44	58	23	36	0	38	2	21	48	22	34	52	27	0	37	9	37
45	47	45	36	25	57	0	38	1	28	48	23	12	2	4	0	37	8	44
46	47	46	14	27	25	0	38	0	36	48	23	49	10	48	0	37	7	52
47	47	46	54	28	1	0	37	59	44	48	24	26	18	40	0	37	6	58
48	47	47	30	27	45	0	37	58	51	48	25	3	25	38	0	37	6	5
49	47	48	8	26	36	0	37	57	58	48	25	40	31	43	0	37	5	13
50	47	48	46	24	34	0	37	57	6	48	26	7	36	56	0	37	4	19
51	47	49	24	21	40	0	37	56	13	48	26	54	41	15	0	37	3	26
52	47	50	2	17	53	0	37	55	21	48	27	31	44	41	0	37	2	33
53	47	50	40	13	14	0	37	54	29	48	28	0	47	14	0	37	1	40
54	47	51	18	7	43	0	37	53	36	48	28	45	48	54	0	37	0	46
55	47	51	56	1	19	0	37	52	44	48	29	22	49	40	0	36	59	53
56	47	52	33	54	3	0	37	51	51	48	29	59	49	33	9	36	39	0
57	47	53	11	45	54	0	37	50	59	48	30	36	48	33	0	36	58	6
58	47	54	49	36	53	0	37	50	6	48	31	13	46	40	0	36	47	14
59	47	54	27	26	59	0	37	49	14	48	31	50	43	51	0	36	56	21

СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	54									55									56								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
0	48	32	27	40	15	0	36	55	27	49	8	56	50	30	0	36	1	53	49	44	32	6	56	0	35	7	39
1	48	33	4	35	42	0	36	54	34	49	9	32	52	25	0	36	0	59	49	45	7	14	35	0	35	6	44
2	48	33	41	30	16	0	36	53	41	49	10	8	53	22	0	36	0	5	49	45	41	21	19	0	35	5	51
3	48	34	18	23	57	0	36	52	48	49	10	45	53	27	0	35	59	11	49	46	17	27	10	0	35	4	55
4	48	34	55	16	45	0	36	51	54	49	11	20	52	38	0	35	58	17	49	46	52	32	5	0	35	4	2
5	48	35	32	8	39	0	36	51	1	49	11	56	50	55	0	35	57	23	49	47	27	36	7	0	35	3	7
6	48	36	8	59	40	0	36	50	7	49	12	32	48	18	0	35	56	29	49	48	2	39	14	0	35	2	22
7	48	36	45	49	47	0	36	49	14	49	13	8	44	47	0	35	55	36	49	48	37	41	36	0	35	1	7
8	48	37	22	39	1	0	36	48	21	49	13	44	40	23	0	35	54	41	49	49	2	42	43	0	35	0	22
9	48	37	59	27	22	0	36	47	28	49	14	20	35	4	0	35	53	48	49	49	47	43	5	0	34	59	27
10	48	38	36	14	50	0	36	46	34	49	14	56	28	52	0	35	52	54	49	50	22	42	32	0	34	58	33
11	48	39	13	1	24	0	36	45	41	49	15	32	21	40	0	35	51	59	49	50	57	41	5	0	34	57	38
12	48	39	49	47	5	0	36	44	48	49	16	8	13	45	0	35	51	5	49	51	32	38	43	0	34	56	44
13	48	40	26	31	53	0	36	43	54	49	16	44	4	50	0	35	50	12	49	52	7	35	27	0	34	55	49
14	48	41	3	15	47	0	36	43	1	49	17	49	55	2	0	35	49	17	49	52	42	31	16	0	34	54	55
15	48	41	39	58	48	0	36	42	8	49	17	55	44	19	0	35	48	23	49	53	17	26	11	0	34	54	0
16	48	42	16	40	56	0	36	41	14	49	18	31	32	42	0	35	47	29	49	53	52	20	11	0	34	53	5
17	48	42	53	22	10	0	36	40	20	49	19	7	20	11	0	35	46	35	49	54	27	13	16	0	34	52	10
18	48	43	30	2	30	0	36	59	27	49	19	43	6	46	0	35	45	41	49	55	2	5	26	0	34	51	16
19	48	44	6	41	57	0	36	38	34	49	20	18	52	27	0	35	44	47	49	55	36	56	42	0	34	5C	20
20	48	44	43	20	31	0	36	37	40	49	20	54	37	14	0	35	43	53	49	56	41	47	2	0	34	49	26
21	48	45	59	58	11	0	36	36	47	49	21	30	21	7	0	35	42	59	49	56	46	36	28	0	34	48	31
22	48	45	56	34	58	0	36	35	53	49	22	6	4	6	0	35	42	4	49	57	21	24	59	0	34	37	36
23	48	46	33	10	51	0	36	35	0	49	22	41	46	10	0	35	41	10	49	57	56	12	35	0	34	46	42
24	48	47	9	45	51	0	36	34	7	49	23	17	27	20	0	35	40	16	49	58	30	59	17	0	34	45	47
25	48	47	46	19	58	0	36	33	13	49	23	53	7	36	0	35	39	22	49	59	5	45	4	0	34	44	52
26	48	48	22	53	11	0	36	32	19	49	24	28	46	58	0	35	38	28	49	59	40	29	56	0	34	43	57
27	48	48	59	25	30	0	36	31	26	49	25	4	25	26	0	35	37	33	50	0	15	13	53	0	34	43	2
28	48	49	35	56	56	0	36	30	32	49	25	40	2	59	0	36	36	40	50	0	49	56	55	0	34	42	8
29	48	50	2	27	28	0	36	29	39	49	26	15	39	39	0	35	35	45	50	1	24	39	3	0	34	41	12
30	48	50	48	57	7	0	36	28	45	49	26	51	15	24	0	35	34	51	50	1	59	20	15	0	34	40	18
31	48	51	25	25	52	0	36	27	52	49	27	27	50	15	0	35	33	57	50	2	34	0	33	0	34	39	22
32	48	52	1	53	44	0	36	26	58	49	28	2	24	12	0	35	33	3	50	3	8	39	55	0	34	38	28
33	48	52	38	20	42	0	36	26	4	49	28	37	57	15	0	35	32	8	50	3	43	18	23	0	34	37	34
34	48	53	14	46	46	0	36	25	11	49	29	36	29	23	0	35	31	14	50	4	17	55	57	0	34	36	38
35	48	53	51	11	57	0	36	24	17	49	29	49	0	37	0	35	30	20	50	4	52	32	35	0	34	35	43
36	48	54	26	36	14	0	36	23	24	49	30	34	30	57	0	35	29	25	50	5	27	8	18	0	34	34	49
37	48	55	3	19	56	0	36	22	30	49	31	0	0	22	0	35	28	31	50	5	1	43	7	0	34	33	53
38	48	55	40	22	8	0	36	21	36	49	31	35	28	53	0	35	27	37	50	6	36	17	0	0	34	32	59
39	48	56	46	43	44	0	36	20	42	49	32	10	56	30	0	35	26	42	50	7	10	49	59	0	34	32	3
40	48	56	53	4	26	0	36	19	49	49	32	40	23	12	0	35	25	48	50	7	45	22	2	0	34	31	8
41	48	57	29	24	15	0	36	18	55	49	33	21	49	0	0	35	24	54	50	8	19	53	10	0	34	30	14
42	48	58	5	43	10	0	36	18	1	49	33	57	13	54	0	35	23	59	50	8	54	23	24	0	34	29	18
43	48	58	42	1	11	0	36	17	8	49	34	32	37	53	0	35	23	5	50	9	28	52	42	0	34	28	24
44	48	59	18	18	19	0	36	16	14	49	35	8	0	58	0	35	22	11	50	10	3	21	6	0	34	27	29
45	48	59	54	34	33	0	36	15	20	49	35	43	23	9	0	35	21	16	50	10	37	48	35	0	34	26	34
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Дақ.	57									58									59								
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	60									61									62									63									64									65								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	66									67								
	Синуслар					Фарқи				Синуслар					Фарқи			
0	54	48	45	49	8	0	25	32	52	55	13	49	2	54	0	24	32	31
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6	54	51	18	51	16	0	25	26	51	55	16	10	2	51	0	24	26	27
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9	54	52	35	8	48	0	25	23	50	55	17	29	19	31	0	24	23	26
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16	54	55	32	34	35	0	25	16	49	55	20	19	41	58	0	24	16	21
17	54	55	57	51	24	0	25	15	48	55	20	43	58	19	0	24	15	20
18	54	56	23	7	12	0	25	14	49	55	21	8	13	39	0	24	14	19
19	54	56	48	22	1	0	25	13	48	55	21	32	27	58	0	24	14	19
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41	55	5	59	33	26	0	24	51	41	55	30	21	26	55	0	23	51	1
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43	55	6	49	5	47	0	24	49	39	55	31	9	7	57	0	23	49	0
44	55	7	14	5	26	0	24	48	39	55	31	32	56	57	0	23	47	59
45	55	7	38	54	5	0	24	47	39	55	31	56	44	55	0	23	46	58
46	55	8	3	41	44	0	24	46	38	55	32	20	31	54	0	23	45	57
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58	55	12	59	54	51	0	24	34	32	55	37	4	36	16	0	23	33	45
59	55	13	24	29	23	0	24	33	31	55	37	28	10	1	0	23	32	44

Дақ.	68									69								
	Синуслар					Фарқи				Синуслар					Фарқи			
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3	55	39	2	14	32	0	23	29	41	56	2	0	50	46	0	22	27	26
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6	55	40	12	37	52	0	23	26	37	56	3	8	9	59	0	22	24	21
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9	55	41	22	51	40	0	23	22	34	56	4	15	19	59	0	22	22	17
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11	55	42	9	35	47	0	23	21	32	56	4	59	1	32	0	22	19	14
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14	55	43	19	34	18	0	23	17	30	56	6	6	56	10	0	22	16	9
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17	55	44	29	22	42	0	23	14	26	56	7	13	41	34	0	22	13	5
18	55	44	52	38	8	0	23	13	24	56	7	35	54	39	0	22	12	3
19	55	45	15	51	32	0	23	12	23	56	7	58	0	42	0	22	11	2
20	55	45	39	3	55	0	23	11	22	56	8	20	17	44	0	22	10	0
21	55	46	2	15	17	0	23	10	21	56	8	42	27	44	0	22	9	59
22	55	46	25	25	38	0	23	9	20	56	9	4	36	43	0	22	7	37
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26	55	47	57	56	49	0	23	5	15	56	10	33	2	21	0	22	3	51
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31	55	49	53	12	51	0	23	0	10	56	12	23	11	16	0	21	58	43
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33	55	50	39	12	8	0	22	58	6	56	13	7	7	42	0	21	56	39
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35	55	51	25	7	19	0	22	56	4	56	13	50	59	59	0	21	54	30
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37	55	52	10	58	26	0	22	55	1	56	14	35	48	9	0	21	52	31
38	55	52	33	53	27	0	22	53	0	56	14	57	40	42	0	21	51	31
39	55	52	56	46	27	0	22	51	58	56	15	19	32	43	0	21	50	29
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41	55	53	42	28	22	0	22	50	56	56	16	2	12	10	0	21	48	26
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44	55	54	50	55	7	0	22	46	52	56	17	7	34	22	0	21	45	21
45	55	55	13	41	59	0	22	45	51	56	17	29	19	43	0	21	44	19
46	55	55	36	27	50	0	22	44	50	56	17	51	4	2	0	21	43	17
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48	55	56	21	56	28	0	22	42	47	56	18	34	29	35	0	21	41	13
49	55	56	44	39	15	0	22	41	45	56	18	56	10	48	0	21	40	12
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58	56	0	8	18	15	0	22	32	33	56	22	3	35	33	0	21	30	55
59	56	0	30	50	48	0	22	31	34	56	22	25	6	28	0	21	29	54

Дақ.	70									71								
	Синуслар					Фарқи				Синуслар					Фарқи			
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6	56	25	2	14	8	0	21	22	41	56	45	54	26	16	0	20	20	37
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59	56	43	31	32	51	0	20	27	33	57	3	28	46	58	0	19	25	23

СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	72									73									74									75									76									77								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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51	57	19	55	47	14	0	18	31	8	57	37	55	56	44	0	17	28	5	57	54	51	54	18	0	16	24	44	58	10	45	21	19	0	15	21	4	58	25	36	0	22	0	14	17	7	58	39	21	35	12	0	13	12	55
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53	57	20	32	48	27	0	18	29	1	57	38	30	51	51	0	17	25	59	57	55	25	42	42	0	16	22	35	58	11	17	2	23	0	15	18	57	58	26	4	33	32	0	14	15	0	58	39	47	59	58	0	13	10	47
54	57	20	51	17	28	0	18	27	59	57	38	48	17	50	0	17	24	56	57	55	42	5	18	0	16	21	33	58	11	30	21	20	0	15	17	52	58	26	18	48	32	0	14	13	0	58	40	1	10	45	0	13	9	42
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СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	78									79									80									81									82									83								
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи			
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7	58	42	50	53	16	0	12	55	54	58	55	14	57	15	0	11	51	16	59	6	34	24	20	0	10	16	52	59	15	49	2	33	0	9	41	37	59	25	58	40	16	0	8	35	31	59	34	3	7	30	0	7	31	17
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21	58	46	50	16	16	0	12	40	44	58	57	59	16	50	0	11	35	11	59	9	3	37	40	0	10	31	24	59	10	3	6	33	0	9	26	27	59	27	57	32	44	0	8	21	18	59	35	45	45	14	0	7	16	2
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23	58	46	15	33	39	0	12	38	25	58	58	22	28	7	0	11	34	1	59	9	26	39	24	0	10	29	14	59	19	21	58	24	0	9	24	17	59	28	14	14	16	0	8	19	8	59	35	1	17	12	0	7	13	51
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33	58	48	21	14	8	0	12	27	50	59	0	17	19	47	0	11	23	14	59	11	3	43	11	0	10	18	25	59	20	55	12	23	0	9	13	26	59	29	36	36	44	0	8	8	15	59	37	12	46	39	0	7	2	57
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36	58	48	58	34	26	0	12	24	37	59	0	51	26	16	0	11	20	0	59	11	39	35	13	0	10	15	17	59	21	22	49	26	0	9	10	11	59	30	0	58	15	0	8	5	0	59	37	33	52	14	0	6	59	41
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45	58	50	49	37	14	0	12	14	56	59	2	32	47	26	0	11	10	22	59	13	11	12	55	0	10	5	27	59	22	44	41	58	0	9	0	25	59	31	13	4	9	0	7	55	13	59	38	36	10	9	0	6	29	52
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47	58	51	15	6	2	0	12	12	47	59	2	55	6	56	0	11	8	8	59	13	31	22	44	0	10	3	16	59	23	2	41	42	0	8	58	15	59	31	28	53	30	0	7	53	2	59	38	49	44	45	0	6	47	44
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52	58	52	14	59	11	8	12	7	25	59	3	50	36	49	0	11	2	44	59	14	21	28	17	0	9	57	52	55	23	47	22	4	0	8	52	49	59	32	8	7	49	0	7	47	35	59	39	23	36	22	0	6	42	14
53	58	52	27	6	36	0	12	6	20	59	4	1	39	33	0	11	1	12	59	14	31	26	9	0	9	56	47	59	23	56	14	53	0	8	51	44	59	32	15	55	24	0	7	46	31	59	39	35	18	36	0	6	41	9
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56	58	53	3	22	22	0	12	3	6	59	4	34	41	17	0	10	58	25	59	15	1	3	15	0	9	53	52	59	24	22	46	48	0	8	48	28	59	32	39	41	40	0	7	43	15	59	39	50	18	47	0	6	37	53
57	58	53	15	25	28	0	12	2	1	59	4	45	39	12	0	10	58	20	59	15	11	6	47	0	9	52	38	59	24	31	35	16	0	8	47	23	59	32	46	54	55	0	7	42	9	59	39	56	56	40	0	6	36	47
58	58	53	27	27	29	0	12	0	57	59	4	56	37	2	0	10	56	16	59	15	20	59	15	0	9	51	22	59	24	40	22	39	0	8	46	18	59	32	54	17	4	0	7	41	5	59	40	3	33	27	0	6	35	42
59	58	53	39	28	26	0	11	59	52	59	5	7	33	18	0	10	55	11	59	15	30	50	37	0	9	50	17	59	24	49	8	57	0	8	45	11	59	33	2	58	9	0	7	39	59	59	40	10	8	9	0	6	34	37

СИНУСЛАР ЖАДВАЛИ ДАВОМИ

Дақ.	84									85									86									87											88											89										
	Синуслар					Фарқи				Синуслар					Фарқи				Синуслар					Фарқи				Синуслар						Фарқи					Синуслар						Фарқи					Синуслар						Фарқи				
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Sinuses and their arcs

Here Ulugbek speaks of a quantity, which is in fact a function, as an argument – a contribution. [3]

If we are given a number X that is less than a number X_0 , and we need to find its function $f(x)$, then the linear interpolation rule presented by Ulugbek can be expressed as

$$f(x) = f(x_0) + (x - x_0) \cdot \frac{f(x_1) - (x_0)}{x_1 - x_0}$$

If replace that $x_1 = x_0 + h$, That

$$f(x) = f(x_0) + (x - x_0) \cdot \frac{f(x_0+h)-(x_0)}{h} \ .$$

Step of the giant table sinuses $h = 1'$. In this case, "there will be no need."

A similar rule of interpolation was given by Beruni in "Kanuni Masudi". From the letter of Jamshid Koshi to his father we know that "Kanuni Masudi" was the main teaching aid of Ulugbek scholars in the Samarkand school.

Here is the method of inverse interpolation described above, which can be expressed by the formula

$$x = x_0 + h \cdot \frac{f(x)-f(x_0)}{f(x_0+h)-(x_0)} \ .$$

Again $h = 1$ there is no need to multiply. The definition of sine given by Ulugbek differs from all previous definitions and is not related to vatar. Ulugbek defines sine as an independent function.

$sin180° = sin360° = 0$ this is what is meant.

Here $\sin(180° - \alpha) = sin\alpha$

$$\sin(360° - \alpha) = \sin(180° + \alpha) = -sin\alpha$$

referencing formulas.

But Ulugbek did not take into account the negative sign in the last two formulas. At the same time, Ulugbek does not pay attention to the periodicity of the sinusoidal function. Here is the root

$$\sqrt{R^2 - sin^2\alpha} = \sin\,(90° - \alpha)$$

or

root $\sqrt{R^2 - sin^2\alpha} = cos\alpha$

Implied: $R = cos\alpha$, when $R = 1$In this topic, the word "quadrant" was translated as "ruble", that is, a quarter.

