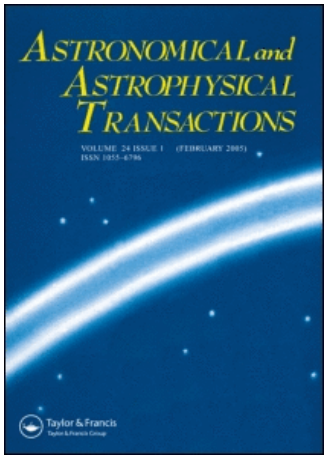

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The celestial map: The symbolism of historical eras and reflection of the world model

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THE CELESTIAL MAP: THE SYMBOLISM OF HISTORICAL ERAS AND REFLECTION OF THE WORLD MODEL

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This paper will reconstruct the history of the celestial map, beginning from prehistoric times and continuing to the present. It will be based on the concept of the gradual development of the astronomical world picture. The development of the map depends on two things: man's attitude towards the whole world in general, and his own place in it, in particular. Each change in this attitude is reflected in the celestial map for the given era. Six major stages are described for this process, their changes being determined by the logic of anthropogenesis.

KEY WORDS Constellations, celestial map, world model, stages of deveopment

1 INTRODUCTION

The study of the sky and stars is an integral part of world culture, often being displayed in different spheres of human activity from astronomy to the history of art. The problems of celestial map genesis, the symbolism of constellations, and the origin of their names have often drawn the attention of science historians. In this paper, one more attempt to reconstruct the history of the celestial map is offered.

This task required reference to archaeological, historical, astronomical and antropological data, together with an analysis of works dealing with the history of zodiacal constellations (Gingerich, 1984; Gurshtein, 1991, 1993, 1998), the problem of dating Aratus' 'Phaenomena' (Ovenden, 1966; Roy, 1984; Zhitomirsky, 1997, 1998), the stepwise development of the duodecimal zodiac in ancient history (Gurshtein, 1991, 1997, 1998; Kurtik, 2000), the history of the zodiac based on the Babylonian cuneiform tables (Van der Vaerden, 1974; Kurtik, 2000) and the zodiacal constellations of ancient Mayas (Yershova, 1997). A comparison of traditional star structuring systems from different historical periods in fact reveals their unity and continuity from the most distant times of antiquity up to the present day.

Studing the sources mentioned above has resulted in our own attempt to create a coherent chronology of the mapping of the sky in different historical epochs, making it possible to divide this process into a number of periods.

2 CELESTIAL MAP AS A CHRONICLE OF THE SCIENTIFIC WORLD IMAGE AND OF MAN'S PLACE IN THE WORLD

The life of social community was influenced not only through climatic, but also through astronomical factors such the periodically observed celestial phenomena. These phenomena, apart from being natural indicators of climatic seasonal changes, provided a basis for religious systems, which in turn made an ideological basis for the establishing of social system. Discoverying that periodically observed celestial phenomena were related to climatic seasonal changes was certainly highly significant for ancient people. They viewed those phenomena as some kind of supernatural heavenly law, which was believed to be responsible for all kinds of both natural and social life. This made it possible for a certain kind of people, namely priests, to fulfill an organizing role, for their knowledge made them, in the eyes of the people, conductors of the will of the deified heavenly bodies. This created the possibility of erecting huge sacred building, of managing people over a large territory, of battling against drought or building up an army.

Along with the human mind's drive to study both the outer world and the self, all the aforementioned circumstances created a need for ancient man to solve the main problem in natural science, which in turn required a certain knowledge of astronomy. In our understanding of this important scientific problem we agree with Karl Popper, who stated, 'There exists at least one philosophical problem, being a matter of concern for all thinking mankind. It is the problem of cosmology, the problem of comprehension of the world, including ourselves, and of our knowledge, being a part of the world as a whole' (Popper, 1959).

Two major tasks were posed for astronomers from the very beginning. The first was to work out a universal astronomical terminology. The second was to create a universal system for the exact measurement of the positions of heavenly bodies (a heavenly coordinate system), as well as appropriate methods for measurement and notation of obtained data, and systems for measuring time.

The history of astronomical science reflects the logic of the development of an integral world picture or world model (Idlis, 1996). This process comes along with the consistent elaboration of the celestial map. The celestial map shows a tendency to develop through a succession of stages, from the point where some noticeable stars are being recognized in the sky, up to the comprehensive scientific model of Universe. Each stage of development of the scientific world picture may be specified by a generalized view of man's own place in the world, shared by the people of that era. It can be also regarded as a key definition of the given era.

We consider it useful to distinguish six key stages in the development of a world picture, which is reflected in successive stages of building up the celestial map. We shall designate them as follows: I Pre-anthropocentrism; II Anthropocentrism; III

Topocentrism; IV Geocentrism; V Heliocentrism and Polycentrism; and, finally, the sixth stage, which actually represents a denial of any kind of centrism.

A certain kind of celestial map corresponds to each of the aforenamed stages. A rather short transitional period follows each major stage of development, providing an essential base for the next stage, as shown in Table 1. The key concepts connected with this chronological scheme, related historical events, astronomical discoveries and personalities are presented in appropriate columns of the table. A brief survey of the six main blocks of Table 1 is given in the following sections.

3 THE EARLY STAGES IN THE CREATION OF THE CELESTIAL MAP

Complete systems of astral symbols, especially zodiacal quartets (Gurshtein, 1994), are developed and used as a way of representing a generalized world outlook derived from observations of sky and nature, which encompass a people's attitude toward themselves and the world around them (i.e., the Space or Universe) at a particular stage in the development of a human civilization.

From the early Paleolithic until the end of the Neolithic age (up to the beginning of the 6th millennium B.C.) man, by virtue of objective reason, identified himself with that part of nature which constituted his immediate environment. As yet unable to pass beyond the boundaries of the world around them, people did not search, or at least did not formulate a concept of 'center', but simply felt themselves to be part of the whole; this fact permits us to place this era before the next one, in which man begins to identify himself with the 'center'. We call it the era of PRE-ANTHROPOCENTRISM.

