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Little known aspects of the history of Georgian astronomy

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Abstract

The present paper reviews the fundamental achievements of ancient Georgian astronomy and the dynamics of the process by which the Georgian astronomical world view developed in the period from the sixteenth century BC to the eighteenth century AD. It is during this period that the Georgian astronomical world view both formed and became fully developed. The author of the present paper divides this extended period into three shorter periods: an archaeological period, a transitional period, and a period of systematics. The characteristics of these three periods are cited. The paper also presents various facts and other information that illuminate the life and work of Georgian astronomers as well as the functioning of ancient Georgian astronomical and other scientific institutions. Several Georgian astronomical manuscripts are mentioned and described in brief, and a number of other questions are also discussed.

Keywords: *Georgian astronomy, cosmograms, David Gareja complex, Gelati Observatory, Narikala Observatory, The Star Book, Vakhtang IV Bagrationi*

1 INTRODUCTION

The aspect introduced here is quite complicated and an arduous Georgian history makes this task even more difficult. Information and materials, sources and facts have to be gathered piece by piece as precious stones on the beach of an impetuous history. This study is merely a first step in documenting a history of Georgian astronomy, and in this paper we try to reflect the dynamic process by which astronomy developed in Georgia over a protracted period of time. We subdivide this period into shorter periods: an archaeological period, a transitional period, and a period of systematics.

Georgian astronomical and astrological manuscripts, that until now have been unknown to Western researchers, are deserving of study. Approximately 300 such manuscripts are preserved in the various institutes and archives of Georgia. These manuscripts form a huge monolith of astronomical data that bring information of a relict character. These manuscripts did not disappear in the fire of social and natural cataclysms, did not sink into oblivion in the depths of ancient centuries. They were preserved through the self-sacrificing work of Georgian authors, translators, and copyists. It is possible that there are many unknown, unstudied sources of historical-astronomical information in the world – in particular in those countries that are only now re-establishing themselves as independent states. Therefore it seems expedient to propose the creation of an international institute of 'unstudied' historical-astronomical materials or, for that matter, of 'unstudied' historical-scientific materials in general. Such an institute would study the previously-unknown materials and would publish the study results in special bulletins in order to bring the 'new-old' information to the attention of the international scientific community.

The ruins of old observatories, fragments and remains of instruments, numerous manuscripts and books, unclaimed discoveries, and forgotten names – this is the world of ancient Georgian astronomy, which until now has been little known outside of Georgia.

The state of Georgia (see Figure 1) is located in the Caucasus on the very border between Europe and Asia. The Black Sea, Caucasus Mountains, and thick forests together create a unique, beautiful landscape and healthy, temperate climate. This territory was already populated by Georgian tribes in ancient times, and a Georgian state has existed for more than twenty-five centuries. Over these long, difficult centuries the Georgian people created their own language, culture, and world view. Numerous monuments of literature, art, and architecture bear witness to the original culture of these people.

Fire worship and other religions were widespread in Georgia until the fourth century AD. Christianity began to spread across Georgia in the first half of the fourth century, and within 100

years it had acquired the status of the state religion. This process was brought about by the strong political and cultural influence emanating from the eastern provinces of the Roman Empire, with which Georgia had close relations. Poti, on the Black Sea near the ancient city of Phazis, was both one of the first cities and one of the first cultural centres. Later Kutaisi and Mtskheta became major cities and cultural centres. At the present time Georgia's most important city and cultural centre is Tbilisi, which is also the capital of the Republic of Georgia. This city was founded in the fifth century AD by the Georgian king and military leader Vakhtang Gorgasali.

Figure 1. Location map of places mentioned in the text.

Celestial phenomena interested Georgians from ancient times. This is confirmed by real proofs. Oral folk art has brought down to us ancient Georgian sayings and legends that mention individual celestial bodies, various celestial phenomena, and so on. The principal thought or moral of such legends was the 'supremacy of celestial laws' and the 'inevitability of punishment by powerful celestial forces'. The ancient Georgians attached a mystical character to the sky and to celestial phenomena, thereby acknowledging their full grandeur. Ancient material objects of brass, bronze, silver, and gold have also come down to us. When we examine these ornaments, implements of labour, weapons, and household wares, we see images of the Sun, Moon, and stars presented in various shapes and sizes. The fact that ancient Georgians depicted celestial bodies on material objects shows that celestial phenomena interested them.

2 THE ARCHAEOLOGICAL PERIOD

What are the most ancient material objects containing images of an astronomical character? In the 1940s Georgian archaeologists (Gambashidze *et al.*, 1986) discovered bronze plates dating from the sixteenth to the fourteenth centuries BC. In all about thirty plates were discovered – primarily in the graves of women – at various burial sites including the large burial ground known as 'Zadengora'. The plates are massive and measure several tens of centimetres in diameter. Their surfaces are covered by numerous convex, circular apertures, Figure 2. Until now Georgian scientific literature has examined these plates only from the archaeological point of view. In the present article we shall examine them from the astronomical point of view for the first time.