In Figure 1 $AB = AD$ B - is the arc power, the sine of the arc, i.e. the sine of the arc closing the quadrant, i.e. $AC = AD - AC = sin\alpha\ (if\ \ OA = 1\ then\ )OC - AD$

$$OC = \sin(90° - \alpha) = cos\alpha\ \ (AO = 1)$$

when it was Ulugh Beg, like all other medieval Muslim scholars, called the difference between the radius of a circle and the cosine an arrow (sahm). Medieval European scholars called the arrow "reflected sine", that is, the sine against.

The rules given by Ulugbek can be written in the following forms:

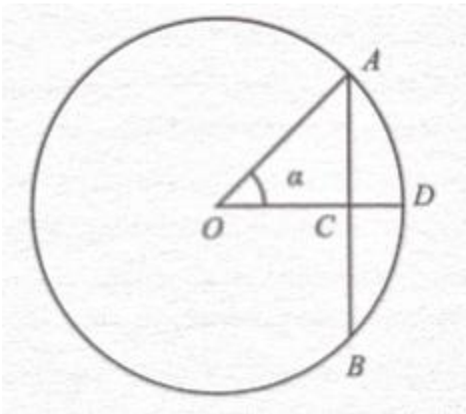
$\sin vers\ \alpha = R - \sin(90° - \alpha)\,,\quad \alpha < 90°$ when was it;

$\sin vers\ \alpha = R + \sin(\alpha - 90°)\,,\quad \alpha > 90°$ when was it;

$R = 1$, these formulas take the following form:

$\sin vers\ \alpha = 1 - cos\alpha,\quad \alpha > 90°$ If;

$\sin vers\ \alpha = 1 + cos\alpha,\quad \alpha < 90°$ If



1 – picture.

Ulugbek's rule for determining the arc along the axis can be written as the following formula:

$\alpha = 90° \mp arcsin(R - \sin vers\ \alpha),\ \alpha \lesseqgtr 90°$ for

We are talking about the rules of linear interpolation, expressed by the formulas in entries 2 and 3. In the case of sines, these rules can be written as formulas:

$$sinx = sinx_0 + (x - x_0) \cdot \frac{sin(x_0 + h) - sinx_0}{h}$$

and

$$x = x_0 + h \cdot \frac{sinx - sinx_0}{sin(x_0 + h) - sinx_0}$$

In Ulugbek's sine tables.
Beruni did not notice that he used a more advanced rule of quadratic interpolation.

Or it was believed that Kazi Zoda Rumi wrote a work called "Treatise" on the definition of sine. Having analyzed some issues of the beginning of work on "Zij", we came to the conclusion that the author of this brochure was not Kazi Zoda, but Ulugbek, and published this opinion together with A. A. Rosenfeld.

As a result of studying Ulugbek's "Zij" and Hussein Birjandi's commentary on it, we are one hundred percent sure that the author of this treatise was Ulugbek. This is evidenced by Ulugbek's words here. Part of this treatise in Birjandi's book is published in Russian translation.

In the city of Birjandi there is a fragment of a lost treatise of Ulugh Beg, and since it is entirely connected with this place of Zij, a complete translation of the fragment with commentary is presented here. This passage contains examples of highlylevel computing technologies typical of Ulugbek's scientific school.

"Since the tables and actions of Ziji Koragonia are based on the table of sines, here we proceed to calculate the number of sines.

Rules for calculating sines

First rule: Maternal sinuses or so-called "head sinuses" about the method of calculating sinuses.

These are the sine of a quadrant (circle), the sine of a sixth, the sine of an eighth, and the sine of half a tenth.[3]

At first people identified the vataras of these two arches and divided them into two. Until these sinuses were found, he used this method, which did not require vataras.

As for the sine of the quadrant of the circle, there is the sinus $90°$ – this is the semi-diameter of the circle. There is no need to calculate it anymore.

The sine of one-sixth of a circle, that is $60°$, the sine of half the square of one-third of a circle. In the 11th sentence of the 13th book of Euclid's "Elements" it is proved that the quadrant of the third circle is equal to three times the quadrant of the semi-diameter. From the 4th sentence of the 2nd book of "Elements" the quadrant of half a line is equal to a quarter of the quadrant of this line. One-third of a circle is equal to three-quarters of the semi-diameter of a quadrant. The quadrant of half a diameter is equal to one multiplied by two.

Three quarters of them are 45, collected once. We extract the root of this. $51^p 57' 41'' 29''' 13^{IV} 58^V 58^{VI}$there will be an event. And this (circle) is the sine of one sixth.

As for the sinus 45° one eighth of the circumference, then from the sentence "Bride" it is known that the square of the diameter is twice as big as the square of the square of the quadrant. From the 4th sentence of the 2nd book "Bases" it is known that the square of the circle (quadrant) is half the volume, that is, one eighth of the circle is the square of the sine, half the square of the semi-diameter.

Half a square of half a diameter is raised $30°$ once. The root of this $42^P 25' 35'' 3''' 53^{IV} 3^V 4^{VI}$. This is the sine 45°. As for the sine 18°of one-tenth of half the circumference, in the 12th sentence of the 13th book of the "Bases" it is proved that they lie on one continuous line, and to this line (the intersection) of the mouth and het are proportional, and the greater is the watari of one-sixth of the circle. In the 5th sentence of this book it is proved that the 1st part of any line divided by the mean and external ratio is equal to the square of the sum of five times the smaller part and the greater part of the half-square. The square of half a line is equal to a quarter of the square of this line. The whole and the greater part are equal to the square of the sum of the halves. A circle –is one-sixth of the square of half a square raised once $15°$. This will be a quarter with the whole $18' 45^P$ part. We get the root from this: $33^P 32' 27'' 40''' 14^{IV} 49^V 33^{VI}$ it is generated. From here we subtract a quarter of half the diameter, that is, from the 15 detail. $18^P 31' 27'' 40''' 14^{IV} 49^V 33^{VI}$ remains. This is the sine of half a tenth.

As for the definition of the sine of one sixth of a circle, according to the proof in the 15th sentence of the 4th book of the “Fundamentalsы» the diameter of one sixth of a circle is equal to half of its $30°$ diameter. The circumference is one sixth of a half, that is, a quarter of the diameter of the sine, which is equal to 30 parts. As for the definition of the sine of one tenth of a circle, that is, half the diameter of one fifth of a circle, then the perpendicular drawn from the center of the circle to the diameter of one fifth, as proven in the 1st sentence of the 4th book of the "Bases", divides this fifth of the diameter equally. According to the sentence "Bride", the square of the semi-diameter is equal to the sum of the square of the perpendicular and the square of one fifth of the length. To the sine of one tenth, that is, to half the square of the circle, we add a quarter of the diameter, that is, 30.

$42^{P}32'27''40'''14^{IV}49^{V}33^{VI}$ is formed. It will $39^{I}16^{P}13'50''7'''24^{IV}45^{V}58^{VI}$be squared. Subtract this square from the square of half the diameter. One fifth of a circle is half a $35^{P}16'1''36'''52^{IV}10^{V}57^{VI}$ square. This circle is the sine $36°$ of one tenth.

The perpendicular drawn from the center of the circle to the point of one-fifth is the sine of this arc. To prove this, let us draw a semicircle ABC with center D and diameter ADC; Let BC be the base of one-fifth circle, and AB the base of one-fifth and one-tenth circle. (Fig. 2)

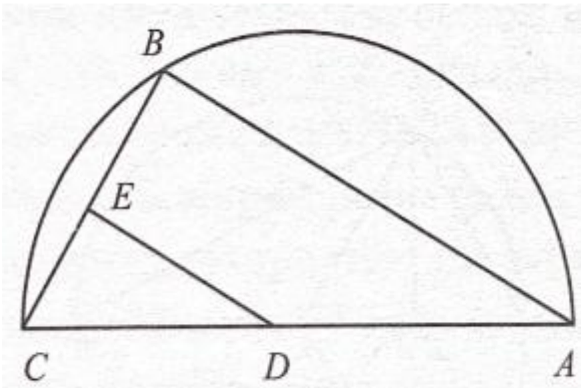


Fig. 2

From the center D we draw perpendiculars BC and DE; which falls on the middle of BC. In triangles ABC and DEC angles B and E are right; Proof of the correctness of angle E. A B is intended for a semicircle. Angle C is common to both. The remaining two angles BAC and EDC will be equal. According to the 4th sentence of the 6th book of the "Bases" this is like the ratio of AB and DE. And DE is one tenth of the circle AB and half the sine of half of one tenth. The value of DE $48^{P}32'27''40'''14^{IV}49^{V}33^{VI}$ is the sine of the desired arc $54°$.

The second sine is the sine of $72°$ one fifth of the circle.
In the 12th sentence of the 14th book of Euclid's "Elements" it is proved that the square of the semi-diameter of the square of the semi-diameter of the square of the semi-diameter of a pentagonal angle inscribed in a circle with a square of the fifth circle is equal to five times the square of the semi-diameter. The size of the angle of a regular pentagon is equal to two-fifths of the circumference.

The square of half the diameter plus a quarter of this square is equal to the sum of half the square of the base of a regular pentagon, that is, the square of one-tenth of the sine of the circle, and half the square of the square of the angle of a regular pentagon. The square of the semi-diameter is equal to the square $1''15'$ of this square, raised once. The circumference is equal to one tenth of the square of the sine, that is, we subtract $20^{I}43^{P}46'9''52'''35^{IV}14^{V}2^{VI}$ from this. The square of half the angle of the regular pentagon, that is, $54^{I}16^{P}13'50''7'''24^{IV}45^{V}58^{VI}$remains; this will be $57^{P}3'48''12'''27^{IV}3^{V}5^{VI}$ the root. And this is the sine $72°$.

The third sine is $22°30'$ sine of one eighth of half the circumference, i.e. a minute. Subtract the sine of one eighth from half the diameter. Multiply the difference by a quarter of the diameter. The root (circumference) of the product is the sine of one eighth of the half. To prove this, let us draw a circle ABCD with center E. (Fig. 3)

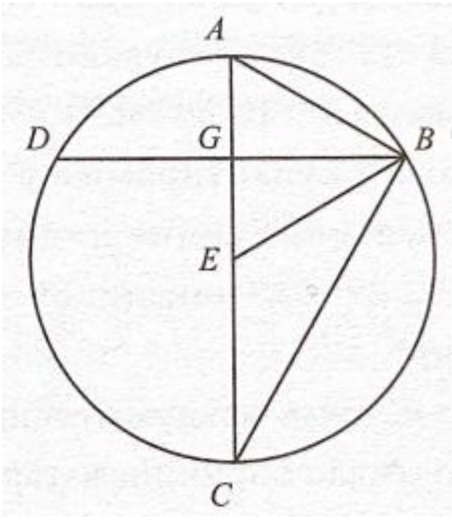


Figure 3.

Let us skip BD and divide it equally at point G. At this point we draw a perpendicular GA to it and continue it to A. We pass lines BA, BE, BC. Since the arc BAD is divided in half at a quarter and point A, then according to the 32nd sentence of the 1st book of the "Bases" the angle EBG is equal to half of the right angle. BG is equal to GE according to the 6th sentence of the book. Subtract BG - the sine of one eighth of the circle from AE, leaving AG. In triangle CBA the angle B is right, since it rests on a semicircle. BG (section) is perpendicular to AC.

"According to the 8th sentence of the 6th book of the "Basicsy", when AG is multiplied by AC, rectangle AB is equal to a square.

Since the square of half a line is a quarter of the square of the diameter of interest AC, multiplied by a quarter (multiplied) by AB, the square of one eighth of a circle. This is desirable.

For calculation the circle will be $42^{P}25'35''3'''53^{IV}3^{V}4^{VI}$ sine of one eighth. Subtract it from its half diameter. $17^{P}34'24''56'''6^{IV}56^{V}58^{VI}$ remains. Multiply this by a quarter of the diameter, that is, by 30 parts, and we get $8^{I}7^{P}12'28''3'''28^{IV}29^{V}0^{VI}$. Its root, that is, AB, will be half of the $22^{P}57'39''37'''16^{IV}59^{V}26^{VI}$straight line. This is $22°30'$ the sine of one eighth of the half circle.

The fourth sine - $15°$ is the sine of a quarter of a sixth circle. To prove this, let us assume that BD is one sixth, that is, half the diameter of the circle. In triangle EBG, G is a right angle. According to the condition of the "Bride" sentence, the square of the semi-diameter BE is equal to the sum of the squares of GE. And ABC is a quarter of the diameter, then the square of GE is a quarter of the square of the semi-diameter. First, we prove the square root of a quarter of the semi-diameter - the sine of one sixth of the circle. If we subtract the root of the semi-diameter AE, that is, EG, from its root, we are left with AG. If we multiply AG by AC, we get the square of AB. If we multiply AC by a quarter of AC, we get the square of half AB.

The calculation $51^{P}57'41''29'''13^{IV}58^{V}58^{VI}$ will be sine of one sixth of the circle. Subtract it from half the diameter. $8^{P}2'18''30'''46^{IV}1^{V}2^{VI}$ remains. Multiply it by a quarter of the diameter. $4'1^{P}9'15''23'''0^{IV}31^{V}0^{VI}$is formed. We get the root of this. $15^{P}31'44''54'''49^{IV}29^{V}12^{VI}$comes out. And this is the sine $15°$. This is known from calculation and proof that any line from the center, perpendicular to the base of the sixth circle, is equal to the sine of the sixth circle.

Second rule. Half an arc whose sine is known to determine the sine.

Subtract the square of the sine from the square of half the diameter and subtract the root of the remainder from half the diameter. Multiply the remainder by a quarter of the diameter. The root of the product is any sine. To prove this, draw a semicircle BAC at the center D and diameter BDC, and the AC sine is some arc. (Fig. 4)

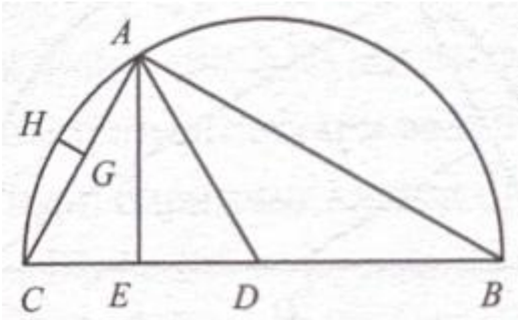


Figure 4.

Draw a perpendicular AE from point A to BC. This will be the sine of arc AC. Draw arcs AC, AB and AD. Angle BAC is right because it forms a semicircle.

"According to the 8th sentence of the 6th book of the "Basicsы», base AC is equal to right quadrilateral CB and CE and CB. According to the 17th proposition of this book. In triangle AED angle Y is right. According to proposition «Bride», square of semi-diameter AD is equal to sum of squares of AE and DE. From this DE is known. let us subtract it from semi-diameter BC, YC remains; therefore, square CE to CB is equal to square AC. Right angle CE to quarter (product) CB is equal to quarter of square AC, that is square AC, that is half AC.

AG (line) – the sine of AH is known, that is, the sine of AC of half the arc. An example of this would be the sine 18°: The area of this $18^{P}32'27''40'''14^{IV}49^{V}33^{VI}$. Subtract this from the square of half the diameter, and this will be: $5'43^{P}46'9''52'''35^{IV}12^{V}59^{VI}$. Multiply this by a quarter of the diameter, $57^{P}3'48''12'''27^{IV}8^{V}8^{VI}$ and you get: $1'28^{P}7'53''46'''28^{IV}27^{V}$.
We get the root, $9^{P}23'9''50'''40^{IV}12^{V}50^{VI}$ it turned out. This is the sine 9° of the degree.

Third rule: Sine is known or doubled about the definition of sine

Divide the square of the known sine by a quarter of the diameter and subtract the quotient from the diameter. The remaining difference is multiplied by the divisor. Then the root of the product is taken: this will be the desired sine.[3]

Proof: In the previous figure (given in figure 4) CG (line) is known – sine CH. It will double. We will get AC vathar. It is known that the square of this is equal to the right quadrangle AC to CE. Dividing it by BC, we get EC. It is seen that the square EC^2 is equal to the right rectangle BE to EC. If this quarter of the square, that is, the square of this sine AG, is divided by a quarter of the diameter, the division will form EC. If we subtract it from the diameter, BE remains. In the 8th sentence of the 6th book of the "Bases" it is proved that (multiplication) of BE by EC is equal to the square of AE.

AE –its root will be the sine of the doubled AH arc AC. An example of this would be: $15^P 31' 44'' 54''' \, 49^{IV} 29^V 12^{VI}$.The area of this $3' 1^P 9' 15'' 23''' 0^{IV} 31^V 0^{VI}$. It is divided by 30 - a quarter of the diameter, becomes division $8^P 2' 18'' 30''' 46^{IV} 1^V 2^{VI}$. Subtract the division from the diameter. $1' 57^P 57' 41'' 29''' 53^{IV} 18^V 58^{VI}$remains. Multiplying this value by this division will give the level, increased once $15'$. The root of this will be 30 parts. This is the sine 30°.

Rule 4: Two Separate Sine Arcs on the definition of the sine of the sum

They are the sine of each multiplied by the sine of the complement of the other. The sum of the two products is the sine of the sum of these two arcs. This is proved in Tahrir Almajisti by Nasiruddin Tusi. In order not to refer to this book (Almajisti), this proof is corrected and explained. From the center E, draw a semicircle ABCD with a diameter AED. Let AB, BC be two different arcs. (Fig. 5)

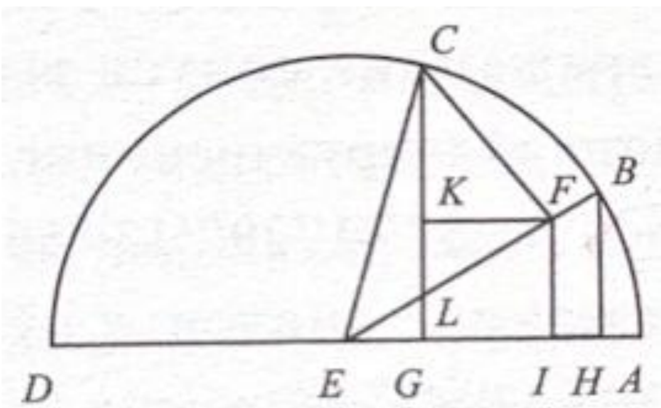


Figure 5.