This epoch of Pre-anthropocentrism, which may be also referred to as the epoch of ANTHROPOHOLISM, because man did not yet fully distinguish himself from his environment, had seen the first crucial step in the long process of building up a celestial map, which consisted of a symbolic division of the sky into three 'worlds': the world of air (the sky itself, and birds, and heavenly bodies); of earth (the earth surface and soil, terrestrial animals and plants); and of water (rivers, seas, and fish). This division reflected people's first knowledge of their natural environment.

At the same time, the most prominent constellation, a seven-star 'hieroglyph' observable all year long in the middle latitudes of the northern hemisphere of the Earth, was distinguished from all other star patterns, and was named the Great Bear. This event presumably took place before the 14th millennium B.C. (Gingerich, 1984; Gurshtein, 1997, 1998).

The likening of this prominent star cluster to a bear had a comprehensible reason. The cave-bear's nutritional and dwelling conditions, its shape and certain habits, such as its astonishing ability to walk on its hind legs, made it in a way similar to ancient man. This similarity could only lead to the identification of bear with man, and the totemization of the animal. The bear was probably regarded as the chief ancestor and sacred patron of Paleolithic man (Frank, 1992; Shepard, Sanders, 1985), an attitude which persisted for a long time in some cultures. It

Table 1. The stages of development of the scientific world model and the celestial map.

Stage, time of its establishment	*Major symbols, sources of information, concepts, and personalities*	*Stage of celestial map development, the study of the motions of lights and planets*
I PRE-ANTHROPOCENTRISM Up to the 6th millennium B.C.	The birth of concepts: parent, ancestor. Matriarchy, the Mother Goddess cult, lunar myths and symbols.	Symbolical division of the sky into three worlds: watery, earthly, and aerial. Observations of the Moon; invention of the seven-day week. Distinction of Ursa Major and other seven-star clusters.
Ia Man finally distinguishes himself from the natural world. Formation of the 'twin myths'.		
II. ANTHROPOCENTRISM 6th–4th millennium B.C.	Twin cult and horse cult. Setting up of solar cults.	The Gemini Quartet. Discovery of the Sun's path and its cardinal points. Observations of the Sun.
IIa The birth of agricultural civilization. Beginning of written culture.		
III TOPOCENTRISM 3rd and early 2nd millennium B.C.	Imhotep (c. 2750 B.C.). The Sphinx and the Great Pyramids. Egyptian Calendar. Elamic and Egyptian cultures; Lion and Bull cults. Eight 'World Elephants' of the Hindu religion. The heyday of solar cults.	The Taurus Quartet and the Octal Zodiac. Discovery of the ecliptic cardinal points' motion. Observation of planets (Venus – c. 1600 B.C., in Babylon). Determination of the planetary cycles.
IIIa The spread of knowledge, interethnic exchange. Megalithic structures. Stonehenge acquired its shape before 1900 B.C. Ability to determine the Celestial Tropics and Equator. Occurrence and dissemination of the geocentric idea. Invention of phonetic writing.		

Table 1. (Cont.)

Stage, time of its establishment	*Major symbols, sources of information, concepts, and personalities*	*Stage of celestial map development, the study of the motions of lights and planets*
IV GEOCENTRISM Late 2nd millennium B.C. to early 1st millenium A.D.	Luxor Temple (c. 1380 B.C.). Amon Temple in Karnak, Temple of Abusimbel (c. 1250 B.C.). Babylonian cuneiform text '*MUL APIN*', c. 700 B.C. Eudoxos of Cnidos (c. 408-355 B.C.), Aratus' *Phaenomena* (c. 275 B.C.). Hipparchus (c 150 B.C.). Ptolemy's *Almagest* (c. 150 A.D.).	The Aries Quartet. Star groups on the lunar path. Babylonian, Greek and Mayan duodecimal zodiacs (500–400 B.C.). Aratus' star map based on a source of c. 2000 B.C. Discovery of precession. Summing up of the knowledge about planet motions in Ptolemy's mathematical model.
IVa Consistency of temple architecture traditions. The Bridge Tower and Charles' Bridge in Prague (1375). Natural philosophic plots in fine arts: Palazzo Schifanoia frescoes in Ferrara, *Adoration of the Magi* by Giotto (c. 1301). Arabian science. Great Geographical discoveries (1492–1502, 1498, 1521–1522). Invention of typography (1445). The first printed celestial map (A. Dürer, 1515).		
V HELIOCENTRISM and POLYCENTRISM Late 15th to 19th century.	The works of Copernicus (1473–1543), Kepler (1571–1630), Galileo (1564–1642), G. Bruno (1548–1600). Recognition of science as a separate field of activity: F. Bacon (1561–1626). I. Newton (1643–1727)	Star atlases by Mercator (1551), Bayer (1603), Hevelius (1687), LaCaille (1752). First telescopic discoveries. Telescopic atlas by J. Flamsteed (published in 1725). The laws of planetary motions being established.
Va *Uranographia* by J. E. Bode (1801) (Figure 1). Discovery of Neptune based on laws of celestial mechanics (1846). Search for an explanation for the abnormal deviation of Mercury's perihelion. Study of Moon's orbital motion mechanics. The *Uranometria Nova* by F. W. Argelander (1843) (Figure 2).		
VI DENIAL OF CENTRISM 20th century.	20th century Cosmology: A. Einstein (1879–1955), A. A. Friedmann (1888–1925), E. P. Hubble (1889–1953).	Confirmation of the list of 88 constellations and their bound-aries (1922, 1928). Abnormal deviation of Mercurian perihelion explained.

Figure 1 Fragment from *Uranographia* by J. E. Bode, 1801.