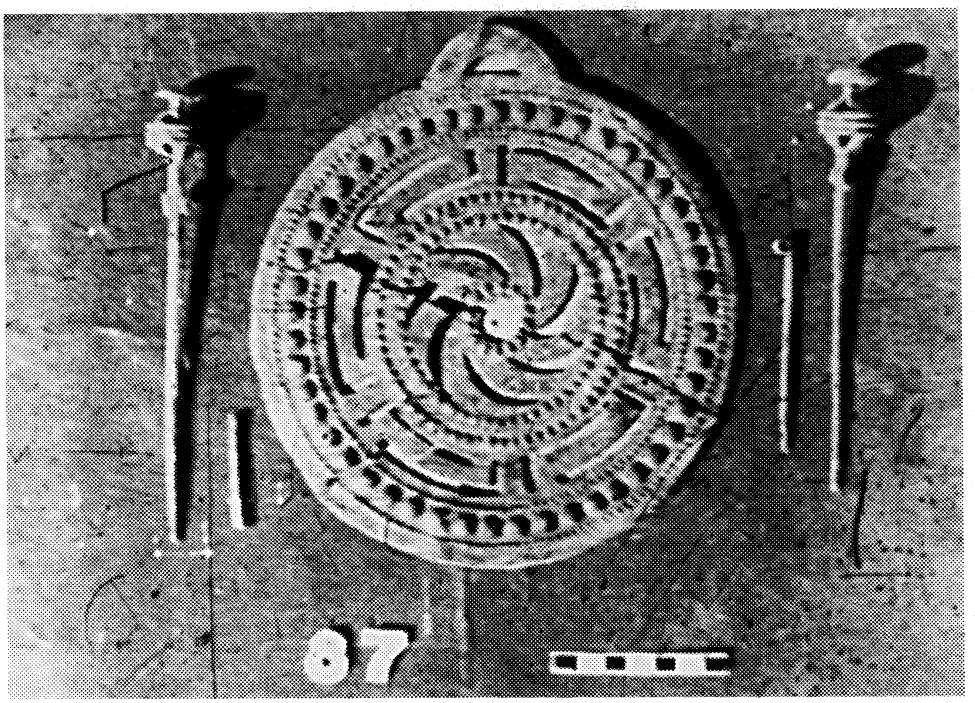

Figure 2. Georgian bronze plate, circa fifteen century BC.

Georgian tribes that populated the eastern regions of Georgia in the sixteenth to fourteenth centuries BC supported themselves mainly through agriculture and by raising cattle. These tribes practised fire worship. Worship of the cults of fire, heat, and light played an important role in the lives of the Georgian tribes. Giving tribute to the Sun as the principal source of light and heat and also seeing its large dimensions, the ancient masters and artists depicted it in the centre of the bronze plates in the form of a circular aperture.

The Moon served as another important source of light for the ancients. It was precisely the Moon that supplied them with bright light at night. Phenomena such as changes in the phases of the Moon provoked their special interest and had overtones of mysticism. As a result, the Moon was depicted on the bronze plates in the form of a sickle-shaped aperture.

The ancients also saw other celestial objects in the sky and noticed that they differed from each other in form, brightness, and colour. Trying to reflect these differences, the ancient Georgian masters gave varying outlines to the spherically-shaped protuberances on the surfaces of the plates. Thus the ancient bronze plates reflect what the Georgian tribes saw in the sky. The religious views of the tribes also played an important role in the distribution of images of celestial bodies on the ancient bronze plates.

The character of the pictures on these bronze plates is clearly systematic. Perhaps the artisans of these plates have put their cosmological understanding in them? Therefore it is suggested to call these ancient Georgian bronze plates 'cosmograms' (Simonia, 2000). It seems to us that these Georgian cosmograms are the earliest known material objects in Georgia to include astronomical images. At the present time the cosmograms are preserved in various Georgian museums and institutes. It would be interesting to conduct a comparison between the Georgian cosmograms and analogous objects that can be found in other parts of the world.

The most ancient Georgian states were formed in the sixth century BC. The western Georgian state was known as Kolkheti, and the eastern Georgian state was called Kartli. (Some literary sources call Kolkheti by the name Egrisi and Kartli by the name Iveria.) New societies and institutions characteristic of that time began to take form in these two Georgian states. Agriculture and cattle-raising continued to develop, but artisanal professions and trade with neighbouring and distant states also arose. In the third century BC the Georgian king Parnavaz united the western and eastern Georgian states into a single state. At that time the religion of Fire-Worship was widespread.

The principal Georgian god was the Moon, which was seen as the symbol for a male warrior. The Moon's sacred animal was the bull, and thus bulls were frequently given as sacrifice. The shape of the bull's horns reminded the ancient Georgians of the Moon. Various depictions of the bull and his horns were widespread on the walls of religious buildings and in the homes of the ancient Georgians. Statues and statuettes of bulls (see Figure 3) and other sacred animals likewise spread widely. Such animals as the lion, boar, donkey, and deer were worshiped by the ancient people and this is the reason for their sacred representation of these animals. Relief images of sacred animals and geometrically complex Georgian ornamental design compositions were cut into the surfaces of such metal objects as containers, women's jewellery, shields, and so on. Among the various compositions and graphical fragments, the diverse symbols and signs of a clearly astral character are of special interest (Figure 4). Symbols showing spatial relationships and symbols of motion are especially widespread.

King Parnavaz played an important role in the development of Georgian language and culture. In the third century BC he invented the first Georgian alphabet. In doing so he became the founder of the written Georgian language, the history of which has been studied by the French orientalist Mary Brosset and the Georgian historian Simon Kauhchishvili (Brosset, 1849-1858). The creation of writing served as a turning point in the development of Georgian culture. The first written inscriptions appeared on material objects, and the process of developing a literature began. We believe that the development of the early Georgian astronomical concepts culminated simultaneously with the creation of a written language. This early period encompasses the sixteenth through the third centuries BC. We propose that this early period be called the archaeological period. In the course of this period the following two processes developed: a) acquisition of the simplest primary knowledge of the sky and celestial objects by the ancient Georgians and b) representation of this acquired knowledge in culture, in oral works, and in the applied arts.

Figure 3. Statuette of bull.