From point B draw perpendicular BH to AD, which will be the sine of arc AB. From point C draw CG perpendicular to AD. This will be the sine of arc AC. Connect E with I and E with C. From point C draw perpendicular CF to BE, which will be the sine of arc BC, will be the sine. Since IN,CF are two known sines, the sine of CG is determined from them.

To find it, we draw two perpendicularsFI and FK from point F to AE and CG. Since arcs AB and AC are not less than a quadrant, CG and BE intersect at point L. In triangle CEF, F is a right angle; The sum of angles FCF and FYC is also a right angle. Angle FEC is equal to arc BC. CF is its sine. Angle FCY is equal to the complement of arc CB. FE is the sine of this complement. It follows that angle CBE is equal to the complement of arc AB. And EH is the sine of its complement.

According to the 4th proposition of the 6th book of the “Fundamentals”, triangles BHE, FIE are similar due to the equality of angles.

KLF since the angle F in the triangle is right, then due to the perpendicular CL dropped to FK, according to the 8th sentence of the 6th book of the "Basics", two similar angles BHE, FIE are formed. In triangles FLK and ELG, angles K and G are right angles, at the point L they are vertical. These two angles are similar according to the 4th sentence of this book "Basics". Thus, triangle LEG is similar to triangles BFH, FEI. According to the 21st sentence of the book "Basics", triangle CFD is similar to these triangles. BE is a semi-diameter equal to 60 parts, and its ratio to FE is similar to the ratio of IN to FI. If you multiply the sine of arc AB by the additional sine FE of arc BC, the product FI is formed. Because GKIF is a rectangle. In sentence 34 of the 1st book of the "Basics", the line FI is equal to KG.

The ratio of the sine of the arc complementary to EH to EH is the ratio of CF to CK. CK is found by this method. If it is added to KG, the sine of CA is CG.

The fifth rule. Sines is finding the sine of the difference of two given arcs.

We multiply the sine of each arc by the sine of its other complement, the difference of the two products is the sine of the difference of the arcs. "Takriri Alisti" by Nasiruddin Tusi is quoted in "Manesty". The result is a semicircle ABCD: AD is its semidiameter, and BH, CC are perpendiculars, BE and the semidiameters CE are shown in Fig. 6. From point B draw a perpendicular YC BF. Let us draw perpendiculars HT and BK. In triangles EIH, EKG, angle E is common, and angles G, I are right angles, therefore angle H is equal to angle C according to the 32nd sentence of the 1st book of "Bases". Thus, these two triangles are similar. The ratio of the semidiameter YC to CG is the ratio of EH to

EI. Let us multiply the sine of arc AC by CG by EH, that is, by the sine of the complement of AB. HI is formed. (Fig. 6)

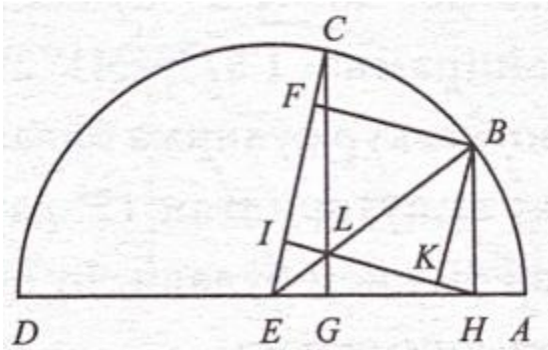


Figure 6.

In triangles BHK, GIL, angles K and I are right angles, interior angles BHK and GLI are equal, since BH and CG are parallel. The other two angles B and C are equal. So these two triangles are similar. Also triangles GLI and CEG are similar, since they have a common angle C, and angles I and G are right angles. Triangle BHK is similar to triangle CEG to EC, that is, the ratio of 60 to EG is the ratio of BH to HK. If the sine of arc AB is multiplied by BH, or the sine of the complement of arc AC is multiplied by EG, you get HK. Subtract it from HI, leaving IK. It is equal to GF, which is the sine of arc BC. This arc is the difference of these two arcs.

Rule Six: Sine is the definition of the axis of a given arc.

We find the root by subtracting the square of the known sine from the square of the half-diameter. If the arc is less than the square, we subtract this root from half the diameter, otherwise we add it. The difference or sum will be the axis of this arc. [3]

To prove this, let us draw a semicircle ABC with diameter ADC from the center D. (Fig. 7)

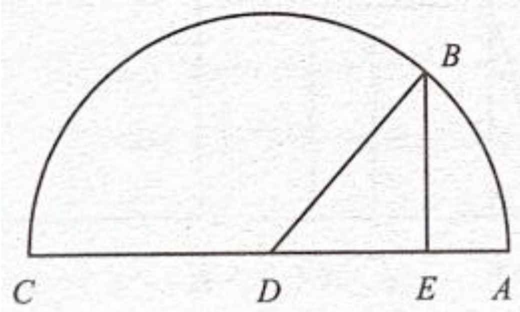


Figure 7.

Let us assume that the arc of the required axis is equal to AB or BC, the sine of which - BE is known perpendicularly. We will give half the diameter BD. At the angle EBD, the angle E is right. According to the sentence "Bride", the square BD is equal to the sum of the squares of BE and ED. If we subtract the square of the sine of BE from the semi-diameter BD, we will have ED, that is, the axis of the arc AB. If we add it to DC, that is, the semi-diameter EC, that is, the axis of the arc CB is formed.

To thisexample: we define an $72°$ arc or its $108°$complementary arc axis. The sine of the first arc is equal to $57^P 3' 48'' 12''' 27^{IV} 3^V 15^{VI}$ whose square is$54' 16^P 13' 50'' 7''' 25^{IV} 45^V 58^{VI}$. Subtract this from the square of the semi-diameter, which is equal to one times two: the difference remains $5' 43^P 46' 9'' 52''' 34^{IV} 14^V 2^{VI}$. The root of this number is $18^P 32' 27'' 40''' 14^{IV} 49^V 33^{VI}$. Subtract this from 60, that is, from half the diameter, and we are left with $41^P 27' 32'' 19''' 45^{IV} 10^V 27^{VI}$. This is $72°$the axis. This is $108°$ the result of the semi-diameter of the root $78^P 32' 27'' 40''' 14^{IV} 49^V 33^{VI}$. The sine of many arcs can be determined. Since the arc of the number can be determined by these rules 3° , the sine of any other arc greater than can also be determined 3°. But some arcs are such that their sines cannot be determined by these rules: only when determining the sine 1°can we assume that the sine of some arc is given. From this, both required sines are formed. If the sine 1°of is known, all the other sines can be found.

The ancients did not find a way to determine the sine 1°. Nasiruddin Tusi in his Tahriri Almajisti says: "It is not possible to determine the watar of a third of a known arc using a broken line."

Let's say,an arc of arcs 6° is known. If the power of one third of it is determined, that is 2°, then the sine 1° is known, which is half the power of the arc 2°. Ancient scientists roughly determined the sine 1° and based their table of sines on it.

Maulana Ghiyasiddin Jamsheed Koshi, the most virtuous of engineers,- may his fate be blessed, - this is one of the actions of a person of subtle nature, -

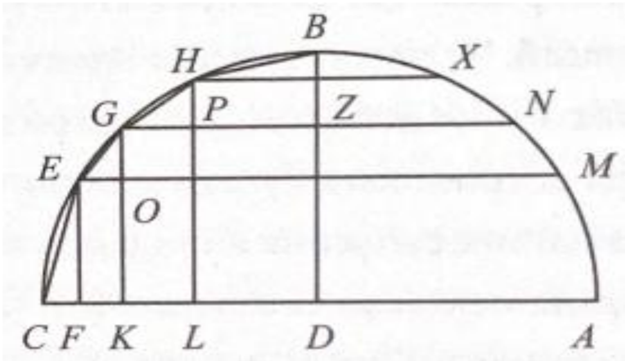
he began astronomical observations in Samarkand, was inspired by the definition of sine 1° and proposed a special treatise on this subject.

The author of Ziji Koragoni, may God bless him, tells of another method of determining the sine 1° and writes another treatise on it.

We will start with an approximate method for finding the sine 1° and present two proof methods.

Hypothesis Let's assume that there are unequal arcs in a circle. If their difference is equal, then the difference of their sines is also unequal, and the sine of the greater difference is less.

Ndraw a semicircle ABC with diameter ADC from the center D. (Fig. 8)



8 – picture.

Let us draw perpendiculars AC and BD, divide each of the quadrants AB, CD into equal parts at points M, N, X and E, G, H. We connect the midpoints of these parts with straight lines and pass wires BH, HG, GE, EC. Then from points H, G, E we draw perpendiculars HL, GK, EF to AC. Then BD is the sine of arc BC, HL is the sine of arc CH, GK is the sine of arc, and EF is the sine of arc EC.

BG, XPG, GOE, and in triangles EFC angles Z, P, O, F are right angles and their arcs are equal. Prove that the ratios of the sines of the angles of a triangle to the corresponding sides are equal.

B angle HX subtends arc BX, angle HGN subtends arc BX, angle HGN subtends arc HXN, angle GEM subtends arc GNM, and angle ECA subtends arc EMA. Angle H is less than angle G, which is less than angle E, which is less than angle C. The ratio of the greatest sine to the corresponding angles BH, HG, EG, and EC is equal to the ratio of the sine of angle H to BZ, the sine of angle G to HP, and the sine of angle C to EF. All these angles are equal, as are their sines, for each of these angles is less than the other. So that BP is less than XP, XP is less than GO, and GO is less.

This After the introduction, the sine of three different arcs 1° is formed according to the rules. But using the arc from and these sines means defining the sine 1°.

First we define the sine$18°$ and sine $15°$. We determine the sine of one and a half degrees using the 5th rule and sine. Then sine $45°$ using $0^P47'7''21'''9^{IV}30^V$ the second rule and this sine.

Using the same rule and sine 18°, we determine the sine 9° . Then we find from this sine the sine of four and a half degrees, and from this sine - the sine of one and a half degrees . This will be $1^P10'40''52'''34^{IV}18^V$.

Similarly, we find the sine of half a sine$15°$ and so on until we find the sine of a degree less than half a quarter; this sine is $0^P58'54''7'''59^{IV}1^V$.

Now if we determine the required sine, we will draw the quadrant AB. LetD is its center, and AD and BD are its semi-diameters. (Fig. 9)

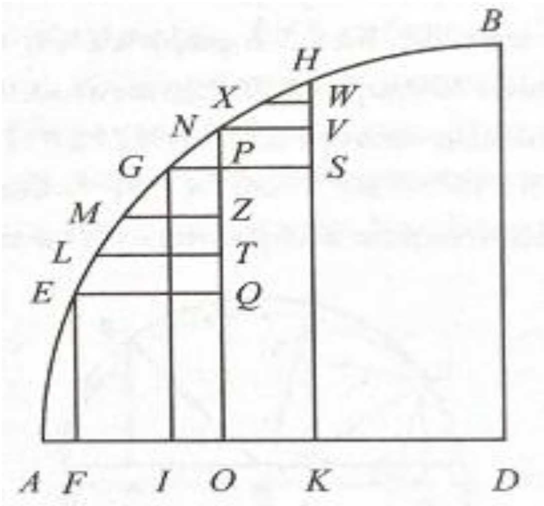


Figure 9.

Let us assume that AE, AG, AH are three arcs whose sines EF, GC and HK are known. Since AE is 45 minutes, AC -$56'15''$is an arc, and AH is one degree 7 minutes 30 seconds, each of the arcs EG and GH is equal to 11 minutes 15 seconds. We divide each of these equal arcs into three equal parts at points N, X and L, M. Then the arc AN is equal to one degree. And the perpendicular NO is its sine, which we must find. We draw perpendiculars EQ, LT, MZ, GP, NV, XW. Then it is clear that PO is equal to GJ, and QO is equal to EF. The excess of GD over EF is PQ, which is divided into three different parts. According to the introduction, this is the smallest of the segments - PS, PQ is one third greater than PS. And PS is greater than PH. The sum of the line PQ, that is, the sine of the arc GD – AG with PQ is greater than the line NO. The excess of NK over GD, equal to the line NO, is divided into three different parts. The line CB, the largest of which is equal to HP. One third of HS is less than NP. The sum of the line PO with one third of GC is less than NO. One of these two quantities is greater than NO, and the other is less than it, and the size of NO is approximately determined.

Taking this into account. The GI line is equal to PO and $0^P 47'7''21'''9^{IV}30^V$. The excess of the first over the second, the PQ line, is $0^P 11'46'''49^{IV}31^V$. Add this to the PO line $1^P 2'49''43'''35^{IV}31^V$, making the NO line less than this sum.[3]

The same can be said about the HK line, it will be $1^P 10'40''52'''34^{IV}18^V$. . Its excess over GI is HS, and its sum is $0^P 3'59''34'''51^{IV}39^V$. Add this to the order line. It forms $1^P 2'49''42'''50^{IV}40^V$.

Thus, the sine 1° is smaller $1^P 2'49''43'''35^{IV}31^V$ and larger$1^P 2'49''42'''50^{IV}40^V$. The difference between them is equal to $0'''44^{IV}51^V$. We add half to the smaller difference, or subtract it from the larger one and get the approximate value of the sine 1°. Amounts to $1^P 2'49''43'''13^{IV}5^V 30^{VI}$.

This An approximate method was carried out by the author of Ziji Khaqani and is described in this work. Another approximate method was used by Tusi, Qaddasa Allah Markadihi, and is described in Tahrir Almajisti.

Introduction information

The ratio of a large arc to a small arc is greater than the ratio of the sine of the first to the sine of the second. To prove this, draw an arc ABC from the center E, let AE, CE be its semi-diameters, smaller than a quadrant. Divide it into two different parts at point B. Passing the chord AB, continue it until it meets the continuation of the semi-diameter FC at point F. Angles AEC, BAE are acute, from points B and A draw perpendiculars CE, BH and AC. The ratio of arc AC to arc BC is greater than the ratio of the sine of AC to the sine of BH. The ratio of sector AEB to sector BEC is greater than the ratio of triangle AEB to triangle

BEF. Some scientists consider this statement indisputably obvious. Sector ABE is greater than triangle ABE. Since sector AEB is greater than sector BEC, then according to the 8th proposition of the fifth book of Euclid's Principles, AEB is greater than sector BEC of the triangle. The ratio of triangle AEC to sector BEC is less than the ratio of the same triangle to triangle BEF. The ratio of sector AEB to sector BEC is greater than the ratio of triangle AEB to triangle BEF, because that which is greater than the greatest of things is greater than all else. According to proposition 1 of book 6 of the Principles, the ratio of triangle AEB to triangle BEF is the same as the ratio of AB to BF. The ratio of sectors to sectors is like the ratio of their arcs. Some consider this statement self-evident. If the semidiameter of a sector is multiplied by its arc, the surface of the sector is obtained. The ratio of the product to one of the factors is the same as the ratio of the other factor to unity. Therefore, the ratio of one of the sectors to half its arc is the same as the ratio of half the diameter. The ratio of sector to sector is like the ratio of arc to arc, because the ratio of multiples of the same thing is always the ratio of halves. [3]

The ratio of arc BC to arc AB is greater than the ratio of AB to BF, according to proposition 12 of book 5 of the Elements. By construction of proportions, the ratio of arc AC to arc BC is greater than the ratio of AF to BF. Euclid's Elements does not describe the construction of such proportions. However, Nasiruddin Tusi explained it in the introduction to The Book of the Sphere and Cylinder. In triangles AGF and BPF, angle F is common, angles G and H are right angles, and the other two angles are equal. According to proposition 4 of book 6 of the Elements, the ratio of AF to BF is the same as the ratio of AG to BH. From the equality, the ratio of arc AC to arc BC is greater than the ratio of sine AC to sine BH. Let arc AC be equal to one degree and one eighth. (Figure 10)

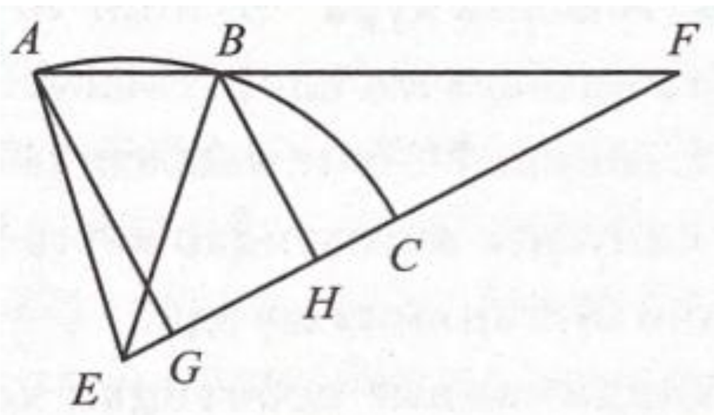


Figure 10.

Its sine will be AG $1^P10'40''52'''34^{IV}18^V$. The arc to our erie is one degree. The ratio of the arc AC to the arc BC is greater than the ratio of AB to BH, and now the arc AC is equal to one eighth of the arc BC. Therefore BH is greater than nine eighths of the sine of AG. Let us take one ninth of AG: $0^P7'51''12'''30^{IV}26^V40^{VI}$will be. Subtract this from the sine of AC. $1^P2'49''40'''3^{IV}33^V9^{VI}$ remains. The sine of a degree is greater than this value.

Suppose that the arc AC is 1° seven-eighths and a half degrees of the arc CB. Then the ratio of the arc AC to the arc BC is one-half of one-eighth. The sine of AC is less than the line BP and is one-eighth of it. The line BH is equal to $0^P58'54''7'''59^{IV}1^V$. One-half of one-eighth of the sum is $0^P3'55''36'''31^{IV}56^V4^{VI}$. Add this to the line BH to get$1^P2'49''44'''30^{IV}57^V4^{VI}$. the line AG, which is the sine 1° less than this sum. We get the difference of these two sines, which is $4'''27^{IV}23^V44^{VI}$; one-half of this is $2'''13^{IV}41^V52^{VI}$. Adding this sum to the small sine 1°, or subtracting it from the large sine, sine1° equals $1^p2'49''42'''17^{IV}15^V12^{VI}$.

Kusher (ibn Labban) is like thisfound the sine of a degree in his "Jami Zij". Having found a method of proof, he found that the first method was closer to the truth than the second.