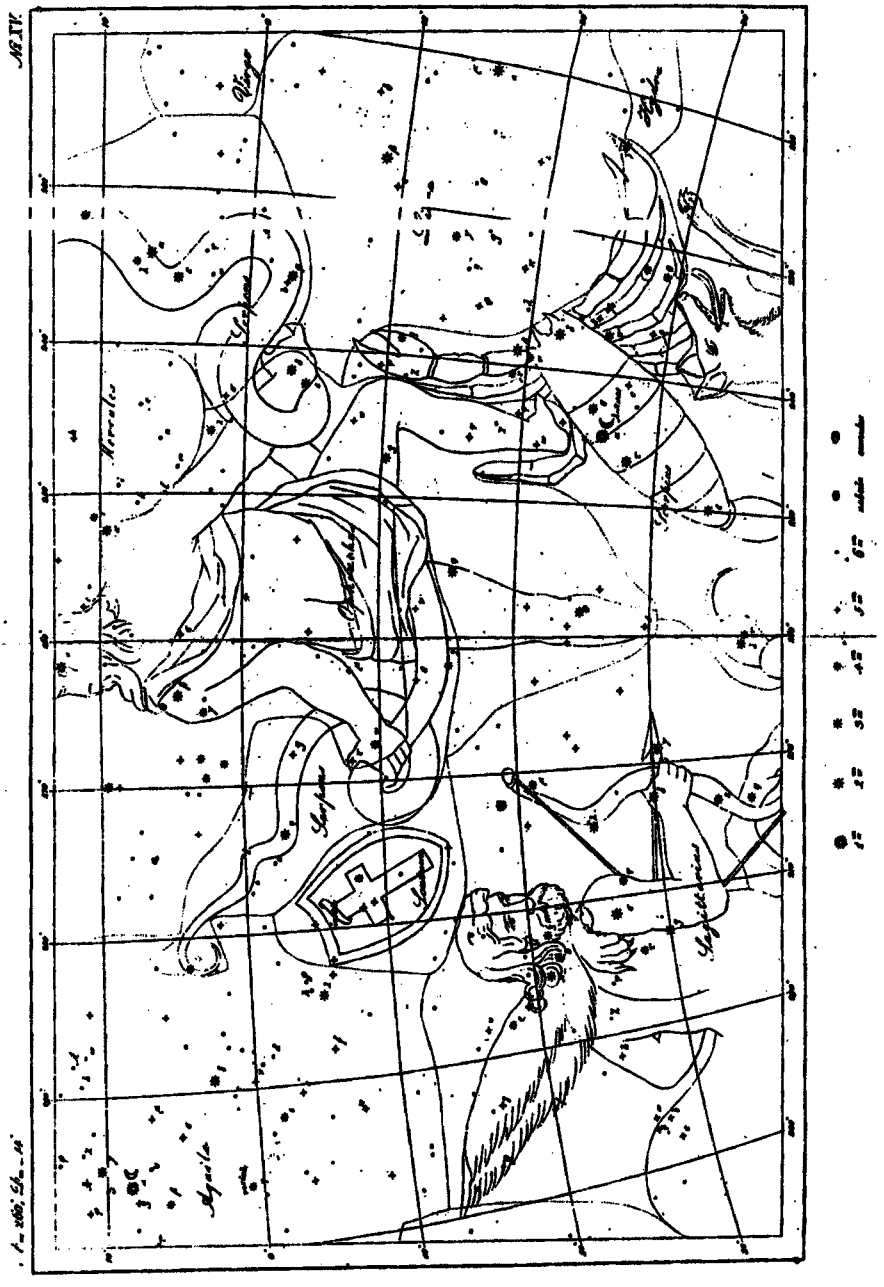

Figure 2 Chart 15 from *Uranometria Nova* by F. W. Argelander, 1843.

is no coincidence, in fact, that the English word *bear* also means 'to give rise, to carry, or to support' (compare also to the German *Bär* – a bear and *gebären* – to give birth to). The sacred status of a bear is reflected in many languages in the fact that it is forbidden to pronounce its name. For example, in Russian, there is no 'direct' word for a bear, but instead there is an indirect, allegorical nickname: '*medved*" – 'the one who likes honey'. Ritual burial-places of bears were found in many localities where prehistoric men dwelt in the northern areas of Europe, Asia and America (Frank, 1992; Shepard, Sanders, 1985).

In the transition from the Paleolithic to the Neolithic age, as a result of the observations of the Moon, the lunar month was established and a quarter of it came to be known as a seven-day week. Also, a correlation was made before seven days of the week and seven bright 'wandering stars' – planets nearest to the Earth. Following the Great Bear, some other sidereal groups were distinguished, each of them having, as a rule, seven stars in its structure, particularly in the early stages. Together with the above-mentioned seven-day lunar (week) cycle, this became the main reason why the number 7 became sacred (Gurshtein, 1995, 1998).

We should also pay attention to the twin cult, which we consider to be the main cosmogonic achievement of the Pre-anthropocentric era, as it formed the basis of the following stage of evolution of natural scientific thought – the stage of ANTHROPOCENTRISM. The 'twin' idea, which penetrates the whole Indo-European mythology and cosmogony, was evidence of a completely new type of human attitude towards himself in relation to the outer world. As a matter of fact, twin cults also carry all the features of solar cults, which flourished world wide in the 3rd and 2nd millennia B. C. One may also notice that one of the chief symbols distinctive of that period is that of a horse, whose domestication went on during that time.

Connection of the 'divine twins' with a horse cult, typical to all ancient Indo-European traditions, is confirmed by widely spread horse sacrifices and burial of horses together with men, which occurred in that period and persisted for many centuries in some cultures. Horses are known to have been a very common object of adoration among the sun-worshipping nations as they were one of the prominent solar symbols (Ivanov and Toporov, 1987). It is thus understandable that the era of twin cults and of horse cults coincided with the era of sun cults; ancient man of that period had turned his attention to the Sun and its daily and yearly motion. This resulted in a very important step in the evolution of the celestial map, namely the allocation of four constellations to the four chief ecliptic points – the zodiacal quartet of Gemini. Other zodiacal constellations came to be distinguished much later in history (Gurshtein, 1998).

During the 6th–4th millennia B.C. man had definitively isolated himself from the outer world. He had worked out the notion of four cardinal points of the world, putting himself in the centre, therefore we denote this new epoch with the name *Anthropocentrism.* The Gemini quartet, with exception of Pisces consists of anthropomorphic symbols: Gemini is usually portrayed as a man and a woman; Virgo as a woman or a spike; and Sagittarius either as a man with a bow or a horse (although this later became a centaur). The only non-human constellation of the quartet, relevant to its 'water layer', is Pisces, a symbol of death and revival.