The acquisition of knowledge during the archaeological period, and likewise the invention and spread of a written language transformed and expanded the world view of the ancient Georgians. A new class of citizens appeared in society – a class whose principal activities included the writing of chronicles, the development of grammar and arithmetic, and so on. From this class we must take note of those (generally people close to the king) who were charged with making regular observations of celestial bodies insofar as these were seen to be higher powers upon which earthly life depended. The observers of that time undoubtedly would have noted that many climatic phenomena (e.g., river flooding, cooling and warming trends) were preceded by various celestial phenomena, such as the appearance of certain stars, and the disappearance of others. Having noted this type of regularity, the ancients would have tried to use it for their practical aims such as agriculture. Purely earthly concerns such as fertility and crop yield would have caused the ancients to study deeply and in detail the regularities in the

disposition and motion of celestial bodies. In this way the prerequisites for the appearance of astronomy as a science were created – in particular the prerequisites for those important parts of astronomy concerned with chronology and the calendar.

Figure 4. Relief images of sacred animals on Georgian silver cup, third century BC.

Georgian historical manuscripts and notes that form a historiography called *The life of Kartli* (Kaukhishvili, 1959) tell us that in the second century BC Georgia used a lunar calendar, and we know that this lunar calendar continued to be used until the end of the third century AD. These chronicles have provided us with the ancient Georgian names of the known planets: Mercury–Djimagi, Venus–Mtiebi, Mars–Tarkhoni, Jupiter–Obi, and Saturn–Morige. These names were used in Georgia until the end of the third century AD. In the fundamental work of Ivane Dzhavahishvili, *The History of the Georgian Nation* (1949), it is shown that Mtiebi is an ancient Georgian word meaning 'the star of sunrise', that is, Venus. The word Morige in the ancient Georgian language meant the name of the highest God of the 'seventh sky'. In some parts of Georgia it was believed that Morige was a god of order. Dzhavahishvili compares Morige with Chronos. He also mentions that the word Obi (or Vobi) meant the name of the God of thunderstorm in ancient Georgia. He therefore compares Obi with Dios. In the same work it is also mentioned that the word Djimagi named the God of Wednesday, which corresponds to Hermes or Mercury, while the word Tarkhoni means the God of War, which corresponds to Mars. Dzhavahishvili stresses that all the above names were widely spread in both Eastern and Western Georgia. The history of these names themselves goes back as far as the times of fire-worship and heathenism. When working on this part of the paper it was thought that it would be a good idea to create a dictionary of ancient astronomical terms and names. Such a dictionary could comprise Arabic, Greek, and Georgian terms and names. Analysis and comparison of these names could lighten up many interesting questions of the history of astronomy. We only have to find co-authors from the East and West.

The existence of a calendar and of Georgian names for the planets tells us that in the period between the second century BC and the third century AD, the Georgians had some degree of knowledge of celestial phenomena and that they used this knowledge in practical life. Naturally, at that time this knowledge could only have a limited character.

3 TRANSITIONAL PERIOD

The period from the second century BC to the third century AD was a transitional period in the development of the Georgian astronomical world view. This transitional period was characterized by simple astronomical observations and likewise the creation and use of the first calendars. It was the priests who observed the sky and who played an important role in the organization of regular knowledge, and during this period many generations of priests succeeded each other. Unfortunately, the Georgian chronicles do not give us their names.

The spread of Christianity in Georgia in the fourth century AD gave an impulse to the development of new elements in Georgian culture. New, progressive – in the context of that time – ideas and views as well as knowledge of man and the world penetrated into Georgia. A feudal society began to form. The first schools and educational institutions began to spring up. The process of systematically translating foreign books into the Georgian language began, and new knowledge enriched the Georgian astronomical world view.

4 PERIOD OF SYSTEMATICS

In the second half of the fourth century AD the Julian calendar came into use in Georgia, and from this moment a new period in the development of the Georgian astronomical world view begins. This period can be called the period of systematics. Fragmentary evidence from various sources shows that in the fifth and sixth centuries AD the teachings of the Greek astronomer Claudius Ptolemy began to spread in Georgia. Ptolemy was a popularizer of the geocentric theory. The educated sections of the population (i.e., the priests and the king's courtiers) evidently were well acquainted with the geocentric system. In the Georgian language there exists the word 'Dedamitsa', which literally translates as 'mother Earth'. Here the word 'mother' signifies beginnings, the start of existence. Thus the question arises, did this word not appear at that time when the ideas of geocentricism first penetrated into Georgia? Additional study will be required to answer this question.

In the sixth century AD the priest Father David and his students founded the David Gareja complex in the rocky mountains of Gareji near Tbilisi (Dzhavakhishvili, 1949; Gubinashvili, 1948). The monasteries in this complex were hollowed directly out of the rocks. In various historical periods the number of monasteries grew to as many as twelve. In the seventh through the ninth centuries AD, David Gareja became a major religious and educational centre, and regular observations of the celestial bodies were conducted there. The works of foreign authors were translated into Georgian. At David Gareja a large library of philosophical works was collected. In our view David Gareja could be, in fact, the first Georgian astronomical centre. This complex continued to function through several more centuries, surviving periods both of flourishing activity and of decline. Fragments and ruins of this complex have been preserved until the present time (see Figure 5). Unfortunately, the sources of the above information do not give any details of the scientific research that was carried out in David Gareja.

The earliest manuscript containing astronomical information to survive to the present day dates from the tenth century AD (Kevanishvili, 1951). This manuscript is 263 pages in length, is written using letters from the first Georgian alphabet, and has both religious and astronomical content. The manuscript illuminates questions of chronology, and it describes and gives tables for computing solar days and months (see Figure 6). It discusses the regularities in the day-night cycle and gives other information as well. Evidently the manuscript's religious portion is not itself an original work but is, rather, a translation into Georgian. This manuscript is the first historical document bearing witness to the development of astronomy in Georgia.