Based on the second rule, we calculate the sine 15°. Let's calculate the sine of the halves, let one of these halves be an arc $0^056'15''$. The sine of this arc is $0^p58'54''8'''0^{IV}20^V24^{VI}$, the second arc is $0^054'3''45'''$, the sine of this arc is $0^p54'43''34'''16^{IV}10^V35^{VI}$, the third arc is $0^03'30''56'''15^{IV}$, the sine of this arc is $0^p3'40''33'''36^{IV}22^V18^{VI}$. Add the first and third arcs, we get $0^059'45''56'''15^{IV}$.We find the sine of this is $1^p2'34''59'''43^{IV}36^V34^{VI}$, the sine of its complement is $59^p59'27''21'''21^{IV}41^V17^{VI}$.

If we write down the second of these arcs and add to it the sum of the other two, the sum will be 1°. If we write down the sine of this arc, it will be $0^p0'54''43'''^{34^{IV}16^V10^{VI}35^{VII}}$. The sine of the complement of this written arc is $59^p59'59''59'''58^{IV}11^V34^{VI}$. Multiply this written by the sine of the sum of the arcs to get $1^p2'34''59'''43^{IV}35^V41^{VI}$. Multiply the sine of the written arc by the sine of the complement of the written arcs, we get $0^p0'54''43'''26^{IV}46^V27^{VI}$. Add the two resulting products. We get $1^p2'49''43'''10^{IV}24^V8^{VI}$. This is the sine of 1°.

The difference between this sine and the previously found sine 1° consists of 50 integrals and subsequent fractions. After the approximate methods of calculating the sine have become clear, we will now give a proof of the method of calculating it. There are two methods of proof here: one is the method given by Sultan Khandasi Ghiyasiddin Jamshid (Koshi), and the other is the method explained by the author, the martyred sultan. We will summarize both of these methods.

Let's assumein the first Cauchy method: let the arc ABCD be equal to 6°. Divide it into equal thirds at points B and C. Draw lines AB, AC, AD, BC, BD and CD. (Figure 11)

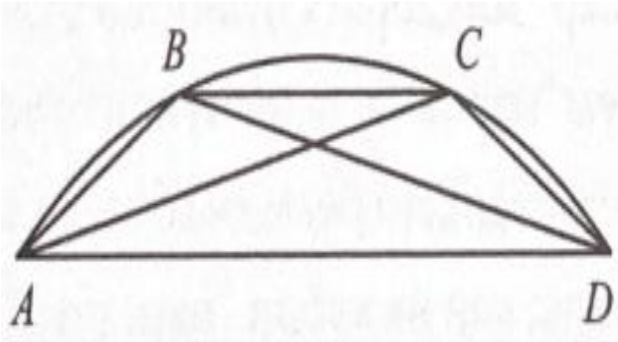


Fig. 11.

Fromcalculated above sine 15° and sine 18° we find 3°; this will be $3^p 8' 24'' 33''' 59^{IV} 34^{V} 28^{VI} 14^{VII} 50^{VIII}$ somin . Doubling this, we find the square AD. $6^p 16' 49'' 7''' 59^{IV} 8^{V} 56^{VI} 22^{VII} 40^{VIII}$. Here it is necessary to determine the length of the arc AB, which is equal to 2°.

"As he proved in the second sentence of the first book of the Almajistiya, in any rectangle inscribed in a circle, the sum of the two rectangles formed by two opposite sides is equal to the rectanglean area formed by the diagonals of a rectangle.

It is known thatAB and CD are equal, AC and BD are also equal. The product of AB and CD is the "square", which algebra and calculus call "mole". The unknown BC multiplied by AD is equal to the $6^p 16' 49'' 7''' 59^{IV} 8^{V} 56^{VI} 29^{VII} 40^{VIII}$ "object". The sum of these two quantities is equal to the quadrant AC, that is, by the condition of the first premise, the rectangle AC and BD. The square AB is equal to the rectangle of half the diameter, that is, sixty, and the excess of the diameter of the complement AC to the semicircle, and the latter corresponds to the condition of introduction. Since the arc AC is twice as large as the arc AB, the "square" is divided into sixty parts, then the division is divided into sixtieths of the "square". This will be the excess of the diameter of the filler. If we subtract this excess from the diameter, that is, 120, then the power of the component alternating current, that is, the "square" part of 60, will remain 120.

Research in algebra and almukobale showed that if you want to find the square of a difference, first multiply the denominator and the denominator by themselves, then add them together. Then subtract twice the product of the denominator from the sum.

As for the definition of the additional variable, first we square 120, which is 14400. If we raise the rank, it becomes four, raised twice, which is four squares. The square of one-sixth of a square is equal to three thousand six hundredths of a square, because the product of the parts of a square is the parts of a square. 120 divided by 60 and squared twice is four squared. The square of the power of the AC filler is equal to four times the diameter of the part twice, 3600th m from four "non-square" "square - square". If we subtract the square of the base of the arc from the square of the diameter, we are left with the square of the base of the semicircle. From these two chords with a diameter, a right triangle is formed, because the chord of this right angle is diametrical. As he proved in the third book of the "Bases", the angle subtended by the semicircle is right. According to the proposition of "Kelin", the square of the base of a right angle is equal to the sum of the squares of its two other sides.

Algebra and Almuqabala also established that if a number is subtracted from another number, then the decrement is subtracted from it, then the subtrahend is added to the decrement, and this number decreases. The square of the diameter is equal to four "squares" and we subtract four "squares", subtract from the subtraction and add to the subtraction, that is, to four "squares".There are 60 squares left.

Subtract the square of the volume of the alternating current filler from the square of this diameter. Without one part of the 3600th part "Square-square" remains the square of the alternating current power. The rectangle formed by AB and CD, where the square of AC is the "square", is the "object" $6^{p}16'49''7'''59^{IV}8^{V}56^{VI}29^{VII}40^{VIII}$. Four squares less one part of 3600 "square-square" are equal to this sum "square". If the above is subtracted from the first part of the equation and added to the second side, then four squares will be equal to one square, $6^{p}16'49''7'''59^{IV}8^{V}56^{VI}29^{VII}40^{VIII}$ "object", and "square-squared" 3600 - m square. This operation is called "algebraic" completion.

What is common to both parts of the equation is discarded and what remains is three "squares" equal to $6^{p}16'49''75'''59^{IV}8^{V}56^{VI}29^{VII}40^{VIII}$ "object" and one "square-square" equal to one part of 3600. This action is called "muqabala".

Among the rules of "algebra and almucobala"of this science, the following can be distinguished: if there is a fraction in one part of the equation, then this fraction is supplemented to a whole, and a number equal to this number is added to the other side. This process is called "filling". If in this example the fraction is "filled", then 18100 "squared" or three "squared" raised twice are equal to

$6^{p}16'49''75'''59^{IV}8^{V}56^{VI}29^{VII}40^{VIII}$ "object" and one squared, because three times 3600 - 18100 will be.

If the digits of this number are multiplied by 3600, each number will double.For example, 3600 somin is 60 sobia, that is, one sodis.

Science has once again established that the numbers "object", "square", "cube", "square - square" and other genera are in the same ratio - in the ratio of one to "object". For example, the ratio of "object" to "square", "square" to "cube" and "cube" to "square-square" is as follows.

If we write the genders as sides, it does not defeat our purpose. If the two genders are in this position, then three "objects" multiplied by two are equal to divided by a prime number and a "cube". After these actions, this problem is reduced to the state when "objects" are equal to $6^{p}16'49''75'''59^{IV}8^{V}56^{VI}29^{VII}40^{VIII}$, a number and a "cube". This problem is not included in the famous six problems of algebra and the subject of Almuqabala. But if a number and a "cube" are divided by the quantity "object", then the quotient will be that unknown "object". Because the quotient in dividing parts of a divisor is one of the divisors. So, when dividing a number and a cube by the quantity "object", the quotient is part of the divisor, that is, the "object".

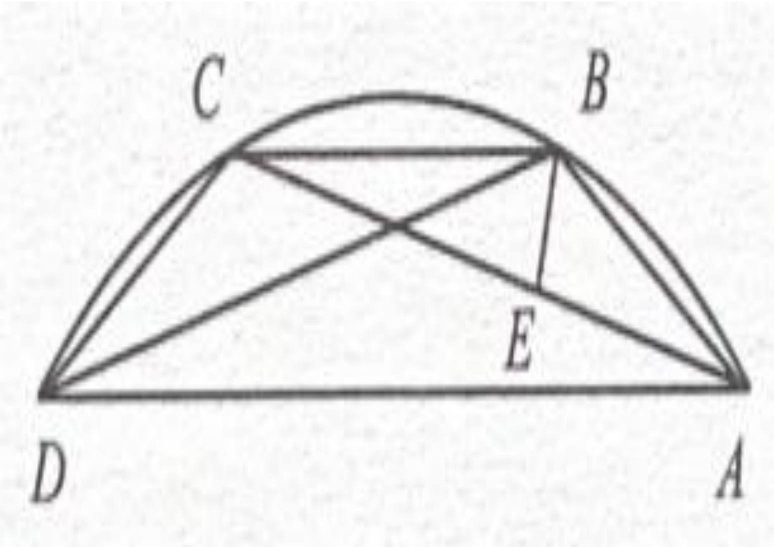
Cube For the case of division, an excellent method has been invented, which consists of the following. First, part of the number is divided by the quantity of the "object" and the cube of the division is added to the remaining number. The remainder of the sum is divided by the quantity of the "object" and from this cube the cube of both denominators is subtracted and the cube of both denominators is taken. Then the cube of the first division is subtracted from the cube and the remainder is added to the total number.

The other part of the second sum is divided by the quantity ""object" and this sum is the cube of the division. Then the excess of the last cube over the cube of the two previous divisions is taken. And the second sum is added to the remainder. After that, the remainder of the third sum is divided by the quantity "object". This continues until the end of the process, until the value of the divisor becomes very small. Then the action ends. In the text of the manuscript, some of the numbers in these actions are indicated in the table, some are omitted. In practice, based on the original numbers, the table was completely calculated. The division in the last line of the table, that is,

$1^{p}2'49''43'''11^{IV}44^{VI}16^{VII}27^{VIII}17^{IX}$

$2^{p}5'39''26'''22^{IV}29^{V}28^{VI}32^{VII}54^{VIII}33^{IX}$ tosia. If we divide it by two, we get the result. This is the sine 1° of this.

Let's look at another way. From point B draw perpendiculars AC and BE. (Figure 12)



12 – figure.

Table

(в. 51а) Биринчи рақам икки marta кўтарилган, уни 3 га икки marta кўтарилган ҳолда ажратамиз, 2 ни оламиз; унинг кубиги 8 бўлади	Кўтарилганлар	[Бутун] даражалар	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	2	3	4	5	6	7	8	9	10	11	12	13
49 га, яъни қисмларга қўшамиз, чиқади	15	57	7	59	8	56	29	40				
Биз уни 3 га ажратамиз, 5 ни оламиз ва у қолади.	1	57	7	59	8	56	29	40				
2 5 йиғиндининг кубини олинг, чиқади		9	2	32	5							
Бундан 2 кубини айирамиз, яъни 8 қолади		1	2.	32	5							
Буни қолган сонга қўшамиз, оламиз	1	58	10	31	13	56	29	40				
Биз буни 3 га ажратамиз, биз 39 ни оламиз ва у қолади		1	10	31	13	56	29	40				
2 5 39ни кубга олиб чиқамиз, у чиқади		9	11	2	32	27	43	39				
Бундан иккинчи кубикни айирамиз, қолади			8	30	27	27	43	39				
Буни қолган сонга қўшамиз, чиқади		1	19	1	41	24	13	19				
Биз буни 3 га ажратамиз, биз 26 ни оламиз ва у қолади			1	1	41	24	13	19				
Субе [numbers] 2 5 39 26 ни олинг, бўлади		9	11	8	14	33	12	23	21	20	56	
Ундан учинчи кубни айирамиз, қолади				5	42	5	28	44	21	20	56	
Қолган сонга қўшамиз, оламиз			1	30	23	29	42	3	21	20	56	
Биз уни 3 га ажратамиз, биз 22 ни оламиз ва у қолади				1	23	29	42	3	21	20	56	
Субе [numbers] 2 5 39 26 22 ни олинг, бўлади		9	11	8	19	22	41	6	52	15	1	56
Бундан тўртинчи кубикни айирамиз, қолади					20	49	23	43	31	10	5	56
Қолган сонга қўшамиз, оламиз				1	28	19	10	46	52	15	1	56
Биз уни 3 га ажратамиз, биз 29 ни оламиз ва у қолади					1	19	10	46	52	15	1	56
Кубикни олинг 2 5 39 26 22 29, бўлади		9	11	8	19	29	2	42	1	39	50	52
Бундан бешинчи кубни айирамиз, қолади						6	21	5	9	24	48	56
Қолган сонга қўшамиз, оламиз					1	25	32	22	1	39	50	52
Биз уни 3 га ажратамиз, биз 28 ни оламиз ва у қолади						1	32	22	1	39	50	52
Кубикни олинг 2 5 39 26 22 29 28, бўлади		9	11	8	19	29	8	50	27	19	59	43
Бундан олтинчи кубикни айирамиз, қолади							5	8	25	40	8	51
Қолган сонга қўшамиз, оламиз						1	37	30	27	19	59	43
Биз уни 3 га ажратамиз, биз 32 ни оламиз ва у қолади							1	30	57	19	59	43
Нинг куб ичига 2 5 39 26 22 29 28 32 чиқайлик, у бўлади		9	11	8	19	29	9	57	28	23	37	1
Бундан еттинчи кубикни айирамиз, қолади							1	7	1	3	37	18
Қолган сонга қўшамиз, чиқади							2	37	28	23	37	1
Биз уни 3 га ажратамиз, биз 52 ни оламиз ва у қолади								1	28	23	37	1
Кубни олинг 2 5 39 26 22 29 28 32 52, бўлади		9	11	8	19	29	9	57	39	47	50	19
Ундан саккизинчи кубикни айирамиз, қолади									11	24	13	18
Қолган сонга қўшамиз, оламиз								1	39	47	50	39
Биз уни 3 га ажратамиз, биз 33 ни оламиз ва у қолади									9	47	50	39
Бу ерда биз ҳаракатларни тўхтатамиз, хусусий бўлади	2	5	39	26	22	29	28	32	52	33		

In two triangles ABE and CBE, one of the angles coming out from point E is right. "Bride" according to the Pythagorean theorem, the square AB is equal to the sum of the squares AE and EB. The square BC is equal to the sum of the squares CE and EB. Considering that AB and BC are equal. BE is the common side, therefore AE and EC are equal. From the second rule we know that if we divide the square AB by the diameter BE, we get BE. If we subtract the square

BE from the square AB, we will have square AE. It is required to determine the line AB, which is the sine of two degrees. Suppose this is an unknown. Its square will be "mole". The diameter consists of twenty parts, two of which are raised once. The square AB, that is, "mole", is divided by two, raised once, the division is half of "mole", that is, "mole" is 30 seconds. And this is the value of BE, and its square is thirty times greater than the square. Since the square AE is equal to a quarter of the square AC, the second book of Euclid's "Elements". The square AC is four squares without the second.

"According to the second form of the second book of Anmansistia, the work AC and BD, that is, the square of AC, is equal to the sum of the rectangles AB by CD and BC by AD. As calculated above, the value of AD consists $6^p16'49''7'''59^{IV}8^V56^{VI}30^{VII}$ of BC is equal to AB and consists of "thing". Multiply it by AD - $6^p16'49''7'''59^{IV}8^V56^{VI}30^{VII}$ this is "thing". Since the rectangle AB CD is also a square, AB - $6^p16'49''7'''59^{IV}8^V56^{VI}30^{VII}$ is a "square". Then it is equal to one second of "square-square" and this "thing". After the inverse addition, three squares are equal to three seconds squared, and this number is equal to something. If we take a third of both norms of the equation, then one square is equal to twenty soles of "square-square" and one third of this "thing". This is one third of $2^p5'36''22'''39^{IV}42^V58^{VI}50^{VII}$ sabia. If we reduce it once, one "thing" will be equal to 30 soles of the cube and one number $2^p5'36''22'''39^{IV}42^V58^{VI}50^{VII}$ - sobia. Done: "thing" is equal to the cube and this number. This is an unknown problem, but if we get a number, the difference of one third of which is equal to 20 seconds of the cube of this number, then this number is the desired number. To make such a number, we take the cube of one third of this number, which will be $9^p10'28''9'''8^{IV}52^V5^{VI}39^{VII}$ sobi'a. We multiply this by 20 solis: $0^p0'3''3'''42^{IV}46^V29^{VI}42^{VII}$ we get. We add this number to a third - $2^p5'39''26'''22^{IV}29^V28^{VI}32^{VII}$ it will be fruitful. And this is the number that we do, which means that this is a two-steppe vathar.

If you take its cube, multiply it by two $20'''$and add to one third of this number, you get the same number. So, it turned out that this is such a number that the cube of 20 solis is added to this number, and the desired sine is formed.

Now to define the sine 1° in the second method of proof, suppose that the arc ABCD 6° is and the center is at point F, let it be each of the arcs 2° AB, BC, CD. (Figure 13)

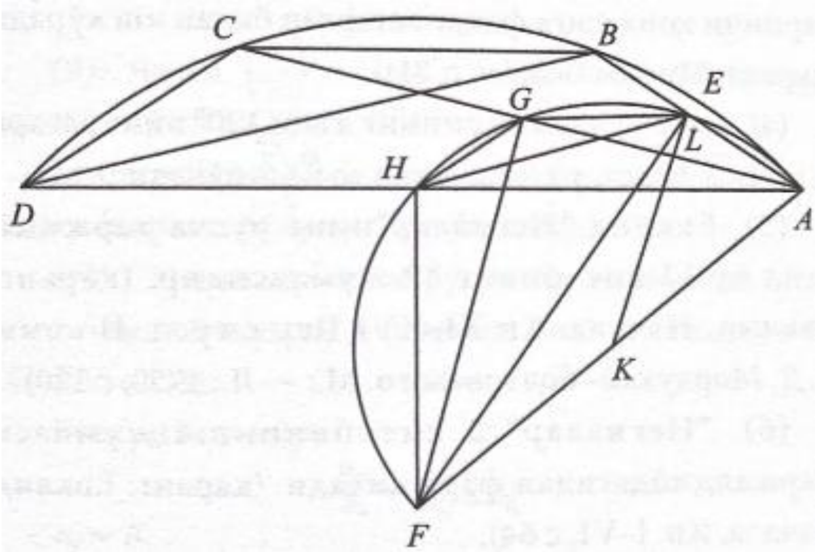


Figure 13.