A dead fish is swimming with the stream, while another, a live one, is swimming against the stream. All of the four symbols are dual by nature. A woman and a spike symbolize gathering of wild cereals and first experiences of agriculture; a man with a bow, as well as a horse, symbolizes hunting and the domestication of animals – the human activities most widely spread in that period.

A human being is the essence of these symbolic figures. A man or a woman is placed in the center of the world. Even the symbol of the Fishes can be understood as a human attempt to determine or formulate the main concepts of life and death, thus putting a human being in the center of the whole world once again, putting his consciousness and self-determination along with the main problems of his economic life, symbolized by the other signs of the Gemini quartet.

The horse symbolism, specific to the Indo-European Gemini cult, is also recognizable in the name of a cult tree, or a sacred axis of the world, which was specified in the same epoch: the Hindu. ***asvattha*** (literally 'a horse tether'), or in the German words ***Hengst*** and ***Horsa*** (ritual poles, used to represent the centre of the world)which are etymologically related to the word for 'horse' (Ivanov and Toporov, 1987). Etymological links with ***horse*** can be traced in a great number of words and personal names: the Slavic god ***Hors*** and Egyptian ***Horus***, or ***Hormachis*** (***Horus-of the-horizon***); the word ***horizon***; ***horologia*** – the art of time measurement, and many others. In that period of time, the constellation of the Great Bear was often associated with an image of a chariot or any other type of horse-drawn carriage.

It was in that period of time that the first exact observations of the Sun were conducted, resulting in the discovery of the four cardinal points of the ecliptic and the denotation of their star markers. Thus, the first quartet of zodiacal constellations appeared, with their universal symbolism which reflected the mentality of the people who lived in that era. The results of these astronomical observations created a basis for the advance of solar cults and calendars, which were then gradually brought into use alongside lunar calendars, the latter being far more archaic in origin.

The main results of the anthropocentric stage was the beginning of agriculture and the creation of written languages. Later on, in the 3rd millennium B.C., a new basis for public life came into existence: a powerful, centralized state authority, which was able to bring together the formerly isolated national communities. This process significantly promoted the acceptance of new ideas concerning the next stage of the world model, *TOPOCENTRISM.*

Anthropomorphic symbols belonging to the Gemini quartet, had now faded into the background, and were being gradually replaced by the mighty figures of a lion and a bull, the former symbolizing imperial authority, and the latter agriculture, the basis of the nation's well-being.

Thus, at the beginning of the 3rd millennium B.C. the constellations of the Taurus quartet appeared on the celestial map (Gurshtein, 1991, 1996). The symbolic figures are no longer anthropomorphic, with the exception of Aquarius, the constellation marking the winter solstice, the point of death and revival (while in the Gemini quartet, on the contrary, the winter equinox symbol, Pisces, was the only

non-human image). The new symbol completely preserved the duality inherent in the previous 'winter' constellation: it was a man holding two vessels from which water came streaming: the water of life from one vessel, the water of death from another. Thus, the idea of death and revival is reflected in an image of a constellation marking the winter solstice, just as it had been in the previous stage.

The symbol of fertility, Taurus was a central figure in this new quartet of constellations. It was the constellation attended by the Sun during the spring equinox. Leo, a new marker of the summer solstice, symbolized the Sun apotheosis and the might of imperial authority. With the symbol of the autumn equinox, Scorpio, nature was closing its annual cycle. And then again came Aquarius, the crucial point of the winter solstice. The dead water, poured down by him, brought death, purification and transformation, the living water meant the beginning of new life.

The four symbols mentioned above were the most widespread Egyptian symbols in the period of the Ancient Kingdom (2700-2300 B.C.). Egypt at that time can be described as a striking example of the topocentric way of looking at things. These ideas received the most vivid incarnation in the unique composite figure of the Great Sphinx, which, together with the Great Pyramids ensemble, served as a symbolic marker of the center of the world (Marshack, 1991). Thus, the Sphinx may serve as further evidence of the transition from Anthropocentrism to Topocentrism.

The disappearance of human figures from three symbols of the Taurus quartet may testify to a higher level of abstraction in the new symbolism. Man was now attaching the concept of 'the center' not to his own person, but to his land, people and state. The world pictures in various cultures of the era have a great deal in common: a high mountain, which was revered as the center of the Earth, with 'universal waters' flowing below, was 'placed' by priests of each national religion in the center of their native country.

The discovery of the Sun's path across the starry sky resulted in the fixing of the four initial zodiacal constellations (the Gemini quartet). The change of the Gemini quartet to a new one (that of Taurus) testifies to the man's comprehension of the fact, that the solar path itself (or, to be more accurate, its cardinal points) gradually changes its position against the background of sidereal markers. This notion was, in fact, the first step in study of the astronomical phenomenon of precession.

The end of the 3rd and beginning of the 2nd millennium B.C. saw the large-scale construction of megaliths. The most famous of them, Stonehenge, acquired its characteristic features about the 19th century B.C. (Marshack, 1991; Britannica: Stonehenge, 1997; Wood, 1978). The creation of these structures was surely based on a perfect knowledge of horizon astronomy, for they were accurately directed towards the points at which the Sun and the Moon rise and set on particular days of the year (the vernal equinox and summer solstice). Most scholars emphasize the uniqueness and originality of each megalithic structure. In fact, each served as a synthesis of a calendar, a clock, a temple, and an observatory. A detailed study of Stonehenge has shown that creation of such structures required a perfect knowledge of the Sun's and Moon's motion against the horizon at the given geographical point, not only in the given seasons of the year, but also within at least one cycle of the 'high' and 'low' Moon. In fact, this kind of knowledge created the possibility of

Table 2. The dating and presumable position of the observer of the sky as described in Aratus' Phaenomena, based on different studies.