In addition to the above we have to say that the name of the author of the manuscript or the name of the copyist who completed his work in year 974, is unknown. The catalogue of Georgian astronomical manuscripts by Galaction Kevanishvili states, though with no proof, that this manuscript is a copy. This at least means that the original manuscript was of an earlier date. We cannot confirm nor disprove the hypothesis that this manuscript has been copied. The manuscript deserves a special study.

Chronicles and other historical materials give evidence that at the end of the first millennium an astronomical observatory was functioning in Tbilisi, in the region called Narikala. The available materials do not allow us to establish the precise date of this observatory's founding, but these same materials do show that it was active in the tenth century. Staff at the observatory carried out various predictive computations and practical observations, and compiled tables and calendars. They also translated the works of Greek and Arab astronomers. There is evidence that Arab astronomers worked at the observatory for an extended period, and thus we cannot exclude the possibility that information about the Narikala observatory could be found in Arab sources. The observatory continued to function until the fourteenth century.

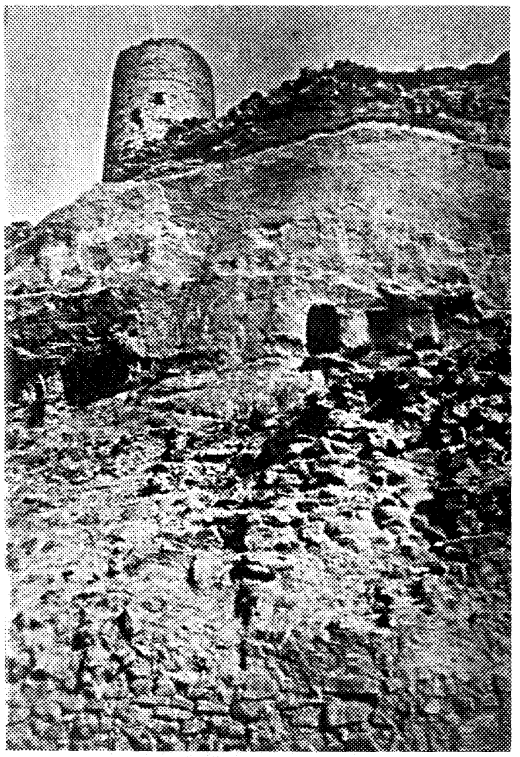

Figure 5. Ruins of part of the David Gareja centre from sixth century AD.

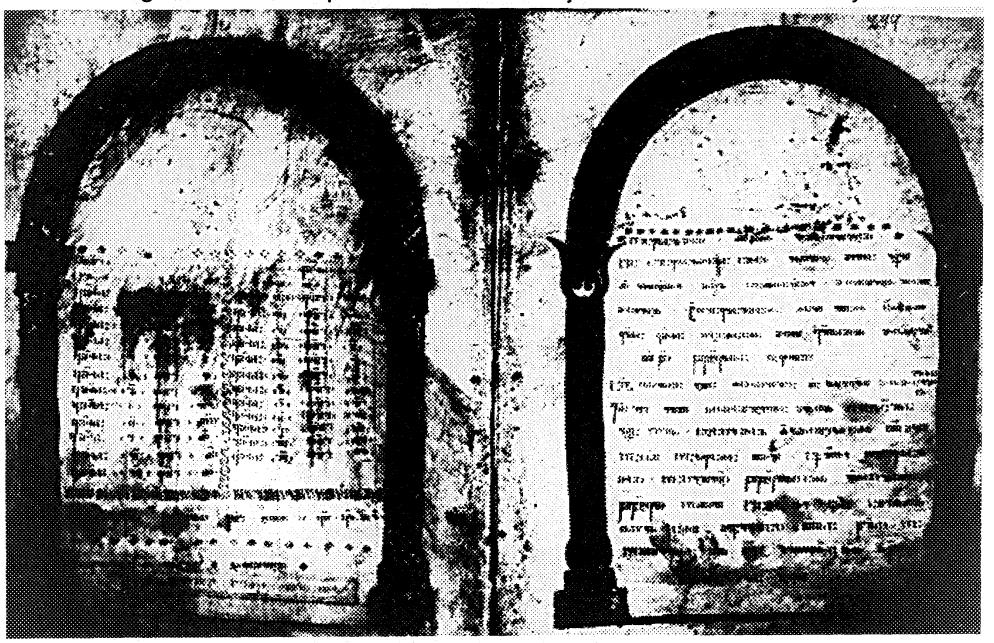

Figure 6. Page from Georgian manuscript, tenth century AD.

In the thirteenth century the Georgian and Eastern astronomer Khlateli (or Ikhlati) worked at the Narikala observatory (Kharadze and Cochlashvili, 1958; Kharadze, 1975). Using simple instruments for making angular measurements, he conducted observations from which he compiled tables, calendars, and so forth. Ikhlati was also a good computer. The well-known Eastern astronomer Nasireddin at-Tusi took note of Ikhlati's scientific abilities and invited him to work at his observatory at Maraga, where Ikhlati adopted the name Fakhredin Ikhlati. As shown in Matvievskaia and Rozenfel'd (1983), Ikhlati was an Eastern astronomer, and one of the closest co-workers of Nesireddin at-Tusi. The authors call the astronomer Fakhr Ad-Din Al-Maragi. We do not know the years when he worked in Georgia. A fair question arises here:

what was the actual name of this astronomer – Ikhlati, Fakhr Ad-Din or Khlateli? In our opinion, he can be called by any of these names, as he contributed to Eastern and Georgian astronomy.