AB, AC, AD, BC and carry CDs. Each of the previous three points is divided into two equal parts at points E, G and H. We pass the lines FE, FG and FH. Each of them is perpendicular to the corresponding plane, according to the third sentence of the third book of Euclid's "Bases".

ABskip the semi-diameter and divide it into two equal parts at point K. Using this point as the center, we draw a semicircle at a distance from the center. Then the angles AEF, AGF and AHF are right angles. This semicircle passes through points E, G, H according to the thirtieth converse proposition in the third book of the "Bases".

According to the first rule, the right onerectangle EH a GA, that is, square AG, the product of AE by HG is a right rectangle, that is, square AE, and the product EG AH, multiplied is equal to a right square. We pass the square AE through the chords EG, GH, HE and from this point draw EL perpendicular to the chord AG. At point L the arc AG is divided in half: this was proved above. Points G and H are the midpoints of the sides AC and AD. GH is parallel to CD. This follows from the similarity of triangles ACD and AGH, where AH is half of AD, GH is half of CD. The proof is as follows: EG is half of BC. AE is half of AB; AE, EG, GH are equal to each other. We draw the perpendicular KL from point K to point AG and divide it into two equal parts at point L and, according to the third sentence of the third book of the "Fundamentals", we reach point E.

Let AE as an "object" is a sine 1°. The sine 3° of AH is $3^p 8' 24'' 33''' 59^{IV} 34^{V} 28^{VI} 15^{VII}$ sobia. The square AE is the "square" of the unknown divided by the diameter AF of the small semicircle, that is, by 60. The division will be one minute of a "square"; according to the second rule, this is the quantity EL. The square of this "square-square" remains one "square" without the second. And the square AL is equal to a quarter of the square AG. The square AG is four “squares” minus four seconds of “square-square”.

By the first rule, the square of GA to EH, that is, the square of AG, is equal to the square of AE to HG. The square of AE - $3^p8'24''33'''59^{IV}34^{V}28^{VI}15^{VII}$ is a "square", and the rectangle from EG to AH is a "thing". After performing an algebraic operation, four "squares" are divided into one equal "square", four seconds "square-square" and this "thing". After tripling the same terms in both parts of the equation, one "square" is equal to one second and 20 solis of "square-square" and the $1^p2'48''11'''19^{IV}51^{V}29^{VI}25^{VII}$ number. This operation is also complete, and the "thing" is equal to the cube and the number. To find this number, we take the cube of this number, that is, $1^p8'48''30'''23^{IV}36^{V}30^{VI}42^{VII}18^{VIII}$ one third, and multiply it by the $1''20'''$ square. Then we add the product, that is, to one third of this $0^p0'1''31'''44^{IV}40^{V}31^{VI}28^{VII}41^{VIII}$ number. $1^p2'49''43'''4^{IV}32^{V}0^{VI}53^{VII}41^{VIII}$ is formed. This will be $1^p8'53''32'''4^{IV}3^{V}50^{VI}59^{VII}14^{VIII}57^{IX}$ cubed. We multiply this by $1''20'''$ solis - $0^p0'1''31'''51^{IV}22^{V}45^{VI}25^{VII}8^{VIII}$ we get. This will be $1^p8'53''26'''26^{IV}7^{V}0^{VI}22^{VII}10^{VIII}$ cubed. We add this to a third of this $1''20'''$ number, we get - $0^p0'1''31'''51^{IV}23^{V}14^{VI}49^{VII}20^{VIII}$. We cube this to $1^p8'53''32'''26^{IV}8^{V}37^{VI}5^{VII}34^{VIII}$ get , and multiply it by the $1''20'''$ square. Add the product to one-third of that number. That's the $1^p2'49''43'''11^{IV}14^{V}44^{VI}16^{VII}26^{VIII}$ total. If we multiply the cube by the $1''20'''$ square and add the product to one-third of that number, that's the last number itself. That number is the sine of -1°.

(1) Explanation: This is taken from the work of Husayn Birjandi in the second chapter of his second book, Shahri. Here the comments on the passage are given in square brackets and are divided into comments on the main work.

(2) "The Mother of the Sinuses" or "the Main Sinuses" Ummahat al-Juida $\frac{\pi}{2}, \frac{\pi}{3}, \frac{\pi}{4}, \frac{\pi}{6}, \frac{\pi}{10}$ and sines of equal angles. Mirim Chalabi gives 5 rules for determining equal sines. Some of them are similar to the rules quoted on the stock exchange.

(3). The definition of the sine as the square of a double arc goes back to the mathematics of the early Middle Ages. Here Birjandi's sines were defined independently of his vataras, and he took a step ahead of his contemporaries.

(4). If the circle is the root of a third, then 120° $a_3 = R\sqrt{3}$, then $sin60° = \frac{R\sqrt{3}}{2}$.

(5). In the Russian translation of Euclid's "Fundamentals" these are 12 sentences from 13 books.

(6). "4 sentences of book 2 "Basics"y" differ from Birjandi's proposals. Euclid has a word about $(a+b)^2 = a^2 + 2ab + b^2 \left(\frac{a}{2}\right)^2 = \frac{a^2}{4}$ reality. Birjandi about reality.

(7). Birjandi, like other Samarkand scholars, continued the tradition of Ptolemy and worked with a circle of radius 60. However, scholars from Samarkand four centuries ago worked with a circle of radius Beruni $R = 1$.

If (4) according to the remark, $sin60° = \frac{R\sqrt{3}}{2}$, $R = 60°$, then according to (6).

Then $(sin60°)^2 = \frac{3}{4} \cdot 60^2 = 45 \cdot 60 \quad or = 45',$

$$sin60° = 51^p 57' 41'' 29''' 13^{IV} 58^V 58^{VI}.$$

Mirim Chalabi brings a clear value only to the scales. Here, and in this work in general, he put marks on the numbers written in the sexagesimal system. For example, 51^p the written P - is the first letter of the Latin word pars - "part". $45'$ and "once promoted to the sixtieth rank", that is $45' = 45 \times 60^2$ and so on in fractions $57'41'' = \frac{57}{6} + \frac{41}{60^2}$ and so on.

(8). "The sentence "bride" - in the form of an arus - is the Pythagorean theorem for the plane, according to this theoremroof inscribed in a circle - for a square

$$(2R)^2 = 2a_4^2$$

(9). That is, $\left(\frac{a_n}{2}\right)^2 = (sin45°)^2 = \frac{R^2}{2} = 30 \cdot 60$

from this

$$sin\,45° = 42^p 25' 35'' 3''' 53^{IV} 3^V 4^{VI}$$

Mirim Chalabi rounded this amount to 4 solis.

(10). "In Russian translation"Basics" means the beginning. According to this proposal

$$\frac{a_{10}}{a_6} = \frac{a_6}{a_{10} + a_6}$$

$$a_6 = \mathrm{R}\,, \quad a_{10}^2 + a_{10} \cdot \mathrm{R} - R^2 = 0$$

for the fact that you this equation is one

$$a_{10} = \frac{R}{2}\left(\sqrt{5} - 1\right)$$

It has a positive solution. Here it is translated as "continuous straight line" - the expression istikamat mutastil.

(11). "The Russian translation of "Basis" means "Beginning". The condition stated here follows from the equality in the previous comment:

$$\left(a_{10} + \frac{R}{2}\right)^2 = 5 \cdot \left(\frac{R}{2}\right)^2.$$

(12). Birjandi uses the term "degree" for both parts of the diameter and parts of the circle. From now on, we will only use the word "section" when talking about the diameter.

(13). This one seems to have an inaccuracy in Birjandi's text due to the copyist's fault. The point is to find, in your opinion,

$$a_{10} = 2sin18°sin18°$$

$$\left(2sin18° + \frac{R}{2}\right)^2 = R^2 + \frac{R^2}{4}$$

equality

$$\left(sin18° + \frac{R}{4}\right)^2 = \left(\frac{R}{2}\right)^2 + \frac{1}{4}\left(\frac{R}{2}\right)^2$$

becomes visible and consistently “rises” and $\left(\frac{R}{2}\right)^2 - 15'$

$$\left(\frac{R}{2}\right)^2 + \frac{1}{4}\left(\frac{R}{2}\right)^2 = 18'45''$$

finds. The root of the following expression

$$sin18° + \frac{R}{4} = 33^p 32' 27'' 40''' 14^{IV} 49^V 33^{VI}$$ will

because now $\frac{R}{4} = 15^p$

$$sin18° = 18^p 32' 27'' 40''' 14^{IV} 49^V 33^{VI}$$ will

Chalabi calculates $sin18°$ with precision down to the soli.

(14). 15 sentences from Book 4 "Basics".

(15). If new, $sin30° = 30,\ R = 60\ then\ R = 1, to\ sin30° = \frac{1}{2}$.

(16). "1st sentence of the 14th book "Fundamentals""ы" states: "The perpendicular drawn from the center of a circle to the side of a pentagon inscribed in it is equal to half the sum of the sides of the hexagon and decagon inscribed in this circle.

$$\frac{R + a_{10}}{2} = \sqrt{R^2 - \frac{a_5^2}{4}}$$

(17). Here Birjandi first finds this meaning

$$\frac{R}{2} + \frac{a_{10}}{2} = 48^p 32' 27'' 40'' 14^{IV} 49^V 32^{VI}$$

This value is then squared and subtracted from to R^2, find the root of the difference, that is,

$$sin36° = 35^p 16' 1'' 36''' 52^{IV} 10^V 57^{VI}$$

Mirim Chalabi rounded the value to $36'''$.

(18). Here Birjandi makes a special distinction between the determination of the sines of the four arcs -$54°, 72°, 22°, 30°, 15°$. Such actions are not mentioned in Chalabi.

(19). In Euclid's "Principles" it is stated in the 4th sentence of the 6th book: "In equiangular triangles, the sides opposite equal angles are proportional, and the bisectors of equal angles are equal."

(20).The word in the sentence spoken by Birjandi in the 2nd sentence of the 14th book of the Foundations.

$$a_5^2 + a_{\frac{2}{5}}^2 = 5R^2$$

It's about equality.

(21). Based on this, the above equality $\frac{a_5}{2} = sin36°$

$$\left(\frac{a_{\frac{2}{5}}}{2}\right)^2 + sin^2 36° = R^2 + \frac{R^2}{4}$$

is displayed. Now

$$R^2 + \frac{R^2}{4} = 1^p 15' = 1 \cdot 60^2 + 15 \cdot 60 = 4500\ and\ \ sin36°$$

as is known

$$\left(\frac{a_{\frac{2}{5}}}{2}\right)^2 = sin72°$$

we find this

$$sin^2 72° = \left(R^2 + \frac{R^2}{4}\right) - sin^2 36°$$

By substituting certain values into the right side of the equation and taking the square root, the stock can be found.

$$sin72° = 57^p 3' 48'' 12''' 27^{IV} 3^V 15^{VI}$$

The Chalabi sine $57^p 3' 48''$ value was used.

(22). "30 sentences from 3 books "Basics".

(23). "The 32nd sentence of the 1st book "Basics" states: "When in any triangle one of the sides is continued, the external angle is equal to two internal and opposite angles, and the three internal angles of the triangle are equal to two right angles."

(24). "In sentence 6 of Book 1 of the "Bases»: «If the angles of a right triangle are equal to each other, then the sides subtending the equal angles are also equal».

(25). "The "Bases" in the 8th sentence of the 6th book: "If in a right triangle"If a perpendicular is drawn through the base of a right angle, then the triangles in the perpendicular are generally similar to each other."

(26). The search rule given here can be expressed as $sin22°30'$

$$sin22°30' = \sqrt{\frac{R}{2}(R - sin45°)}$$

$$sin45° = R\frac{\sqrt{2}}{2} = 42^p 25' 35'' 3''' 53^{IV} 3^V 4^{VI}$$

$$sin22°30' = 22^p 57' 39'' 37''' 16^{IV} 59^V 26^{VI}$$

is easily proven.

(27). Thison the ground

$$sin15° = \sqrt{\frac{R}{2}(R - sin60°)}$$

according to the rule.

(28). The height of a regular triangle with a side perpendicular

$a_6 = 2sin30°$ to is: or the second leg of a right triangle with one leg $sin30°$, hypotenuse $2sin30°$. Then the second leg or equilateral triangle will be equal to $sin60°$.

(29). Here

$$\sqrt{\left(R - \sqrt{R^2 - R^2 sin^2\alpha}\right)\frac{R}{2}} = R\sqrt{\frac{1 - cos\alpha}{2}} = Rsin\frac{\alpha}{2} = sin\frac{\alpha}{2}$$

compared Birjandi's second rule with M. Chalabi's second rule.

(30). Note (25) above.

(31). In sentence 17 of the book "Basics": "If a straight line is proportional, then the square of the rectangle bounded by the edges is equal to the square of the middle of the rectangle: and if the rectangle bounded by the edges is equal to the square of the middle, then these straight lines are proportional.

(32). A comparison of Birjandi's second rule with Chalabi's second rule shows that Birjandi determined the sine of half of a given arc and its sine. Chalabi showed the general case: the sine of a given arc is determined by the sine of its half, and vice versa, the sine of the entire arc is determined by the sine of half of the arc.

(33). Quantity $sin9°$

$$sin\frac{\alpha}{2} = \sqrt{\left(R - \frac{1}{R^2} - sin^2\alpha\right)\frac{R}{2}}$$

can be written in the present tense. If $sin\alpha = Rsin\alpha$

$$\sqrt{\left[2R - \frac{(Rsin\alpha)^2}{\frac{R}{2}}\right] \cdot \frac{(Rsin\alpha)^2}{\frac{R}{2}}} = 2Rsin\alpha \cdot cos\alpha = Rsin2\alpha$$

can be written as $R = 1,\ then\ sin2\alpha = 2sin\alpha cos\alpha$

(35). Note (25) above.

(36). Unlike Birjandi Chalabi, the double arcsine is given as a special rule.

(37) It is stated here $sin\alpha cos\beta + sin\beta cos\alpha = sin(\alpha + \beta)$ identity and then, here will be $sin\alpha = Rsin22°\alpha$; $R = 1$

$$sin\alpha cos\beta + sin\beta cos\alpha = sin(\alpha + \beta)$$

(38). In Birjandi Nasir al-Din Tusi's work "Tahrir al-Majisdi", written in the 10th chapter of the city, this sentence is explained in detail and evidence is given.

(39) . The text is in commentary 19.

(40).The text is incomment 25.

(41). Euclid in the 21st sentence of the 6th book of the "Elements": "Forms similar to a rectilinear figure are similar to each other."

(42). "In sentence 34 of Book 1 of the "Fundamentalsы»: «In surfaces composed of parallel lines, opposite sides and angles are equal to each other, and the diameter divides them in half».

(43). This is the rule stated here

$$sin\alpha cos\beta - sin\beta cos\alpha = sin(\alpha - \beta)$$

Strongly equivalent to the present: it is in $R = 1$.

(44). The manuscript of the UzR FA GGI No. 464 is located on page 316.

(45). (23) – comment.

(46). The axis of the arc is the rod.

(47). Here Birjandiy quoted a passage from Zij, which he explains in the 12th commentary.

(48). Manuscript of UzR FA GNI No. 464 on 326 pages.

(49). Birjandi Koshi contradicts the truth by saying that "he started astronomical observations in Samarkand". Because the history of astronomical observations in Samarkand in the Islamic era dates back to the 9th century. In addition, even before Koshiya came to Samarkand in 1417, Ulugbek and Kazi Zoda Rumi started astronomical observations here.

However, there is no doubt that the construction of the Samarkand The observatory is associated with the name of Koshiya. This is reported by Abu Tahir Hajja: “Four years after the founding of the madrasah, Mirza Ulugbek and Kazi Zoda Rumi, having consulted with Maulana Giyosiddin Jamshid and Maulana Muni iddin Kashiy, built an observatory building in the Obi Rakhmat stream on Kokhak Hill.

(50). Birjandiy confirmed the words that he wrote a treatise on the definition of Ulugbek's sine1°.

(51). M. Chalabi gave the introduction as the fourth rule. In fact, it is Theon of Alexandria, the poet of the Almagista.

(52). This is the theorem of sines on the plane

$$\frac{sinA}{a} = \frac{sinB}{b} = \frac{sinC}{c}$$

implied.

(53).Here the greatest sine - A'zam - is the sine of the rectangle. In the Middle Ages this phrase was translated into Latin as sinus totus, which means "full sine". This Latin phrase also corresponds to the second name of this sine - jaib al-kull.

Birjandi finds these proportions by applying the plane sine theorem to right triangles BHZ, HGP, GEO, ECF.

$$\frac{sintot}{BH} = \frac{sinH}{BZ},\ \frac{sintot}{HG} = \frac{sinG}{HP},\ \frac{sintot}{EG} = \frac{sinE}{GO},\ \frac{sintot}{EC} = \frac{sinC}{EF}.$$

In the figure, arcs BC and AB are equal, and since each of them is divided into four parts, the angles $HGH = EG = CE$ and angles H, G, E, C are known, and the legs BZ, HP, GO, EF are easily found.

(54). Since 1° Jamshid cites Birjandi's approximate method of finding the sine of Cauchy, by "author" he means Cauchy. The "Ziji Khaqani" remembered by Birjandi is in fact "Ziji Elkhani" with the full version of "Ziji Elkhani" dedicated to the library of Koshiy Ulugbek.

Jamshid Cauchy in his $sin1°$ approximate method

$$1^p2'49''42'''50^{IV}40^V < sin1° < 1^p2'49''43'''35^{IV}31^V$$

from the inequality as follows. In general,

$$f(x_0) < f(x) < f(x_0 + h)$$

from this

$$f(x) = f(x_0) + \frac{f(x_0 + h) - f(x_0)}{2} = f(x_0 + h) - \frac{f(x_0 + h) - f(x_0)}{2}$$

We are talking about the history of the interpolation method.

(55). On "another approximate method" $sin1°$ of approximate calculation by Nasriddin Tusi.

(56).The introduction described by Birjandi was widely used by ancient and medieval astronomers. Beruni in "Kanuni Masudi" gives a proof of this introduction by "Serona's method". But before Serena, this position was proved by Ptolemy himself and he proved it in chapter 10 of book 1 of "Almagisti": "On the numbers of lines in a circle": "I say that if a circle is given an unequal line, then the arc of the larger line is equal to the smaller and is small in proportion to the arc of the smaller line."