Authors of the studies	*Years B.C.*	*Degrees NL*
Maunder, 1909	2500	35–40
Crommellin, 1923	2460	36
Ovenden, 1966	2600 ± 800	36 ± 1.5
Roy, 1984	2000 ± 200	
Zhitomirsky, 1997	1800 ± 250	

predicting eclipses (Nikolov and Kharlampiyev, 1991; Wood, 1978).

Closer interethnic communications inevitably led to the establishment of a geocentric world scheme, which united various local ethnocentric ideas into an integral conception of Planet Earth. This process was furthered by astronomical observations conducted in different geographical regions. This circumstance, in turn, inevitably resulted in the creation and distribution of a unified system of heavenly and terrestrial coordinates, for the creation of heavenly and terrestrial maps (Gingerich, 1993).

This assumption is greatly supported by the research of Aratus' poem *Phaenomena*, which is dated to 275 B.C. It is well known that Aratus had borrowed his knowledge of the subject from Eudoxos of Cnidos, who lived a hundred years before (c. 408–355 B.C.) but it has been proved by a number of scholars that his primary source is far earlier (see Table 2).

Astronomical studies and statistical analysis confirm that the primary source of Aratus' poem had appeared long before the pre-polis period of the Hellenic civilization. A more detailed history of the question, the contents of the poem, the applied techniques, and discussion of results are presented in (Zhitomirsky, 1997, 1998).

Therefore, it appears that Aratus' original source dates from the era in which the ethnoastronomical monuments like Stonehenge were built. A number of similar sanctuaries sanctuaries/observatories, designed to indicate the Sun's rising and setting points at the solstices and equinoxes, have been found elsewhere in the world in the past decades. Note that these important points of the horizon have a direct relation to the heavenly equator and tropics. The heavenly equator passes through the points of sunrise and sunset during the vernal and autumnal equinoxes, and the northern and southern heavenly tropics pass through the points of sunrise and sunset at the summer and winter solstices, respectively (in the northern hemisphere of the Earth).

While observing the stars rising and setting in the places of the horizon, marked by some kind of reference points, a priest-astronomer of such an observatory obtained knowledge of the passage of the heavenly tropics and equator through the constellations, thus creating something of a natural (mental, or imagined) armillary sphere. Knowing the inclination of the solar, or lunar, path near the horizon,

the observer could mentally extend it towards the stars of certain reference constellations. Shortly afterwards (about 1600 B.C.), the first recorded observations of planets were made (Van der Vaerden, 1974). Thereby the equatorial coordinate system was born, thus opening a possibility of creating a system of geographical coordinates as a mirror reflection of the celestial coordinates on the Earth's surface (Gingerich, 1993).

The knowledge of equatorial and tropical constellations provided the ancient people with a reliable navigating base. The part of *Phaenomena* which was devoted to indication of weather changes, was an essential supplement, making it a complete corpus of information necessary for the ancient navigators as well as for nomadic peoples. The connection of the poem's original source with horizon astronomy is confirmed in particular by its second part, which is wholly devoted to the simultaneous rising and setting of constellations.

The antiquity of *Phaenomena's* primary source is also confirmed by remnants of archaic notions about the flat Earth, floating in the Ocean. A matter of special interest is the division of circles into eight parts, for, according to Gurshtein (1996, 1993), at that time there were only eight known zodiacal constellations.

At the same time, such features as the presence of all twelve zodiacal constellations in the text of the poem, as well as the circles' intersection with the constellations Virgo, Cetus and Pegasus, whose locations indicate the era of antiquity, may be easily explained by later editing of the text. For one may notice that the choice of constellations, affected by the 'corrections' in the text, is far from being accidental. All of them lie close to the zodiacal points, marking the days of the equinoxes in ancient times. It is not impossible that Eudoxos or one of his predecessors, while observing the rising and setting of the Sun and stars at the equinoxes, had noted apparent discrepancies between the positions of circles in the ancient text and the data from his own observations, and took the liberty of introducing appropriate modifications (Zhitomirsky, 1997).

This circumstance, without calling into question the real date of the poem's original source, only strengthens our hypothesis about the existence of various stages in the formation of a celestial map. It is most likely that the primary source was modified about 400 B.C., and the inviolability of the original text during the first 1500 years of its existence may well be explained by the religious status of astronomical knowledge which was constantly maintained by the ancient priests.

4 CRETE: ANCESTRAL HOME OF THE HEAVENLY CIRCLES?

The sky as described by Aratus must have been observed in a strictly determined geographical area, located somewhere near the 36th parallel, i.e. far to the north of the areas occupied by the most advanced civilizations of 3rd and 2nd millennia B.C. – Sumer (later, Babylon) and Egypt.

It is useful to remember that between 35 and 36 degrees north in the Mediterranean Sea lies the island of Crete, where in the same era a highly developed Minoan

culture flourished. We do not at present possess any reliable information concerning the level of scientific achievements in the ancient Cretan state. Nevertheless, this should not rule out the possibility of some new findings in this area, taking into consideration the fact that the hieroglyphic writing of ancient Crete has not yet been fully deciphered. Furthermore, one must pay special attention to spatial orientation of architectural monuments, palaces and temples towards the quarters of the earth, and geometrical structures used in the ancient cities of Crete, for it is known that they may reflect in a symbolic form various astronomical principles and generalizations. The importance of cults related to symbols of the lion and the bull in the Minoan culture is beyond any doubt (Pendlebury, 1939; Bongard-Levin, 1983, 1988, 1989). The astronomical significance of these symbols has also been discussed in a number of works (Gurshtein, 1998, 1992).

The Minoan civilization is known to have begun about 2500 B.C. About 2000 B.C., during the Middle Minoan period, the urbanization process began, cities grew up, and the first palaces were constructed. Such cities as Knossos, Malia and Phaistos were a merely Cretan phenomenon. Foreign trade extended to a large scale. The peak of development was attained between the 18th and 15th centuries B.C., when Crete dominated the south of the Aegean sea and a number of island settlements (Bray, Trump, 1970). The magnificence of Minoan culture produces a strong impression. Though many of its attributes had their origin in Anatolia, Egypt and Syria, the Cretan civilization was an entirely independent phenomenon, which in many respects surpassed the majority of civilizations of that time. Proceeding from these facts, we can easily make an assumption that the compendium of knowledge which constituted the original text of Aratus' *Phaenomena*, might have had its original source in that highly developed culture. This astronomical information might have been of great use to seafarers making trips between the southern Archipelago and the southern part of continental Greece.