In 1106 the Georgian King David IV Bagrationi founded the scientific and cultural academy Gelati in the western part of Georgia, not far from the city of Kutaisi (Gamsakhurdiia, 1975; Kaukhchishvili, 1948). David IV (1073-1125) played a special role in the history of the Georgian state. Having only a small army, he nevertheless succeeded in liberating Georgian territory from foreign invaders. He also succeeded in uniting the fragmented parts of Georgia into a single state. David IV created state institutes and structures that were progressive for their day. In addition, he devoted a significant amount of time to scientific and cultural activities of various kinds. David IV has gone into Georgian history as David the Builder. He is buried in the grounds of Gelati.

Several of Gelati's buildings and structures have survived to the present day. Some sources (e.g. Kareeva, 1894 and Khakhanov, 1898) note that the Georgian philosophers Arsen Iqaltoeli and Ioanne Petritsi were invited to work at Gelati, where they conducted active scientific, pedagogical, and translating work. These same sources indicate that geometry, arithmetic, music, philosophy, rhetoric, grammar, and astronomy (or, as it was called at that time, astrology) were all taught at Gelati.

Gelati had an astronomical observatory (Figure 7) where a variety of observations were carried out using astrolabes and other instruments. David the Builder in his own works writes that he devoted many nights to the stars, studying their positions in the sky and their effect on the fates of man and the state.

The Georgian astronomer Abuserisdze Thbeli (1190-1240) made an appreciable contribution to the development of the Georgian astronomical world view. Working in the ancient Georgian language, he wrote a fundamental treatise on calendars and chronology, the title of which can be translated approximately as *The Complete Time Keeper* (Dzhavakhishvili, 1945; Lordkinanamidze, 1977). This treatise contains information related to calendars, descriptions of different systems for maintaining chronology, dates of church holidays, tables of moonrise and moonset, information on special cycles, and so on.

Abuserisdze Thbeli did not conduct astronomical observations himself, nor did he work in any astronomical laboratory. His treatise has a theoretical character and is connected to a large degree with his mathematical investigations. *The Complete Time Keeper* is, in fact, the first astronomical work of a theoretical nature produced in Georgia, and this elevates Abuserisdze Thbeli to a special place in Georgian astronomy.

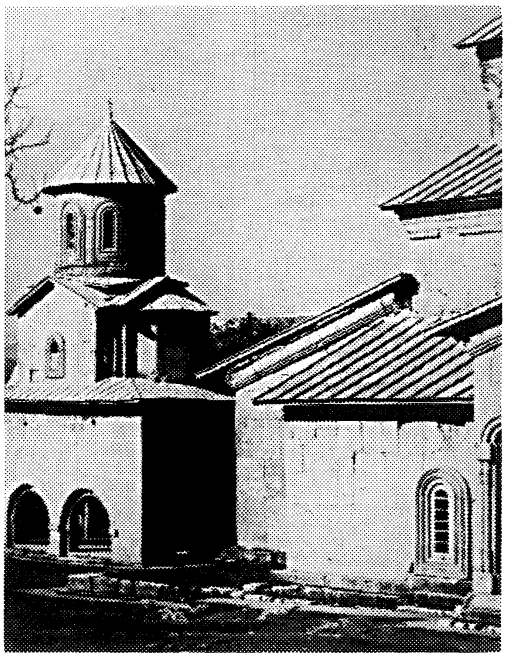

Figure 7. The astronomical observatory at Gelati.

Analysis of manuscripts, books, and material objects shows that the basis for the Georgian astronomical world view in the tenth through the thirteenth centuries remained Ptolemy's geocentric system, a description of which can be found in almost every astronomical manuscript from that period. There are some variations in the description from one manuscript to another, and there are differences in detail. Nevertheless, one can find mention of the Ptolemaic system even in non-scientific manuscripts. These facts show that the geocentric idea had complete control of the minds of Georgian astronomers and philosophers at that time.

The scientific work of Georgian observatories in the tenth through the thirteenth centuries expressed itself primarily in the study of star positions. The following peculiarity is noteworthy: as a rule those manuscripts containing the fundamentals of theory are translations of foreign authors into Georgian, whereas the manuscripts and books of a calendar-chronology character belong to the pens of Georgian authors. This fact implies that fundamental theoretical ideas penetrated into Georgia from outside. The Georgian astronomers and philosophers concerned themselves with developing the more practical, applied areas of astronomy that were necessary to both the people and the state. In particular, they concerned themselves with those practical areas that were needed for the construction of precise calendars, for the determination of time periods, for the prediction of dates for church and civil holidays, and for commercial, military, and other purposes. This was natural, of course. One cannot imagine the normal development of a state without knowledge of precise time, or without the possibility of predicting climatic phenomena connected with the different seasons of the year. We could give the name 'scientific systematics' to these practical works by Georgian astronomers.

Such systematics have both positive and negative aspects. On the negative side, extreme practical aims pushed aside the important necessity of perfecting basic theoretical ideas. On the positive side, the deepening of practical knowledge and habits must have stimulated the development of related disciplines. In particular, constant improvements in the calendar system in Georgia gave a powerful stimulus to the development of Georgian mathematics.

Of course, early scientific systematics were not unique to Georgia. Other countries with analogous social and economic structures and with analogous world views also passed through this phase. An interesting peculiarity of that time is that along with astronomical information and descriptions, the majority of written materials also contained astrological information. As a rule, the astrological information encompasses those questions concerned with predicting, forecasting, or otherwise determining people's fates in accordance with the disposition of the stars and so forth.

Society at that time continued to be under the influence of various types of mystical ideas and concepts. We can conjecture that there was something like a state-supported institute of astrologers in Georgia and that Georgian kings had court astrologers who were responsible for predicting the fate of the king, the state, and even individuals. Astrologers wrote their works, compiled tables and graphs, and distributed all of this among the appropriate layers of society. It is interesting to note that manuscript materials always exhibit a sharp, definite dividing line between their astronomical and astrological parts. It was usual that certain paragraphs in these manuscripts would be devoted to astronomy, while other parts would be concerned with astrology. Astrological predictions in Georgian manuscripts may be characterized by descriptions of life and health of a man in various periods of time (months, weeks, days). These facts demonstrate that in Georgia in the tenth through thirteenth centuries the distinction between astronomy and astrology was already understood. Figure 8 shows the use of symbols for the zodiacal constellations in a Georgian manuscript (Kevanishvili, 1951).