His proof was also given by Nasiruddin Tusi. The evolution of this introduction over 1500 years is remarkable. Beruni worked with vataras and contractions. Ptolemy worked with right sections of the circle, and Nasiruddin Tusi and Birjandi worked with sines, and their coefficients are different.

(57). "The "Bases" in the 8th sentence of the 5th book: "From unequal quantities"The larger is greater than the smaller, and the smaller is greater than the larger."

(58). This includes Archimedes' axiom.

(59). In the first sentence of the 6th book of "Bases": "Triangles and parallelograms of the same height are proportional to each other as their bases."

(60). The science of geodesy is the science of measuring surfaces, that is, “geometry” in the ancient sense.

The exact formula in effectmeasurements of the surface area of the sector

$$S_{sek} = \frac{1}{2} P_{sek} \cdot r$$

gave an equally strong rule: in the formula, $P_{sek} -$ the length of the arc of the sector,R - is its radius.

(61). 13 sentences from the fifth book "Basics".

(62). "Creation of coefficients" is a structural coefficient. Euclid speaks about the "proportionation" of proportional quantities in propositions 17, 18 of the 5th book of the "Principles"y".

Nasriddin Tusi's "Book of the Sphere and Cylinder" is actually a commentary on Archimedes' work of the same name.

(63). "Incomments are given 4 sentences (19) of the book "Basics".

(64). Kusher (ibn Labban) - Abul Hasan Kiyo Kusher ibn Labban al-Jili, an Iranian astronomer and mathematician who lived in the 10th century, originally from Gilon in the southwest Caspian Sea (Jilon in Arabicized form). His main astronomical work, Az-Zij al-Jami', consists of four books based on the observations of the great scholar Muhammad ibn Jabir al-Battani (850 – 929) and served as a guide for astronomers of his time. Kiyo Kushyar's second astronomical work, Kitab al-lomi' fi amsiloti az-Zij al-Jami' (The Wonderful Book of Examples of Zij-Jami'), was a revision of his previous one. He also wrote a work entitled Maqola fi-l-Hisob (Article on the Report).

(65). Here the word "error" is translated as "difference".

(66). In the copy of Birjandiy "Sharkhi", stored in the SHI FA UzR under number №458, the name of the author - Ulugbek - is mentioned here. Here Birjandi once again emphasizes that there are two different ways of proving1°sinus, and one of them belongs to Koshi, and the other to Ulugbek.

(67). Ptolemy's Theorem: It is presented in Chapter 10 of the first book of the Almagest.

(68). “If a straight line is given in a circle, then a straight line is also given that draws half of the arc related to the first straight line” in the 10th sentence of Birjandi’s “Almajistiya” book 1.

(69). Here, mol is an expression from medieval Islamic mathematics: it means the square of the unknown, which is written in quotation marks as "square". The known area is called "jam". It is written as a square without quotation marks. One of the unknowns is called 1° si shai, that is, "object". The cube and bisquare of the unknown are called kaab - that is, a cube, and mol al - mol, that is, "square - square".

Birjandi calls algebraists "men of algebra and almuqabala." Thus, Birjandi recognized that algebra in his time was an independent mathematical science.

(70). Here the rule expressed by the word

$$(a-b)^2 = a^2 + b^2 - 2ab$$

there is a measure. Euclid did not give a precise definition of this measure.

(71). "Bases" in sentence 31 of book 3: "the angle adjacent to the semicircle inside the circle is a right angle, the one in the large segment is smaller than the rectangle, the smaller one is larger than the rectangle, and, in addition, the larger angle of the segment is larger than the rectangle, and the angle of the smaller one is smaller".

(72). "Comment (8) to the sentence "bride".

(73). Identity $a-(b-c) = (a-b) + A$ is intended here.

(74). "The completion of "Algebra" and al-muqabala (comparison) are the two main operations of medieval Muslim algebra. These operations were first described in the history of science by the great Uzbek scientist Muhammad ibn Musa al-Khwarizmi in his work entitled "Al-kitab al-mukhtasar fi lisab al-jabr wal-muqabala" (A Brief Book on Algebra and the Calculus of Al-muqabala) and he founded the science of algebra. In the first operation, one part of the equation is "filled" with the dividend member. And a member equal to it is added to the second part of the equation. "Straightening" simplifies the equation by reducing the same members in both of its parts. The Latin spelling of the word "Algebra" later became the name of Algebra, the science founded by Khwarizmi.

(75). Here we have roughly translated the word "filling" - the literal meaning is "bringing to perfection". This operation consists of multiplying both parts of the equation by the denominator of the fraction and "filling" it completely. Birjandi perceives this as a special step.

(76). Here we are talking about proportions

$$\frac{1}{x} = \frac{x}{x^2} = \frac{x^2}{x^3} = \cdots$$

The first mention of such a chain of proportions was made by Diophanius (3rd century) in his Arithmetic. Abu Bakr Muhammad al-Karaji (10th-11th centuries) was the first Muslim mathematician to draw attention to this and explain it in his treatise Al-Fakhri.

(77).The last form of the equation with a two-degree arc vector is the unknown X:

$$3''x = 3 \cdot 60^2 E = 6''16'49^p 7'59''8'''56^{IV} 29^V 40^{VI} + E^3$$

where

$$6''16'49^p 7'59''8'''56^{IV} 29^V 40^{VI} = 2sin3° \cdot 60^2$$

therefore the equation is reduced to the form $px = q + x^3$.

(78). That is, the equation $px = q + x^3$ does not belong to the six famous problems of algebra, Birjandiy has in mind the equations first classified by Khorezmi in the form

$$ax^2 = bx, \qquad ax^2 = c, \qquad ax = c, \qquad ax^2 + c = bx, \;\; bx + c = ax^2$$

Birjandi's statements about the canonical forms of equations confirm the opinion of B. A. Rosenfeld and A. P. Yushkevich that the algebraic treatise seen by Umar Khayyam (11th-12th centuries), containing the canonical forms of 25 algebraic equations, was forgotten in Central Asia by the 15th century.

(79). “The cube method described here for solving an equation of the type “participated in division” $px = q + x^3$ is an iterative method that was widely used by Koshiy and other scholars from Samarkand.

(80). Here $px = q + x^3$ the method of integrating the solution of the equation is as follows: first it is divided by the number of “objects”, that is, by the coefficient P in front of the unknown.

$$x = \frac{x^3+q}{p}.$$

Since the unknown x in this equation is the sine of a power, it is already known to be less than one: x^3 obviously less than that. Therefore, x^3 adding q to the constant term does not affect the previous three digits of x. Suppose that when q is divided by p, the "first divisor" is a, and b is the "remainder", i.e. the remainder, $q = a \cdot p + b$, then from $q = ax\ \ p + b$, where

$$x = a + \frac{b + x^3}{p}$$

We can take the first term a as a first approximation of the unknown x and replace it with $+x^3 \;\; by \;\; b + a^3$. The next step $b + a^3$ is to divide by p and get this product:

$$b + a^3 = c \cdot p + d$$

where c - is the second division, d - is the second remainder.

From this equation we determine b and substitute (I) into the equation .

$$x = a + c + \frac{d + (x^3 - a^3)}{p}$$

Now, in the second approximation, $a + c$ we find:

$$x = a + c + l + \frac{L + [x^3 - (a - c)^3]}{p}$$

This is the third $a + c + e$ approach.

This process continues "until the divisor value becomes very small", that is, in the current phrase, until it becomes as small as desired.

(81). It is found by the iterative method described here $sin1° = 60x \quad sin1°$ value is given. The steps of the calculation algorithm are given in the table. As found,

$$60 \times sin1° = 1^p 2' 49'' 43''' 11^{IV} 14^{V} 44^{VI} 16^{VII} 27^{VIII} 17^{IX}$$

for the fact that

$$sin1° = 1^p 2' 49'' 43''' 11^{IV} 14^{V} 44^{VI} 16^{VII} 27^{VIII} 17^{IX}$$

will be. If we write this value in simple decimal form, it will look like this:

$$sin1° = \frac{10552832792603237}{604661760000000}$$

(3) Then Ulugbek applied Ptolemy's theorem to angle ABCD and said the following

$$AC \cdot BD = AB \cdot CD + BC \cdot AD \quad (4)$$

finds an expression. In this equation

$$AC = BD, \qquad AB = BC = CD = X \quad and$$

$$AD = 6^p 16' 49'' 7''' 59^{IV} 8^V 56^{VI} 30^{VII} \qquad (4)$$

We obtain the value AC^2 (4) by substituting it into (3).

$$4x^2 - \frac{x^4}{60^2} = x^2 + x \cdot 6^p 16' 49'' 7''' 59^{IV} 8^V 56^{VI} 30^{VII}.$$

After this, Ulugbek performs algebraic and inverse operations, then divides both parts of the equation by 3 and by X, and fills the coefficient in front of the upper term with a solis: and as a result, the equation looks like this:

$$x = \frac{20x^3}{60^3} + 2^p 5' 36'' 22''' 39^{IV} 42^V 58^{VI} 50^{VII} \qquad (5)$$

or $$x = px^3 + q \qquad (5')$$

Since it is already known that the value of the unknown X is small, Ulugbek assumes that the difference must $x - q = Px^3$be very small. Therefore, he takes as a first approximation "one third of this number", that is $x_1 - q$; after this

$$x_2 = q^3 p + q = x_1^3 \cdot p + q$$
$$x_3 = (q^3 p + q)^3 \cdot p + q = x_2^3 \cdot p + q$$
$$x_4 = [(q^3 p + q)^3 \cdot p + q]^3 \cdot p + q = x_3^3 \cdot p + q$$
$$x_5 = \{[(q^3 p + q)^3 \cdot p + q]^3 \cdot p + q\}^3 \cdot p + q = x_4^3 p + q.$$

It is not difficult $x_n = x_{n-1}^3 \cdot p + q$ to see that this process will converge.
Here, the interaction method is also used, as in solving equation
$px = x^3 + qE = px^3 + q$ (79) see note. Here, when solving the equation, E assumed: $x = a_1 + a_2 + \cdots$
where the values $a_1, a_2, a_3, \ldots$ - are consecutive values of the hexadecimal system, and in the notations they are

$$a_1 = q$$
$$a_2 = q^3 p$$
$$a_3 = (q^3 p + q)^3 \cdot p$$
$$a_4 = [(q^3 p + q)^3 \cdot p + q]^3 \cdot p$$
$$a_5 = \{[(q^3 p + q)^3 \cdot p + q]^3 \cdot p + q\}^3 \cdot p + q$$

looks like. So, as a result of such a decision

$$x = 2^p 5' 39'' 26''' 22^{IV} 29^V 28^{VI} 32^{VII} - 2^\circ$$

arc vector, that is, the value of x is found. From this

$$sin1° = 0^p 1' 2'' 49''' 43^{IV} 21^{V} 14^{VI} 44^{VII} 16^{VIII}$$

If we convert this hexadecimal number to decimal, the value will be accurate to 14 decimal places.

$$sin1° = 0{,}01745240643728$$

(86). In the 3rd sentence of the book "Bases" 3: "If a line passing through the center of a circle intersects another line not passing through the center, then it is a line cutting off angles; and if it cuts it at right angles, it cuts it also in the middle."

(87). There is no proposition contrary to Book 3 of the 30 propositions of the "Basis". However, the words spoken here can be justified by proposition 31 (71) of this book. Since the angles at the ends E, G and H of triangles AEF, AGF, AHF rest on the common diameter AF.

(88). (86) in the comments.

(89). "In the 2nd sentence of the 6th book of the "Basis": «If you draw a straight line parallel to one of the sides of a triangle, then the sides of this triangle intersect proportionally; and if the sides of the triangle are cut proportionally, then the line connecting the segments will be parallel to the remaining side of the triangle».

(90). (86) in the comments.

(91). $\frac{AE^2}{AF} = EL$ The proportional rectangles ALE, AEF also follow from the similarity of triangles. Indeed,

$$\frac{EL}{AE} = \frac{AE}{AF}$$

(92). Birjandiy cited two evidentiary methods for $sin1°$ determining what belonged to Ulugbek and undoubtedly had Ulugbek in mind as the "author" in this part of his work.

Salih Zaki's reports stated that the last proof was only with Cauchy. Salih Zaki's book "Ulugbek's Trigonometric Tables" states: "Ghiyasiddin and Ulughbek based their tables of sines and tangents on this method" $sin1°$.

In this second method, Ulugbek obtained an arc ABCD of length 6° and a central point F; each of the arcs AB, BC, CD is equal to 2°. The midpoints of the arcs AB, AC, CD are the points E, G, H. Since AB, BD, CD are vectors - 2° , half of it is the sine of the determined degree AL, that is

$$AE = R \times sin\ 1° = x$$

$$AH = R \times sin3° = 3^p 8' 24'' 33''' 59^{IV} 34^V 28^{VI} 15^{VII}$$

$\frac{AE^2}{AF} = EL$ because it is $A^2 = X^2$ so, it is $\frac{x^2}{60} = EL$ so. According to the Pythagorean theorem,

$$AL^2 = AE^2 - EL^2 \ , \quad AL^2 = x - \frac{x^4}{60^2} \qquad (1)$$

Applying Ptolemy's theorem to the inscribed rectangle AEGH and $AG = EHAE = EG = GH$ taking into account that , we find:

$$AG^2 = AE^2 + GE \cdot AH \quad and \quad AG^2 = x^2 + E \cdot sin3° \qquad (2)$$

AG^2 let's substitute the value into (1) and (2). After some algebraic manipulations and substitutions, this equation looks like this:

$$3x^2 = \frac{4x^4}{60^2} + x \cdot sin3° \qquad (3)$$

Let's reduce both sides of the equation by 3 and find:

$$x^2 = \left(\frac{1}{60^2} + \frac{20}{60^3}\right) x^4 + x \cdot \frac{sin3°}{3}$$

Now, reducing this value to x, the final form of the equation is:

$$x = \left(\frac{1}{60^2} + \frac{20}{60^3}\right) x^3 + 1^p 2' 48'' 11''' 19^{IV} 51^V 29^{VI} 25^{VII} \quad (4)$$

Thus, as in the first case, Ulugbek again made the equation $X = px^3 + q$ appear. The solution algorithm was the same as before. This time it consists of the root that Ulugbek found:

$$x = 60 \cdot sin1° = 1^p 2' 49'' 43''' 11^{IV} 14^V 44^{VI} 16^{VII} 26^{VIII}$$

or

$$sin1° = 0{,}017452406437.$$

The original equation for Cauchy and Ulugbek

$$3x = \frac{4x^3}{60^2} + sin3° \qquad (3)$$

being, Koshi and this

$$45 \cdot 60x = 15 \cdot 60 \cdot sin3° + x^3 \qquad (5)$$

view, and in the representation (4) Ulugbek is indicated. Then each of them solved the equation in their own way, but by the interpolation method known to all Samarkand scientists.

Scale literally means "measure" - a translation of the Greek word G_{nomar} ; the Greeks called the peg attached to the ground or to the wall "gnomen" which was the main part of the "Bird" clock. In Islamic countries, scales performed the same task.

The first shadow or reflected shadow is zilli earlier or zilli maqus - tangent line; the second shadow or flat shadow is zilli duvum(sani) or zilli mustavi - cotangent.

The reason for the so-called lines is that in the first case the shadow of the horizontal scale falls on the vertical wall, that is, in contrast to the correct shadow in the second case, in which case the shadow of the vertical scale falls on the horizontal plane.

The line connecting the end of the scale with the end of the shadow is called the diameter of the shadow - kutri - zill - Ulugbek combined two trigonometric expressions with this name: in the case of a reflected shadow, its diameter means the secant line, in the case of a flat shadow - the cosecant line. Muhammad al-Khwarizmi was one of the first to present these concepts in his astronomical treatise.

If the height of light is h, the length of the scale is 1, and the length of the shadow is S, then

$$ctgh = \frac{s}{l}\ , \ \ tgh = \frac{l}{s}\ .$$

If $h = 0$, then since the scale is parallel to the horizon, $l = 0$

That's why

$$tgh = 0, \qquad ctgh = \infty, \qquad h = 90°, \qquad l = l$$

$$tgh = \infty \ \ and \ \ ctgh = 0.$$

This has 60 parts (pieces); 12 parts (aksom) and 7 steps (akdam) were units of measurement of the length of the scale in the countries of the Near and Middle East in the Middle Ages.

"The commentary of Hussein Birjandi on this passage from Zij is noteworthy. From this explanation one can get some idea of the state of trigonometry in our regions in the first quarter16th century.

SquareABC with center D and radii AD and CD are mutually perpendicular. Choosing a point in the quadrant, he draws lines, and when they are continued, KL draws them perpendicular to the point. Two subsequent perpendiculars are considered equal. Then, if AD is the quadrant of the arc height, CD is the plane of the horizon, HF is the scale of the flat shadow, KL is the scale of the reflected shadow, DB is the ray line falling from the illumination on these scales, BC is a flat shadow of height DF, reflected by KL of this height. Thus, LD is a tangent, and FD is a tangent line.

Then the proportion is formed from $\frac{AE}{AD} = \frac{DF}{HF}$ the similarity of right triangles ADE, FDH. Similarly, the proportion is $\frac{LD}{LK} = \frac{CG}{CD}$ formed from the similarity of right triangles LDK, CDG. Now, if we take the radius AD as the scale, then AE will be its direct shadow, that is, the cotangent. Similarly, if we measure the second radius CD, then CG is its tangent. In both cases, the quadrant of the height of the light source will be point B.

Here Birjandi considers shadows, that is, tangents and cotangents, as trigonometric functions of the arc, that is, the argument.

Ifthe length of the scale $l = 60$ and the height of light h are known, then with 15 according to the explanation

$$s = l, \;\; ctgh = 60 \quad ctgh = \frac{60}{tgh}$$

Here are the rules

$$tgh = \frac{sinh}{\sin{(90° - h)}} = \frac{sinh}{cosh}$$

$$ctgh = \frac{\sin{(90° - h)}}{sinh} = \frac{cosh}{sinh}$$

formulas can be written in the form . These rules were long known to Muhammad al-Khwarizmi.

Here

$$R \quad tgh = \frac{R}{ctgh}$$

from this identity

$$tgh \cdot ctgh = 1$$

when

$$Rtgh \cdot ctgh = R \cdot 1 = R$$

it will be like this.

Ulugbek probably means the peculiarity of these functions

$$tg45° = ctg45° = 1$$

saying that "the circle comes down to eight to one."