Besides that, 36 degrees 23 minutes north in the Mediterranean Sea lies the island of Thera (Santorino), which was abandoned by its inhabitants at hte time of a ferocious volcanic eruption about 1400 B.C. The 36th parallel also crosses the southern part of the island of Rhodes. These islands, as well as some lesser ones in that geographical area, could have been where the first outlines of the astronomical work were formulated. They would remain almost immutable up to the time of Eudoxos and Aratus, who only ventured to augment them with some observations of their own.

The highly developed civilization of Crete is of special interest when dealing with certain chronological and symbolic parallels between Minoan and Egyptian cultures. For example, the religious cult of the bull and the lion, having existed both on Crete and in Egypt, was undoubtedly related to the zodiacal position of points of the vernal equinox and the summer solstice (Gurshtein, 1991, 1996).

The history of Egypt in the 14th and 13th centuries B.C. was marked by specific religious transmutations, partly connected with the transition from the octal to the duodecimal division of the zodiac, as well as the change of the constellation-marker of the vernal equinox, which occurred in exactly that era (Gurshtein, 1998). Taking place at the same time was the second and final upsurge of temple building in the

history of ancient Egypt, which was also connected to the grandiose celebration of an anniversary of the Egyptian sacred calendar (Kuzmin, 1999).

By the end of the 1st millennium B.C., after the final establishing of the duodecimal zodiac and the ecliptic and equatorial standard systems of heavenly coordinates in their contemporary form, another major achievement in astronomy was made almost simultaneously. The concept of a zodiac sign was geometrically defined as one-twelfth of the zodiacal circle. This happened due to the need for more precise observations and adequate descriptions of them. The amount of data obtained by that time allowed a novel view on the properties of the solar path to be formed. Hipparchus of Rhodes (c. 150 B.C.) gave the first accurate scientific description of the precession of equinoxes after generalizing the available data and conducting his own systematic observations, including a comparison of star locations he had detected, with those found in some older catalogs, (Britannica: *Stars and Star Clusters: Astronomical Maps*, 1997; Van der Vaerden, 1968).

The studies of planet cycles, the earliest known records of which belong to the old-babylonian period (Van der Vaerden, 1968), were generalized by Ptolemy in the form of a mathematical model 300 years after Hipparchus, c. 150 A.D.

These theoretical generalizations accompanied the formation of the *GEOCENTRIC* model of the world, which prevailed in the whole system of scientific knowledge up to the beginning of the 17th century A.D. The *HELIOCENTRIC* model was adopted mainly due to Johannes Kepler's works (1571–1630), which led to the refutation of the prevealong notion that celestial bodies moved in perfect circles.

5 17–20th CENTURY COSMOLOGY: FROM HELIOCENTRISM TO THE DENIAL OF CENTRISM

Johannes Kepler's major aim was to ingrain the Copernican theory into the very core of modern science, and he certainly succeed doing that. The idea of questioning the accepted notion of circular planetary orbits can itself be called groundlonealing, for the circle had been hitherto respected as the most perfect figure. This erroneous idea manifested itself in nearly all areas of human activity. See how many architects tackled the problem of a perfectly centered temple, with a perfectly round dome (Tananayeva, 1996)! Despite an obvious resistance, Kepler succeeded in presenting his 'ellipses' in *The New Astronomy*, issued in Prague in 1609, and thus radically reformed the whole of celestial mechanics.

Six years before *The New Astronomy*, the star atlas by Johann Bayer was published, the first work to completely represent a celestial map in its truly contemporary form.

The stars on Bayer's atlas charts are indicated by Greek and Latin characters, and are drawn against the scale of heavenly coordinates. The sky is presented as a direct image, just as it is seen from the Earth. In Hevelius' star atlas, printed in 1687, constellations were presented in a mirror image, reflecting a somewhat higher level of abstraction. The star catalog compiled by Bayer comprised some

information on the stars' brightness and also on the relation of heavenly objects to Greek mythological names and images.

Some new constellations appeared in Bayer's atlas for the first time. They reflected new symbolic images inspired by the new geographical discoveries. Europeans now began to travel to the southern hemisphere of the Earth. This confirms the idea that new images are found in the sky which symbolically reflect the realities of human life in each era, leaving the astronyms of previous eras almost completely unchanged. The invariability of the majority of traditional constellations' names up to the present day confirms this thesis about the stability of astronyms.

Johannes Hevelius, who introduced new constellations in his star atlas, did so without straying into the areas of existing constellations. His desire was only to fill the areas of the stellar sphere which were as yet untouched with new symbols. This resulted in a number of rather small constellations, such as the Vulpecula or Musca, as well as constellations which do not contain bright stars (e.g. Monoceros, Lynx). This supports the idea of the step-by-step formation of the twelve-figure zodiac, especially its final step: the appearance in the sky of the Aries quartet (Aries, Cancer, Libra, and Capricorn). These constellations, because they were allocated at a late stage, were insignificant in size and did not contain bright stars, but they were necessary for marking certain points of the ecliptic (Gurshtein, 1991, 1998). In Hevelius' atlas, a return to images from Greek mythology and other allegorical features is also apparent.

The constellation Felis (the Cat), allocated in 1799 by J. Lalande (not now present on the celestial map), was one more vivid example of the human desire to place images of the terrestrial world in the sky.

An important fact in the history of creating the celestial map was that a hundred years after the first telescope discoveries in astronomy, the first telescopic star catalog was compiled by John Flamsteed (1646–1719). It was printed posthumously in 1725. The catalog became a part of the *Historia Coelestia Britannica* (1725).