We should like once again to turn to the catalogue of Georgian astronomical manuscripts by Galaction Kevanishvili (1951). It states that the above manuscript contains 209 pages. It was copied (into ancient Georgian language) in 1210, by someone named Isaim. The pictures of zodiacs and Moon phases are done in gold. The manuscript contains descriptions of calendar systems, zodiacs, and Moon phases. Unfortunately, we do not have any reference to the name Isaim.

The most complicated period in Georgian history began with the start of the Tatar-Mongol invasion in the middle of the thirteenth century. This invasion involved numerous battles and resulted in widespread death among the population, and the destruction of cities and cultural centres. The Tatar-Mongols attempted to seize the territory of Georgia. However, loyal

Georgian armies and strong opposition among the populace became an insurmountable barrier in the path of the newcomers. Although at a great cost, the Georgian government was preserved, and relative peace was restored. But Georgia to all intents and purposes lost its freedom through external political action, being forced to pay large tributes and to supply soldiers for the Tatar-Mongol armies on a regular basis.

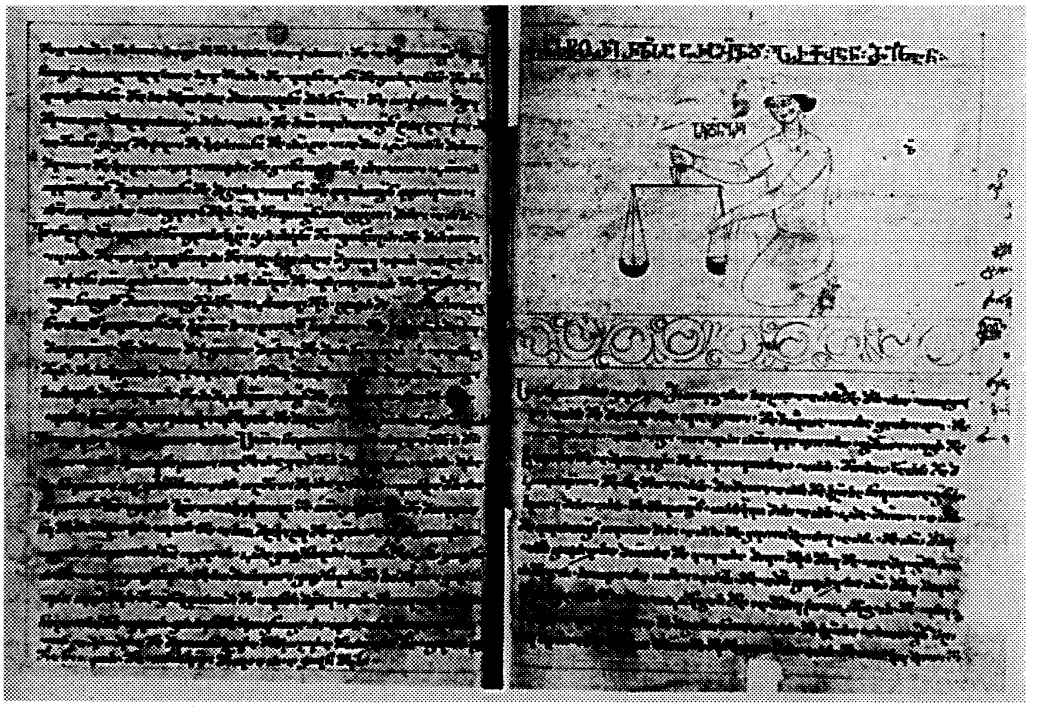

Figure 8. The zodiacal constellation of Libra depicted by symbols in an ancient Georgian manuscript.

Georgian King Georgi V (reigned 1313-1346) used flexible politics to strengthen the Georgian state. As a result Georgia was able finally to free itself from the Tatar-Mongols by the middle of the fourteenth century. This period of calm turned out to be short, however, with Tamerlane's (Timour, 1335-1405) invasion beginning at the end of the fourteenth century. Georgian soldiers and people resisted fiercely, but the forces proved too unequal. Nevertheless, resistance continued. One of the most notable resistance figures was Georgian King Georgi VII (reigned 1393-1407). With the death of Tamerlane, Georgia once again secured its liberation.

The events of the thirteenth through the fifteenth centuries had a negative effect upon the development of Georgian culture and science. The invading hordes destroyed the academies and observatories and burnt the libraries, and the Georgian people had to start over again from the beginning. The process of restoring the Georgian state began at the start of the sixteen century. Cities and cultural centres were resurrected, schools were opened, and the people gradually returned to their accustomed style of life.

The resurrection of scientific thought accompanied the general restoration of the state. Special interest was paid to the science of the sky – in particular to its practical applications. In the sixteenth and seventeenth centuries no fewer than nineteen astronomical works were translated into Georgian – most of them dealing with calendars and chronology. Georgian authors, translators, and book copiers all realized the importance of restoring astronomical knowledge, which to all intents and purposes had been lost in the period from the thirteenth through fifteenth centuries. The writing and translating of astronomical manuscripts continued even into the eighteenth century.

Let us take a closer look at one of these manuscripts entitled *The Star Book*, which dates from the beginning of the eighteenth century (the original is preserved in the Georgian Manuscript Institute in Tbilisi under catalogue No. Q 867). The manuscript, whose author is unknown, consists of 250 pages and is divided into 31 chapters, each of which is devoted to a specific topic of an astronomical or astrological character.