The rule of interpolation of tangents mentioned by Ulugbek is written as follows:

$$tgx = tgx_0 + (x - x_0) \cdot \frac{tg(x_0 + h) - tg(x_0)}{h}$$

and

$$x = x_0 + h \cdot \frac{tgx - tgx_0}{tg(x_0 + h) - tgx_0}$$

In the tables of tangents given by Ulugbek below, $h = 1°$ and the following argument values. Beruni took $h = 1°$ the "Law of Masoudi", but used the rule of quadratic interpolation. Ulugbek says that "the deviation of any four points of the ecliptic, the deviation of the points equidistant from the two equinoxes of the ecliptic, with longitude λ, $180° - \lambda,$ $180° + \lambda,$ $360° - \lambda$ can be equal only in absolute terms, since for the points of the northern half of the ecliptic $\delta > 0$ for the points of the southern half and $\delta < 0$.

Ulugbek calls the deviation of the porthole the deviation δ, that is, the continuation of the equatorial coordinate δ, that is, the ecliptic coordinate.

The amount of the largest rejectionia, which Ulugbek brings here is $\varepsilon = 23°30'17''$ remarkable. Ulugbek himself and his critics Birjandi and Mirim Chalabi said nothing about how and in what years this value was found as a result of observations. However, Ulugbek calculated this value based on the rules for finding E by the expansion of the city ε, and h_{max} and $h_{min}$for the height of the Sun during the summer and earthly solstices. According to these rules,

$$h_{max} = 90° - \varphi + \varepsilon\ ,\ \ h_{min} = 90° - \varphi - \varepsilon\ ,\ \ \varepsilon = \frac{h_{max} - h_{min}}{2}\ ;$$

$$\varphi + \varepsilon > 90°,\ \ h_{max} = 90° + \varphi - \varepsilon\ ;\ \ h_{min} = 90° - \varphi - \varepsilon$$

when

$$\varepsilon = 90° - \frac{1}{2}(h_{max} - h_{min}) = \frac{1}{2}[(90° - h_{max}) + (90° + h_{min})]$$

where φ −is the expansion of this space.

Ulugbek found the greatest deviation of Ulugbek to the Samarkand expansion $\varphi = 39°37'23''$. However, although he said "according to our observation" about the magnitude of this expansion, he did not tell the rule and history of its finding. The magnitude of the greatest deviation in the Arabic version of "Zij" is equal to $\varepsilon = 23°30'16''58'''$, which is $3'''$ less than in the Persian version. Therefore, Ulugbek included the tables of "Zij" and rounded the value to seconds in the Persian version used in practice. The tables of Ulugbek were compiled as historical in 841 AH, /1437 AD/.

Newcomb's formula

$$\varepsilon = 23°27'8''26 - 0'', 4864(t - 7900)$$

$$t = 1437 \ per\ year \quad \varepsilon = 23°30'45'', 1292 \quad \text{will}$$

The value found by Ulugbek is less than this exact $45''$ value.

Determining the value of this parameter has always been one of the main tasks of astronomy for astronomers. Because the accuracy of this value is closely related to the accuracy of the coordinates of stars and cities. Below is a table of known values of E from Erotofender (3rd century BC) to Ulugbek: Table

№	Астрономлар	Давронлар		Хатолар
1	2	3	4	5
1	Эратосфен	230 г. до н.э.	23°51′2″	+7′34″
2	Гиппарх	130 г. до н.э.	23°51′20″	+8′21″
3	Птолемей	140 г. н.э.	23°51′20″	+10′27″
4	По ал-Хорезми	в 622 г.	23°51′20″	+14′13″
5	Йахйа ибн Абу Мансур	828 г.	23°31	−2′30″
6	Халид ал-Мерверруди	832 г.	23°33′52″	−1′37″
7	Мансур ибн Талха	850 г.	23°34′	−1′20″
8	Ал-Баттани	880 г.	23°35′	−17″
9	Абу-л-Хусайн ас-Суфи	969 г.	23°35′	+1′23′
10	Абу Хамид ас-Сагани	985 г.	23°35′	+44″
11	Абу-л-Вафа ал-Бузджани	987 г.	23°35′	+44″
12	Абу Сахл ал-Кухи	989 г.	23°31′1″	+16′46″
13	Абу Махмуд ал-Ходженди	994 г.	23°32′21″	−1′52″
14	Ибн Юнус	1001 г.	23°34′52″	+43″
15	Абу Райхан Беруни	1020 г.	23°35′	+1′
16	Насир ад-Дин Туси	1270 г.	23°30′	+1′57″
17	Улугбек	1437 г.	23°30′17″	−28″

From the values presented in the table, it is clear that the value found by Ulugbek was the second in terms of the greatest deviation after al-Battani's value among the values found before the era of optical astronomy. It is therefore no coincidence that only two Muslim "zijs" are known in Europe - al-Battani and Ulugbek. The first of them was popular in the first half of the current millennium, and the second - in the second half.

The biggest deviation is the Bessel formula $t = 1750$ per year, which is outdated and less accurate than Newcomb's formula when checking E values from different authors.

$$\varepsilon = 23°28'0 + 0{,}48368t - 0'', 00000272295t^2$$

According to this formula, Ulugbek's error $32''$ will increase. Designating the "first" and "second" deviations, defined here conditionally δ_1 *and* δ_2, as "the distance of the ecliptic level to the equinox" of Ulugbek, that is, the greatest deviation from the ecliptic longitude δ, the rules for finding these parameters can be as follows: written in the form

$$sin\delta_1 = sin\lambda \cdot sin\varepsilon\,, \qquad tg\delta_2 = sin\lambda \cdot tg\varepsilon$$

With according to these rules, let AB and AC be the quadrants of the ecliptic and the celestial equator, and A be the vernal equinox. Figure 14

Figure 14.

Then the arc AC of the solstice collius measures the angle A, that is, the greatest deviation is equal to E. We pass the arc DE of the circle of deviation. Therefore, we need to δ determine the sum. Let AD be the longitude of the point D of the ecliptic L, that is, "the distance of a degree of the ecliptic to the equinox point." Since the celestial equator intersects the circles of declination at a right angle, the angle E is acute.

Then, since the $EA = \varepsilon$, angle of the leg $DE = \delta$ and the hypotenuse $AD = \lambda$ of a right spherical triangle is AED , according to the theorem of spherical sines, the following proportion is suitable

$$\frac{sinA}{sinDE} = \frac{sinE}{sinAD}.$$

After "ranking down" by entering the appropriate values $(A = \varepsilon,\ DE = \delta, AD = \lambda)$, the proportion takes the form:

$$sin\delta = sin\lambda \cdot sin\varepsilon$$

That was all I wanted.

Ifin this figure, if we call DE the arc of the extension circle, that is, B, then D will be a right angle, because the ecliptic intersects the extension circles at right angles. Then, applying the theorem of spherical sines to the spherical triangle ADE with legs , angles , D$AD = \lambda \quad DE = \beta$

$$\frac{tgA}{tgDE} = \frac{sinD}{sinA}$$

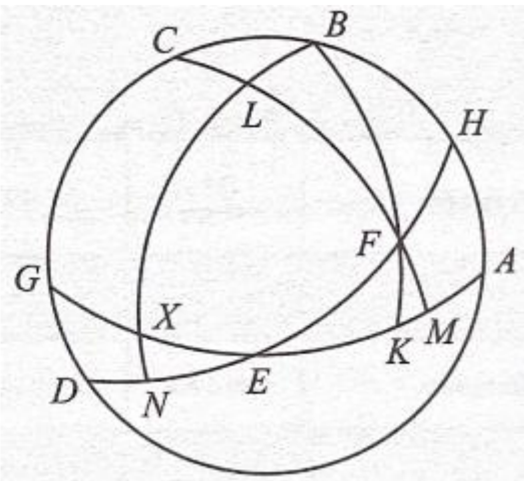
we make a proportion. Again, after "reducing" by setting the appropriate values, as before, the proportion takes this form. From this

$$\frac{tg\varepsilon}{tg\beta} = \frac{1}{sinx}.$$

Ulugbek says that the inverted deviation of the degree of the ecliptic L is like a mancus - the inverse deviation of a point of the ecliptic having such a length L, but calculated from the (Jadian) beginning of Ulugbek's "second deviation" , half Both rules for finding the width of the lamp B can be written in the form of these formulas.

$$sin\beta = \frac{sin\delta}{cos\delta_*} \ , \qquad cos\underline{\beta} = \frac{cos\varepsilon}{cos\delta_*}$$

This formula can be easily derived from the diagram below. Let ABCD be the color of the solstices, E its pole, AEG the celestial equator with pole B, DEH the latitude of the ecliptic with pole C, H the degree of the ecliptic to be determined, and the longitude l. (Figure 15)



15 – figure.

Let the circle of deviation be BFK, and the circle of expansion CFM. Then the $FK = \delta$ deviation of the point F of the ecliptic, $FM = \beta$ and its continuation.

Let the point M be the pole and draw the great arc BLXN. Since the circle of latitude CFM and the celestial equator pass through the pole of this great circle, it also passes through their poles N and B. Therefore, the arcs LN and FN are quadrants. Since $EF = \lambda\,, E = 90° - L$ and therefore $NE = FH,\ XN = \delta$ the ecliptic will be the "inverted declination" of the point F or the "first declination" of the point N; from which the arc $XL = 90° - \delta$ measures the angle M of the spherical triangle LXM. Then, by the theorem of spherical sines, the proportion

$$\frac{sinM}{sinKF} = \frac{sin90°}{sinMF}$$

is suitable in a spherical triangle MFK with a large acute angle and a hypotenuse with a right angle K. Substituting the appropriate values and taking into account the proportion takes the form $FK = \delta FM = \beta sinx = R \cdot sinE$

$$\frac{cos\delta_*}{sin\delta} = \frac{1}{sin\underline{\beta}}$$

or

$$sin\underline{\beta} = \frac{sin\delta}{cos\delta_*}$$

from which the desired B is found. To find the second formula, we apply the spherical Pythagorean theorem to the spherical triangle MFE with acute angles

$$FEM = \varepsilon \quad \text{и} \quad FEM = XL = 90° - \delta,$$

leg and form a proportion $FM = \underline{\beta}$

$$cos\varepsilon = cos\delta \cdot cos\underline{\beta}.$$

Thanks to this, the desired B is found.

Ulugbek gives positive or negative directions of spherical coordinates with the word “side” - aspect.

The argument of the distance is the arc of a circle between the light source and the celestial equator. Since ecliptic latitudes are calculated from $0°\ to\ 90°$ north pole and $0°\ to\ 90°$ north pole, depending on the location of the light source, the distance will be the sum of the north and south argument latitude values. Therefore, we denote the argument of the distance, that is, the sum or difference of their widths, as $\Delta\beta$, that is $\beta \pm \underline{\beta} = \Delta\beta$. In this case, if $\Delta\beta > 0$, if $|\beta| > \left|\underline{\beta}\right|$ and $\Delta\beta < 0$ then $|\beta| < \left|\underline{\beta}\right|$.

MainThe main goal of this chapter is to determine the "distance of the light source to the celestial equator", that is, the deviation δ. Ulugbek considers the deviation B as a function $\Delta\beta,$ that is $\delta = \delta(\Delta\beta)$.

Here are two rules for determining deviation δ by the "distance argument" $\Delta\beta$, "overturned deviation" δ^*, the "second deviation" β and maximum deviation E

$$sin\delta = sin\Delta\beta \cdot cos\delta\ , \quad sin\delta = \frac{sin\Delta\beta \cdot cos\varepsilon}{cos\underline{\beta}}$$

can be written as.

In their coIn Birjandi's comments he sees different positions of the luminary relative to the ecliptic and accordingly gives interpretations of Ulugbek's rules.

Let ABCD - be the color of the solstice and E - its pole, AEC - the ecliptic with its pole H, BED - the celestial equator with its pole G, F- the luminary whose deviation must be determined. (Fig. 16)

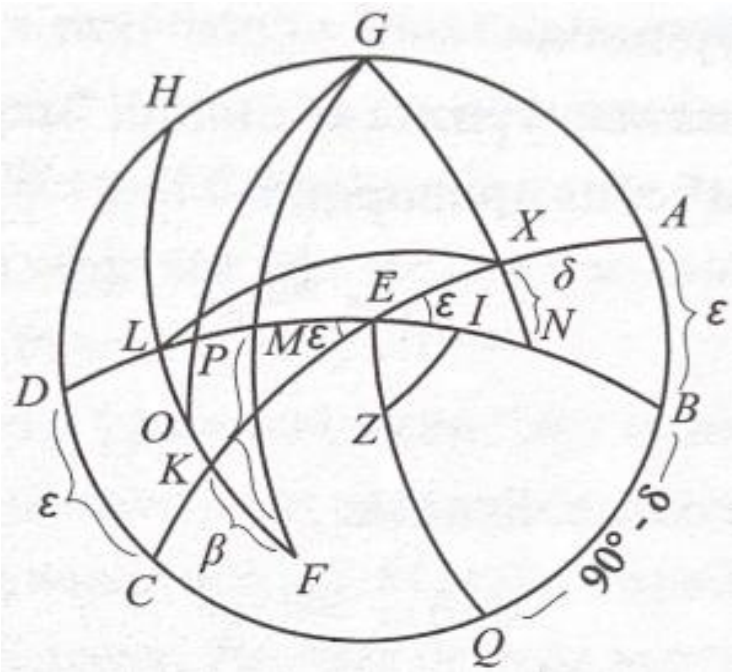


Figure 16.

Let the circle of deviation be FMG, and the circle of expansion FKLH. Then K points on the ecliptic - is the degree of illumination, that is $EK = \lambda,\ FK = \beta,$ $KL = \underline{\beta},\ FL = FK + KL = \beta + \underline{\beta} = \Delta\beta -$ is the "argument of distance", and $FM = \delta$ is the "distance".

Let KX be the radius of the quadrant, and draw a great arc of the circle NXG. Then XN is the "inverted deviation" of the point. Let the points L and X be connected by the arc LX of the great circle.

Since the poles of all expansion circles lie on the ecliptic, and the arc KH is a quadrant, then the pointX of the ecliptic is the pole of the expansion of FKLH. Since the pole of the circle GNX FKLH passes through X, it also passes through its pole. Since the poles of all declination circles lie on the celestial equator, the point L is the pole of the circle GXN, and the arcs LX, LN are quadrants.

Corner L of a right spherical triangle LXV is measured by an arc $XN = \delta$, and since the angle XLF is right, the angle MLF is the complement of the inverted deviation. That is,

$$\angle MLF = 90° - XN = 90° - \delta.$$

According to the spherical theorem for a right-angled spherical triangle with right angle M, leg $= \delta$, hypotenuse $LF = \Delta\beta$, the appropriate proportion is

$$\frac{sinM}{sinLF} = \frac{sinL}{sinMF} \; . \qquad (1)$$

The proportion after “lowering” by replacing the corresponding values takes the form

$$\frac{1}{sin\Delta\beta} = \frac{sin\delta}{sin\delta_*}$$

From this,

$$sin\delta = \frac{sin\delta_*}{sin\Delta\beta}.$$

In a right-angled spherical triangle DLH, according to the same theorem, the proportion

$$\frac{sinL}{sinDH} = \frac{sinD}{sinLH} \qquad (2)$$

follows from proportions (1) and (2)

$$\frac{sinME}{sinHD} = \frac{sinFL}{sinLH}$$

After taking into account the relevant values, the final proportion after making the appropriate substitutions is

$$\frac{sin\delta}{cos\varepsilon} = \frac{sin\Delta\beta}{cos\underline{\beta}}$$

takes shape. From this:

$$sin\delta = \frac{sin\Delta\beta \cdot cos\varepsilon}{cos\underline{\beta}}$$

This was confirmed by the reign of Ulugbek.

Now let it bethe luminary is located at a point between the celestial equator and the ecliptic: in this case $OK = ß$, the expansion $LK = \beta$, the "second deviation" $LO = LK = OK = \beta_1 - \beta_0 = \Delta\beta_0$ $-$is the argument of distance.

We pass the circle of deviation OPG. Then there will be a deviation of this point. Then $OP = \delta_0 -$ the deviation of this point. Then by the theorem of sines from a right-angled spherical triangle PLO with a right angle $L = 90° - \delta$ proportion

$$\frac{sinP}{sinLO} = \frac{sinL}{sinPO} \qquad (3)$$

is passing.

After substituting the appropriate values, the proportion takes the form

$$\frac{1}{sin\beta_0} = \frac{cos\delta_*}{sin\delta_0}$$

In this case $sin\delta_0 = sin\Delta\beta_0 \cdot cos\delta_*$. This confirmed the first rule of Ulugbek. Solving proportions (2) and (3) together to form the proportion

$$\frac{sinPO}{sinHD} = \frac{sinLO}{sinLH} \quad \text{or} \quad \frac{sin\delta_0}{cos\varepsilon} = \frac{sin\Delta\beta_0}{cos\underline{\beta}}$$

From here

$$sin\delta_0 = \frac{sin\Delta\beta_0 \cdot cos\varepsilon}{cos\underline{\beta}}$$

that is, the second rule of Ulugbek is also proven for point 0.

Birjandi supplements Ulugbek with a rule based on the use of longitude $FL = \lambda$ ecliptic. To do this, we first apply the theorem of spherical sines to a spherical triangle ELK with a right angle K and form proportions

$$\frac{sinK}{sinLE} = \frac{sinE}{sinLK}$$

from this $sinFL = \frac{sin\beta}{sin\varepsilon}$.

Then successively applying this theorem to spherical triangles KLE and FLM,

$$\frac{sinMF}{sinEK} = \frac{sinFL}{sinEL}$$

we create proportions.

$$MF = \delta,\ EK = \lambda,\ FL = \Delta\beta,\ EL = \frac{sin\beta}{sin\varepsilon},$$

we find after suitable substitutions.

$$sin\delta = \frac{sin\lambda \cdot sin\Delta\beta \cdot sin\varepsilon}{sin\underline{\beta}}$$

it can be proved that this formula is also true for the luminary. Let's consider a numerical example. Let the moon be at the beginning of Yavza, that is $\lambda = 60°$.

Its expansion will be $\beta = 5°$. The "second declination" of the Moon will be $\underline{\beta} = 20°38'18''48'''$. Thus, the distance argument is equal to

$$\Delta\beta = \beta + \underline{\beta} = 25°38'18''48''';$$

whose sine is $sin\Delta\beta = 25^p57'41''35'''$. For a point with $\lambda = 60°$ longitude, the sine of the complement "inverse deviation" is $cos\delta_* = 58^p47'41''43'''$. Of the last two values,

$$sin\delta = sin\beta \cdot cos\delta_* = 25^p26'24''27''',$$

from which it becomes $\delta = 25^{\circ}4'13''51'''$.