There are a large number of constellations which are associated with symbols of scientific devices; these are due to N. L. LaCaille, who persistently investigated the southern sky (his sky atlas appeared in 1752). On the one hand, this is a symbolic reflection of the astronomer's personal aptitudes; on the other, it indirectly proves that by that time, science as a separate sphere of human activity was held in great esteem. This fact can partly explain the eventual disappearance from star maps of Christian and 'court' plots which had finally fallen out of favor among astronomers by that time. Christian and 'court' names had been used previously in unsuccessful attempt to replace the classical names of star groups. If they had been used to name those areas of the sky which were still free, they may have survived. This is yet another example of the ancient astronyms' stability.

The beginning of the 20th century was marked by discoveries in the natural sciences which entirely changed our notions concerning the Universe. Our metagalaxy, as well as the whole observable astronomical Universe, was now described by means of a homogeneous and isotropical, boundless and spherically closed relativistic cosmological model (Idlis, 1996; Britannica: The Cosmos: Cosmological Models, 1997).

The first relativistic cosmological model was offered by A. Einstein in 1917. In 1922, the Russian physicist, geophysicist and cosmologist A. A. Friedmann had proposed a series of non-stationary, relativistic cosmological models of the Universe regularly expanding or compressing itself, or else cyclically pulsating.

Some years later (1929), the American astronomer E. P. Hubble, who had observed a systematic Dopplerian reddening of far-off galaxies, tried to compare this effect with their distances from the Earth and came to the conclusion that these galaxies regularly and systematically move away from our own galaxy and from each other as well. This meant that our metagalaxy as a whole is constantly expanding (Idlis, 1996).

The above-mentioned discoveries caused a considerable reformation of ideas in astronomy, cosmology and physics, indicating a transition from the helio- and polycentric model to a COMPLETE DENIAL OF CENTRISM. The importance of this event can be compared to that of *The New Astronomy* by Kepler, which had established a heliocentric model of the world in about 1609.

It is especially remarkable for the present study that the transformation of the astronomical picture of the world at the beginning of the 20th century, as well as at the beginning of the 17th century, coincided with a transformation of the celestial map. The exact new boundaries of the constellations were approved by the International Astronomical Union in 1922 (*Transactions of the International Astrological Union*, 1922), and the final result of this decision, in the form of a modern celestial map, was published in 1930. It is significant that the two aforementioned important dates coincided with the publications of Friedmann's theoretical models and their verification by Hubble's observations, respectively.

The main difference between the contemporary star map and Bayer's map, apart from its greater accuracy, is as follows. On the modern map, the former figures of the constellations, isolated from each other, were replaced by their exact geometrical borders, so that no empty spaces were left on the celestial sphere. The great majority of traditional names of constellations, including the most ancient ones, were preserved, as well as the areas occupied by them, in spite of a number of voices in favor of abandoning not only the figured images, but also the traditional names of constellations, and replacing then with equal rectangular squares. This once again demonstrates the stability of astronyms and the immense historical value of the constellations' symbolic names. The reform of 1922–1928 has approved the unified list of 88 constellations with precise denotations of their borders and squares. The borders were aligned to celestial parallels and to circles of declination, according to the coordinate grid proper to the spring equinox of 1875 (Figure 3). The coordinate grid is continuously shifting in the course of time due to the precession of equinoxes, the constellations' borders are gradually changing their position against the circles of declination and celestial parallels. This discrepancy will become more obvious in future eras, while a slight inclination of the constellations' borders is already observable close to both poles (see Figure 4). Moreover, some stars, predominantly those located in the neighborhood of the borders, may sooner or later change their celestial positions by entering adjacent constellations. However, this may only affect minor stars owing to the fact that the borders were deliberately drawn across