On page 7, chapter 1, of *The Star Book*, we find the following statement: "Zokhar has a single star in the sky." Zokhar is Venus, and the reference to a star "in the sky" is a way of indicating that Venus has a satellite. On page 8 we also find: "Marekhi has a single star in the sky." Marekhi is Mars, and the reference to a star here is also a way of indicating the presence of a satellite. In both cases the manuscript gives a measure of the satellite's orbit. It is difficult to explain these two statements. At that time there were no optical instruments capable of revealing the satellites of Mars, and of course Venus has no satellites at all.

Chapter 8 of *The Star Book* concerns the Moon. Page 42 states: "First we must know that God created the Sun and Moon and ordered that the Moon should receive its light from the Sun. The Moon itself is blank. The Moon illuminates us after receiving its light from the Sun." These quoted sentences, translated from Georgian, show unambiguously that the manuscript's author understood the fact that the Moon shines by reflected light. Page 42 also includes the statement: "Many philosophers, first of all Alexander, say that Galileo built a ten metre tube and, after using it, asserted that the visible dark spots on the Moon's surface are in fact mountains, seas, and rivers." The description of a 10-metre telescope is confusing but we have given the exact meaning of this part of the manuscript. Nevertheless, this citation shows that the author was acquainted with seventeenth and eighteenth century European literature and knew of some of the achievements of European astronomers. The author of the manuscript does not give any information about Alexander, but we have done a wide search of the sources (Metreveli, 1979), and among a long list of names we found Alexander Bagrationi (1674-1711), the son of Georgian King Archil II Bagrationi. Apparently Alexander Bagrationi was doing a lot of things, including translating and copying of the manuscripts Our careful guess is that this is the same Alexander.

Chapter 12 deals with eclipses of the Sun and Moon. Page 59 states: "Belorano was a scientist who for wisdom has no equal in our times. If he had lived at the time of Aristotle, then the latter would have paled before him. This scientist greatly simplified astronomy. He could determine in which year, in which month, in which week, on what day, and at what time eclipses of the Sun and Moon would take place." In translating these lines from the Georgian language we have tried our utmost to preserve the author's style. It is apparent that the manuscript's author was familiar with the scientific works of the European astronomer Belorano. Figure 9 shows page 59 of the manuscript together with an original drawing. On page 60 we find a detailed description of the conditions for both total and partial solar and lunar eclipses. Unfortunately, all our attempts to determine who Belorano was have failed. We hope that our collegues will be interested in this question and we will be able to solve it together.

Chapter 14 concerns planetary motion, and page 72 contains a drawing that reflects the author's cosmological world view. From the centre to the edge we find regions that are labelled as follows: "Earth water," "air," "fire," "sky Mtvare" (the Moon), "sky Otarid" (Mercury), "sky Zokhar" (Venus), "sky Mze" (the Sun), "sky Marekhi" (Mars), "sky Mushtar" (Jupiter), "sky Zokhal" (Saturn), "the fixed sky," "the second movable sky", and "the first movable sky." From this we can see that the author had a geocentric world view.

Chapter 15 is devoted to the motion of the celestial spheres. Page 77 states: "The sky itself moves and rotates, but the stars are fixed to their places. Hence we speak of the 'fixed sky'." Page 78 states furthermore that "its width is 250,230,000 agadji." (The agadji was an ancient Georgian unit of measure that is equal to approximately 4-5 km.) On page 78 we find the following: "The ninth sky – the second movable sky – is like crystal." Chapter 15 contains information on the dimensions, motion, and periods of the different spheres and on the dimensions of the stars, and it also gives information of a religious character. Indeed, chapter 15 is the author's attempt to describe the universe as a whole, and the quoted fragments tell us something about his world view.

The manuscript's subsequent chapters contain information on the 12 zodiacal constellations, on the number of stars in the constellations, on star brightness, on the annual motion of the Sun through the constellations of the zodiac, on the motion of the Moon, on the calendar, on the changes of seasons, on several types of climactic phenomena, and on crop yields to be expected in coming years. The manuscript also contains extensive information of an astrological character.

This general review of *The Star Book* shows that it contains diverse types of information. On the one hand the manuscript contains information that was modern for its time, for example,

information on telescopic observations by Galileo, on the sizes and shapes of the planets, and on the daily and annual motion of celestial bodies. On the other hand the manuscript also includes detailed descriptions of Ptolemy's outmoded geocentric system. It is our view that the manuscript's author attempted to create something of an encyclopaedia – astronomical handbook – containing various types of information that would reflect contradictory world views and ideas. The author evidently relied on various sources and used the achievements and works of various astronomical schools. *The Star Book* is an important historical-astronomical document that reflects the level of the Georgian world view at that moment in its scientific development. (It would be useful to translate and publish *The Star Book* to make it available to researchers.)