For the second rule withtaking into account we get $cos\varepsilon = 55^p1'17''53'''$

$$sin\Delta\beta \cdot cos\varepsilon = 23'48^p26'19''3'''.$$

Now, ureading that $cos\varepsilon = 56^p8'57''40'''$ and substituting the corresponding values into the second formula, we get:

$$sin\delta = \frac{sin\Delta\beta cos\varepsilon}{cos\underline{\beta}} = \frac{23'48^{p}26'19''3'''}{56^{p}8'57''4'''} = 25^{p}26'24''28'''$$

If the ecliptic is not a continuation of a degree, that is, a point is given on the ecliptic itself, then the deviation of this point δ is an arc of a circle perpendicular to the celestial equator, and the spherical distance from this point is the point of the ecliptic corresponding to the equator.

The illuminator's expansion circle is appropriate when it passes through the equinox point.Ulugbek's rule for determining the deviation δ in this case can be written as a formula

$$sin\delta = sin\beta \cdot cos\varepsilon$$

On the 17th In the figure we draw the circle of expansion EZQ so that it passes through the light Z to the equinox point E. Since the point A is one of the poles of this circle, the arc BQ has the complement of the greatest deviation - $90°E$ and it measures the angle E of the triangle BEQ. It is clear that IZ is the deviation of the light Z and the shortest distance from it to the equator. Applying the theorem of spherical sines to the right-angled spherical triangle EIZ,

$$\frac{sinI}{sinEZ} = \frac{sinE}{sinIZ}$$

we make a proportion.

$F = 90° - E,\ IZ = \delta,\ BZ = \beta,$ having made the appropriate substitutions, we find: what $sin\delta = sin\beta \cdot cos\varepsilon$ we want.

Nthe greatest value of the deviation of light is reached only at two points - the summer and winter solstices, that is, at the points of the solstice, Cancer and the beginning of the Zodiac. In these cases, the argument of the distance is the distance itself, equal to Y.

Since the distance of the "light" level to the nearest point is actually $90°$, the complement of this level is there fore $90° - L,$ if we say that the width of the illuminator is equal to ß, Ulugbek quoted here, “to the circle passing through the four poles,” that is, the Sun, the rule for determining the distance þ to the light of their positions can be written in the form sinþ $= cosLxcos$ß.

The main part of Ulugbek's "Zij" consists of trigonometric, astronomical, geographical and astrological tables. The sine table is given in Chapter 2.

The table of sines is constructed as follows: The first row above the table indicates the degrees, and the first column on the left indicates the minutes of the arguments of sines, i.e. their order is opposite to the order of the current trigonometric tables. The step in the column is equal to one minute, therefore in all manuscripts 60 lines from $0'$ to $59'$mitutes are given on two sheets ($from$ $0'to$ $29'$ and $from$ $30'$ to $59'$).

At the intersections of the degree column and the minute line, the corresponding values of the sines and the difference (time), i.e. corrections, are given. The values of the sines and corrections are given with an accuracy of up to six decimal places. With the exception of the sines $87°, 88°$ и $89°$ at the end of the table, which are given with accuracy to the decimal places. The maximum value of the sine is 60.

In the process of working with the tables, it was necessary to correct some figures in them according to the manuscripts used. These corrections varied from 15-20 to 40-50. In the entire table of sines alone, there were several hundred such corrections.

Comparison of the values of sines according to Ulugbek with the current ones shows that they are practically the same, since the difference, if there is any, is extremelyis small, so the graphs of the two values of this function do not differ significantly.

About the first shadow - zilli,to - tangent - 14 comments. The first half of the table of tangents, i.e. to ****, Ulugbek compiled on the principle of the table of sines. Here, too, the first line gives degrees, the first column minutes // and the values of tangents and differences at their intersection. But starting $45°$with Ulugbek increases the step of the table to $= 5^1$ and places the arguments only in the first table. The value of tangents is given in the table with an accuracy of up to a shift. Ulugbek called the length of the scale per unit, because in it $= I$ and in whole parts of the values of tangents he gives degrees of 60 degrees $89°5'$.

We have converted the values of 21 significant sines in the table of sines of Ulugbek to decimal places and compared them with the current values and gave suchtable: Table

Улугбекнинг sinus қийматларини замонавий қийматлар билан таққослаш жадвали

Даража	Улугбекнинг синус қийматлар		замонавий қийматлар
	в шестидесятеричных дробях	в десятичных дробях	
0°	0	0	0
5°	$5'13''45'''38^{IV}26^{V}$	0,08715	0,0872
10°	$10'25''8'''0^{IV}23^{V}$	0,1736	0,1736
15°	$15'31''44'''54^{IV}49^{V}$	0,2588	0,2588
20°	$20'31''I6'''21^{IV}3^{V}$	0,3420	0,3420
25°	$25'21''25'''32^{IV}40^{V}$	0,4226	0,4226
30°	$30'$	0,5	0,5
35°	$34'24''52'''30^{IV}37^{V}$	0,57357	0,5736
40°	$38'34''2'''7^{IV}25^{V}$	0 64278	0 6428
45°	$42'25''35'''3^{IV}53^{V}$	0 7071	0,7071
50°	$45'57''45'''35^{IV}59^{V}$	0,7660	0,7660
55°	$49'8''56'''50^{IV}30^{V}$	0,81915	0,8192
60°	$51'57''41'''29^{IV}14^{V}$	0,866	0,8660
65°	$54'22''42'''28^{IV}55^{V}$	0 9063	0,9063
70°	$56'22''53'''36^{IV}22^{V}$	0,93969	0,9397
75°	$57'57''19'''58^{IV}43^{V}$	0,9659	0,9659
80°	$59'5''18'''28^{IV}29^{V}$	0,9848	0,9848
85°	$59'46''18'''3^{IV}17^{V}$	0,99619	0,9962
87°	$59'55''3'''58^{IV}46^{V}14^{VI}$	0,9986	0,9986
89°	$59'59''27'''6^{V}7^{V}45^{VI}$	0,9998	0,9998
89°59'	$59'59''59'''59^{IV}27^{V}6^{VI}$	0,99999993	1,0

To determine the size of the tangent table, we compared the 20 most characteristic values from this table with the current tangents. Table

Улуғбек да тангес қийматларни замонавий билан таққослаш жадвали			
Аргумент	Улуғбек да тангес қийматларни		замонавий қийматларни
	шестидесятеричные	десятичные	
0°	0	0	0
5°	$5'14''57'''33^{IV}5^{V}$	0,087488	0,0875
10°	$10'34''46'''37^{IV}40^{V}$	0,1763	0,1763
15°	$16'4''36'''41^{IV}32^{V}$	0,2679	0 2679
20°	$21'50''17'''34^{IV}14^{V}$	0,36397	0,3640
25°	$27'58''42'''27^{IV}55^{V}$	0,4663	0,4663
30°	$34'38''27'''39^{IV}22^{V}$	0,57735	0,5774
35°	$42'0''44'''49^{IV}42^{V}$	0,7002	0,7002
40°	$50'20''45'''31^{IV}13^{V}$	0,83909	0 8391
45°	1^{P}	1	1
50°	$1^{P}11'30''48'''46^{IV}34^{V}$	1,19189	1,1918
55°	$1^{P}25'41''39'''58^{IV}10^{V}$	1,4282	1,4282
60°	$1^{P}43'55''22'''58^{IV}28^{V}$	1,7320	1,7320
65°	$2^{P}8'40''53'''29^{IV}41^{V}$	2,14469	2,145
70°	$2^{P}44'50''55'''7^{IV}21^{V}$	2,747	2,747
75°	$3^{P}43'55''32'''58^{IV}28^{V}$	3,732	3,732
80°	$5^{P}40'16''36'''52^{IV}23^{V}$	5,671	5,671
85°	$11^{P}25'48''11'''17^{IV}51^{V}$	11,43	11,43
89°55'	$11^{I}27^{P}32'55''55'''47^{IV}1^{V}$	687,543	687,5

The comparison shows that Ulugbek's table of tangents is also quite accurate for its time. However, both Ulugbek's table of tangents and the table of sines have one drawback: they only work on one side, i.e. it is impossible to determine cotangents from the table of tangents, just as it is possible to determine cosines in the opposite direction from the table of sines. Therefore, Ulugbek provides a separate table of cotangents.

In this table the values of cotangents are in two units, in fingers and in steps with an accuracy of up to solis, the step of the table $h = 1°$ of differences is not specified.

"In all used copies of Zij, the table of the "first deviation" consists of six sheets, the title of each sheet indicates the value of the greatest deviation. But in the lower right corner of the sixOn the leaflet a more precise value is indicated - $23^{\circ}30'16''58'''$.

Beruni gave such a table in "Kanuni Masudi". Along with the similarity of the tables, there was also a slight difference. Despite the fact that Ulugbek used the works of Beruni, he introduced major innovations. For example, if Beruni Hamala is considered the first level matolias $\lambda = 0°54'59''23'''$, then according to Ulugbek's calculation it was $\lambda = 0°55'1''18'''$, that is, it differed from Beruniy by $1''55'''$. Similar differences are also present in the fabric of the remaining degrees of the ecliptic. This is known from the fact that this table of Ulugbek was compiled completely independently.

Thistable - one of the largest tables of Ulugbek "Zij". It contains the values of the mat degrees of the ecliptic on the horizons from the earth's $1°$ до $50°$ latitude.

Ulugh Beg's first book, Zij, is devoted to the movements of the Sun, Moon and other planets. Although Ulugbeg's theory of planetary motion is generally Ptolemy's geocentric theory, except for some minor points, he does not mention Ptolemy's name in his theory, unlike Muslim astronomers before him.

"This book of Zij is the most complex part of his work, since it contains a number of concepts and phrases related to Ptolemaic astronomy, which Ulugbek considers already known, and gives almost no explanations or explanations and proofs of anybo theoretical proposal. Hussein Birjandi and Mirim Chalabi in their cities quote the introductory articles before this book, explaining the concepts of Ptolemaic astronomy used by Ulugbek.

"The subject of this chapter of Zij and the table under consideration is a fundamental question of astronomy since ancient times, because the question of the motion of the planets is connected with it. That is why astronomical works of all periods,including Muslim Zij, contain tables of ephemerides and planetary motions. In the Zij of al-Khwarizmi, one of the earliest examples of Muslim astronomical works (dated 840), Ulugbek's table is devoted to the "middle Sun", but the time period of these tables is limited to 1192 AH.

In the work of Kusher ibn Labban al-Jimi "Al Zij al-Jami" (date 1000) such tables are limited only to the 600th anniversary of Yazdigard (1231). Abu Rayhan Beruni in his "Book of Masudi" (date1031) can calculate the parameters mentioned by this Ulugbek, up to the year 820 of Yazdigard, i.e. until 1451. In "Ziji Elkhani" by Nasriddin Tusi (date 1231), these parameters are calculated until the year 791 of Yazdigard (1422).

This table of Ulugbek allows you to calculate these parameters not only for a limited period, but also for any amount of years of the Hijra. If you take into account that the year 1421 of the Hijra corresponds to 4618 AD, you can be surprised by the abilities of Ulugbek "Zij".

In the fifth and sixth columns of the table, the hexadecimal ranks of the main parameters are "increased", i.e. they must be "decreased" to determine hexadecimal numbers from them. For example, if the argument 15 hours is rounded to minutes, it will be 37 minutes. The arguments of hours 15 minutes 15 seconds can be determined from the same cell. They will be 37 seconds and 37 solis.

In Chapter 3 of the third book of Zij, Ulugbek defines the real positions of the planets. Ulugbek describes the "true position" of the planets in the calendar, but does not define them. Birjandi and other medieval authors say that the true position of the Sun is its ecliptic longitude, that is, the arc from the equinox of the ecliptic to the point where it intersects the equator of the Sun. The true position of the "beginning", that is, the lunar node, is also its ecliptic longitude.

But in the Zij of Ulugbek, by its very nature, not only the movement of the Moon, but also the movement of the planets in general, is not consistently described. This shortcoming of the Zij is fully compensated by Birjandi's commentary, since he explained the movement of the Moon in detail and somewhat facilitated the understanding of this chapter of Ulugbeg's work.

As Birjandi has repeatedly stated, Ulugbek relies in his Zij on the works of Nasriddin Tusi (1201-1274) Zij Elkhani and Tazkira fi ilm haya. Ulugbek's Zij consists of four books, as does Tusi's Zij Elkhani. In addition to these two works, Birjandi Ulugbek also mentions the works of Tusi's student Qutbiddin Shirozi, entitled Nihayat al-idrak fi dirayat al falak and At tuhfa ash shahiya. The scholars of Samarkand were influenced by the works of Nasriddin Tusi and his students.

The scholars of Samarkand interpreted the physical phenomena of solar eclipses in their own way, as well as lunar eclipses. The following passage from Hussein Birjandi's commentary on Zij gives a clear idea of it.

The Moon is a solid body that reflects the light of the Sun, and the Sun is larger than the Moon, so more than half of the Moon is always illuminated. The side of the Moon opposite the Sun is called the cone of the Earth's shadow.

Samarkand scientistsIt was established that the largest angular radius of the Moon during solar eclipses is equal to $18'26''$ and the radius of the Sun $16'5''$: their sum is equal to $34'31''$.

During a half lunar eclipse, the excess of the Moon's movement over the Sun's movement is called the moments of silence.

The eclipsed part of the Moon is measured in minutes. The moments of the eclipse represent the arc of a great circle, the center of which is the center of the Universe and which is part of the diameter of the Moon's belt during the eclipse.

In the era of Samarkand scientists, the possibility of accurately predicting a lunar eclipse in advance is less than now. Let us dwell on the terminology used by Ulugbek in eclipses:

Becausethe shadow is larger than the lunar eclipse, during a total eclipse the Moon will remain in darkness for some time. This period is called the time of total eclipse and is designated by the Arabic phrase "max". Half of this period is called maximum hours. The excess of the Moon's motion over the Sun's motion during half the maximum time is called maximum minutes. The first half of the lunar eclipse time is called the retrograde hour. The second half is called the hours of the eclipse's return.

To determine the true longitudes of the Sun and Moon and the latitude of the Moon, the scholars of Samarkand followed the "zij" as follows: the midday hours of the day are multiplied by the luminous bay and the product is divided by 24; To the longitude of this light at midday, the division is added to obtain its longitude at sunset.

In the Middle Ages, there were two views on the question of the position of the Moon in Muslim countries: one among the Indians, the other among the Arabs.

As for Ulugbek’s own astronomical observations, they should have begun long before the construction of the Samarkand Observatory, since the construction of the observatoryIt began in 1420 and according to some sources was completed the following year, and according to some sources it was not completed until 1429.

The story of Ulugh Beg "Zij", including the star map in it, was told several times on 1 Muharram 841 AH (5 July 1437 AD).

At the beginning of the table, Ulugbek's words "we observed and found" are extremely valuable for this story, since these words once again testify to the fact that the scientist himself compiled these tables and wrote "Zij". However, Ulugbek took into account that the stars move in 70 years according to the precessional. This pull is only longitudinal. Between the history of the Sufi book of Abdurrahman in 964 and the history of Ulugbek "Zij" in 1437, 573 years passed. The longitudes of the stars in Ulugbek's maps should have changed more than compared to the longitudes in the Sufi maps.1°8°

Ulugbeg's "Fixed Star Chart" has been published several times in the past. It was first published in Persian by the English scholar Thomas Hyde in Oxford in 1665. Then the table was published twice more in England: by H. Sharp in 1767 and by Bailey in 1843.

The table has been prepared for publication on the basis of ten manuscripts stored in the libraries of Tashkent, St. Petersburg and India. Like other tables of Ulugbek, it is explained intable of fixed stars. He compared the longitude and latitude of the tables with the longitude and latitude of the Sufi tables and Beruni's tables. Ulugbek and his two predecessors divide the magnitude of their stars into six ranks and consider the star of the first rank to be the largest, and the star of the sixth rank to be the smallest.

A used copy of Zij has a completion date stamped on it, like this one.

It is common knowledge that the great geographical discoveries were made in the 17th-18th centuries and that they were carried out mainly by the English. Of the 1018 stars in Ulugbek's "Zij", only 310 are southern, all the rest are northern, but a British sailor - a ship captain of the 17th - 18th centuries was able to observe the stars in all the seas and oceans, they served as a guiding star for him.

Vasco da Gama was the first European to visit Eden in Asia in 1487. But there was Ahmed ibn Majid, an Arab Lasman from Panjshir, who knew his Muslim traditions well, including those of Ulugh Beg.

However, Vasco da Gama, being Portuguese, had no successors in his homeland, and the Portuguese in general, unlike the English, could not develop either scientific or literary maritime literature in their native language.As a result, the Portuguese occupation of Aden came to an ignominious end.

The greatness and vitality of Ulugbek's Zij is that the chapter of the first of his four books is called "On the Determination of the Epochs of China and the Uighurs" and in it he studied the Chinese calendar very well.

The Chinese calendar consists of calendars and periods, which are further divided into smaller parts in their own way, although they started their calendar from the moment of the creation of the universe.

One of the eras of the Chinese calendar begins in 204 BC. According to the Chinese calendar, the earliest period is 60 years, and the Chinese call it Shan Yuan. They called the second 60-year period Zhang Yuan and the third Xia Yuan. Thus, the total number of terms is 183 years. Three of these 180-year periods make up a large period of 540 years. Thus, from 204 BCFrom our era to the year 2021 of our era, 2225 years have passed, which is 4 of the 540-year great period, that is, 2140 years, and another 55 years, which is the fifth 540-year great period, the second 25 years of 60 years.

Hussein Birjandi interprets this calendar as 1524 AD. What was the need for Ulugbek and Birjandi to know the Chinese calendar in detail? Perhaps there are reasons unknown to us. But at that time, Ulugbek's estate and the Chinese lands were far from each other and completely independent. Despite this, the question of Ulugbek's Chinese calendar "Zij" remains open.

Perhaps Ulugbek foresaw the great future of China? Whatever the case, Ulugbek's "Zij" is the greatest monument of science of the 15th century, and it will live as long as the Chinese calendar.

Ulugbek's work "Zij" as an outstanding creative workaffairs of the Samarkand scientific school of the 15th century, arose from the importance of directing its information to Chinese scientific and practical astronomy.

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