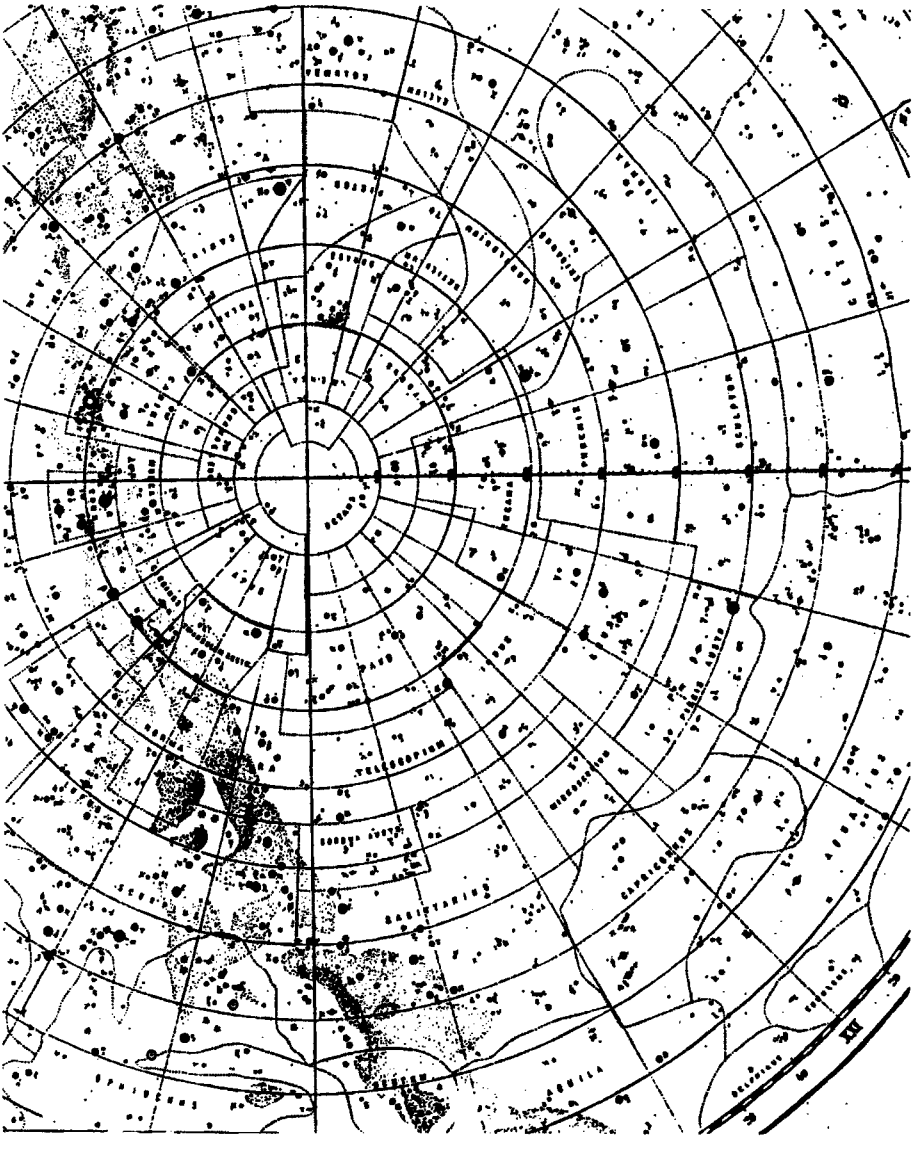

Figure 3 Fragment of the southern sky map by B. A. Gould (vernal equinox 1875.0) in which the new method of constellation bordering was used for the first time.

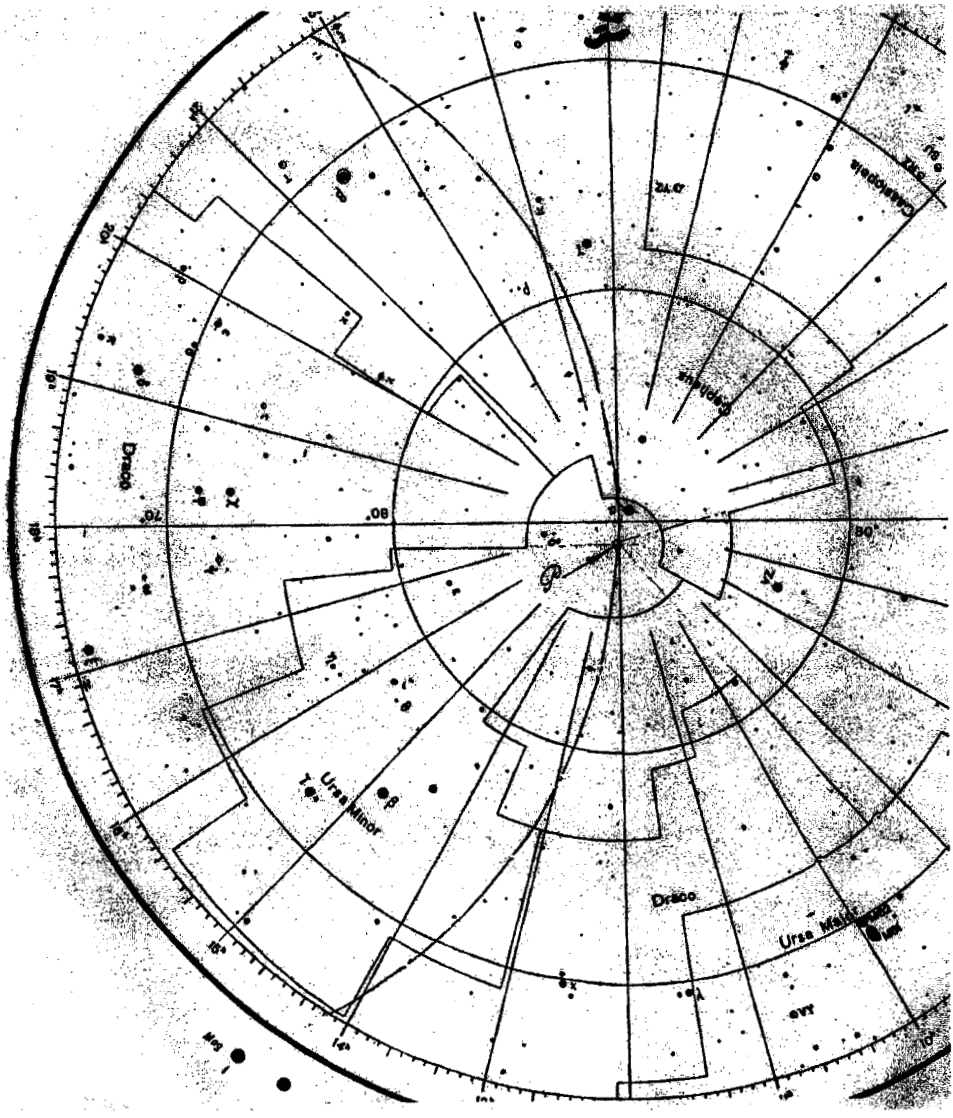

Figure 4 Map of the northern sky (equinox 2000.0). The dotted line shows the approximate path of the celestial North Pole across the heavens, according to the contemporary model of precession. It should be noted that the constellations' borders drawn in the direction from north to south are intersecting in the point of the North Pole proper to the equinox 1875.0 (P).

sky areas devoid of any prominent celestial objects. The borders were drawn in such way as to maximally coincide with the places in the sky where traditional star figures were pictured by the astronomers of the past.

6 SUMMARY

1. Reconstructing the chronology of the structuring of the celestial sphere, including its earliest stages, has shown that this approach is largely accurate. We consider it useful to continue the study to attract scientific sources from different spheres of knowledge.

2. This reconstruction is based on the idea that there are six main stages in building up the celestial map, the latter being a reflection of the world model by people of the given era in a specific symbolic form. The change from one stage to the next is determined by the logic of anthropogenesis.

3. The principle underlying all changes of celestial maps since the 17th century A. D., is essentially no different from the same process which was reconstructed by us for earlier stages. Its main features, both in antiquity and in subsequent times up to the 20th century A. D., are as follows:

   i symbolic images which held great importance for the astronomers as people of that historical era were mirrored in the celestial map;

   ii a great continuity of the tradition is seen in the almost complete preservation of the constellations' names and outlines from one era to the next;

   iii the discovery of new constellations does by no means impair the old ones, because the new constellations, particularly in the northern hemisphere, are generally smaller and do not contain bright stars or any objects remarkable to the naked eye.

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