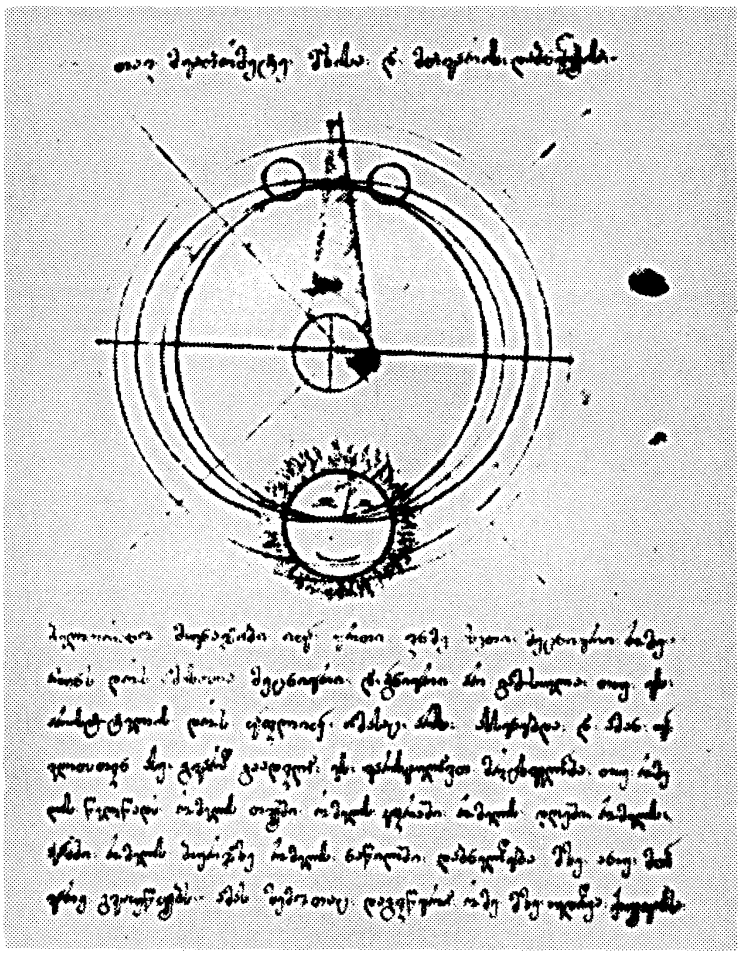

Figure 9. Page 59 of the Georgian manuscript, *The Star Book*.

The first quarter of the eighteenth century was marked by the scientific and educational activity of Georgian King Vakhtang VI Bagrationi (reigned 1703-1723) and his associates. Vakhtang VI was not just a statesman. He was also a scientist. Astronomy, which he studied using ancient Georgian and eastern manuscripts and books, was one of those disciplines that held special interest for him. In his first period of scientific work, Vakhtang VI translated fundamental astronomical works from among the classics of Eastern astronomy into Georgian. Vakhtang VI translated the works of Ulugh Bek, Naseredina Tusi, and Ali Kushchi. In 1721 Vakhtang VI established a printing house in Tbilisi. That same year the printing house issued several hundred copies (according to various sources between 200 and 300) of an astronomical treatise by Ali Kushchi in a translation by Vakhtang VI. Several copies of this book have been preserved to the present day, and one copy is in the rare book division of the Georgian National Library in Tbilisi. Figure 10 shows pages from this book in which we can see a figure representing the geocentric system. King Vakhtang VI also produced his own astronomical works that for the most part were descriptive in nature and as a rule were devoted to descriptions of the geocentric system.

Figure 10. Georgian text and drawing of an astronomical treatise which was translated and printed by king Vakhtang VI Bagrationi.

In his second period Vakhtang VI conducted scientific work that was more practical in character. Persian masters built an astrolabe using plans drawn by the king himself. Vakhtang VI conducted regular observations with the astrolabe and used the results to construct special tables and other materials. Vakhtang VI's astrolabe (Figure 11) is preserved in the Georgian History Museum in Tbilisi.

King Vakhtang VI established scientific contacts with scientists from Georgia and from various countries. One of his main local associates – in both the political and scientific fields – was the Georgian philosopher, writer, and educator Slukhan-Saba Orbeliani (1658-1725}, who compiled an explanatory dictionary of the Georgian language under the title *Bouquet of Words*. This dictionary includes several hundred astronomical terms of both Georgian and foreign origin. Some of the terms first entered the Georgian language from Greek, Arab, or other languages and were then transformed to Georgian lexical forms and began to be used widely in scientific speech. By analysing the astronomical terms in the dictionary of Slukhan-Saba Orbeliani, we can study the process by which Eastern and Western astronomical ideas and views influenced Georgian astronomy (Simonia & Simonia, 1994; Georgobiani, 1986; Gavriushin, 1983).

The period of systematics in the development of Georgian astronomical world view can be characterized by the following processes:

a) formation of fundamental knowledge about celestial objects;
b) creation of a Georgian scientific astronomical literature in the form of a set of manuscripts;
c) practical and theoretical work by Georgian astronomers; and
d) the operation of Georgian astronomical observatories.

Figure 11. The astrolabe of king Vakhtang VI Bagrationi.

The idea of a heliocentric model began to spread through Georgia in the mid-eighteenth century, and by the end of that century the new astronomical world view based upon the heliocentric system of Nicolaus Copernicus had firmly taken possession of the minds of Georgian astronomers and philosophers. During this period the arrival of scientific and educational literature from various countries – including Germany, France, and Russia – acquired an intensive and regular character. Some of the books and scientific publications that arrived from these countries are preserved in the Georgian National Library and in various Georgian museums and archives. These preserved books and publications bear witness to the increased Georgian exposure to Western scientific literature in the eighteenth century.

With the arrival of the nineteenth century we come to the end of our survey.

5 CONCLUDING REMARKS

Of course, it would be unthinkably difficult in the bounds of a single paper to illuminate all details concerning the development of astronomy in Georgia for a period of more than 2500 years. To do so would require a whole series of diverse and complementary studies. We have not touched upon questions connected with the study of ancient Georgian astronomical inscriptions on the walls of such structures as monasteries and churches. We also have not discussed the instrumental aspects of measuring time in ancient days, although in Georgia the tradition of preparing and using solar clocks was well developed. Of course, these as well as many other topics and questions should be analysed in subsequent studies.

What we have tried to do here is describe the principal events, achievements, problems, and ideas of Georgian astronomy, information that was, until now, previously unknown outside of Georgia. We hope that we have been at least partially successful in bringing little known aspects of Georgian astronomical history to an international audience.

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