CHAPTER 11

Other problems and hypotheses arising from the dating of the Almagest catalogue

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1. CERTAIN AUXILIARY ODDITIES OF THE ALMAGEST

1.1. What coordinates was the Almagest catalogue compiled in initially?

As we already know, one of the Almagest's most important parts is the catalogue of stars that contains around 1000 entries, with the indication of their ecliptic latitudes and longitudes. N. A. Morozov (in [544], Volume 4) voiced the opinion that the Almagest catalogue was initially compiled in natural equatorial coordinates, just like the modern catalogue, and was only converted into a catalogue with ecliptic coordinates as a result of some calculations. The matter is that the mediaeval astronomers considered the ecliptic coordinates "eternal", believing their latitudes to remain constant and the precession-driven growth of coordinates to happen at an unchanging rate. When it was discovered that ecliptic coordinates also change over the course of time, their "benefit" ceased to exist.

Vestiges of the conversion of equatorial coordinates into their ecliptic equivalents as mentioned above can be found with several methods. The compiler of the Almagest catalogue describes the stars of the Northern Hemisphere first, beginning with the northernmost constellations and slowly proceeding southwards. It would therefore be natural to assume that he should start his catalogue with the description of the constellation located at the centre of the hemisphere, namely, the ecliptic pole. Which constellation of the Northern Hemisphere is the closest to the ecliptic pole? It is the constellation of Draco. The position of the ecliptic pole has only changed marginally over the last 2000 years (as a result of the ecliptic's fluctuations) in comparison to the sizes of the constellations. Therefore, the compiler of the catalogue, whatever his chronological location on the time axis between today and the epoch of the "ancient" Greece, would have to start his catalogue with the constellation of Draco. Oddly enough, this isn't the case with the Almagest, whose catalogue begins with Ursa Minor and not Draco, for some strange reason ([704], page 224). The compiler proceeds to describe the stars of Ursa Major, and only then lists those of Draco, naming the latter constellation third, no less! See fig. 2.1 in Chapter 2, which depicts all 48 constellations described in the Almagest. In fig. 2.13 of Chapter 2 we see the order of the constellation as listed in the Almagest. This order is rather odd.

Everything shall fall into place once we come back to the equatorial coordinate system. The matter is

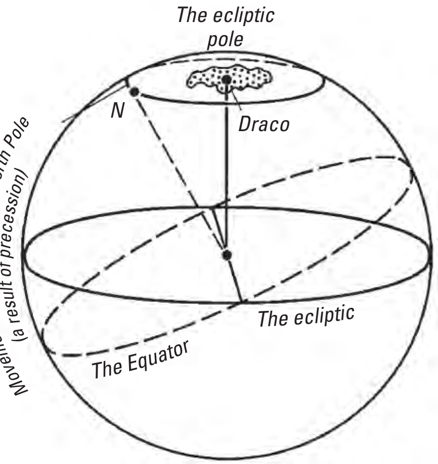


Fig. 11.1. The motion of the North Pole around the ecliptic pole as a result of precession. The constellation of Draco is located at the North Pole of the ecliptic coordinate system.

that there was indeed a period of the historical time interval when Ursa Minor was the closest constellation to the pole, or the centre of the equatorial coordinate system. Thus, the compiler of the catalogue de facto shows us the initial version of the latter by beginning the list with the stars of Ursa Minor – therefore, the Almagest catalogue began with the pole of the Equatorial coordinate system (see fig. 11.1).

N. A. Morozov wrote the following in this respect: "However, in this case, why didn't he leave the actual equatorial values alone, the way it is done in all the modern star catalogues, and had to convert them into ecliptic latitudes and longitudes with the laborious graphical method? … The result was the inevitable secondary error that compromised the value of the catalogue in general … The tremendous amount of the author's labour required for converting the "immobile stars'" coordinates into ecliptic coordinates from the initial equatorial values … makes such exorbitant waste and happens to be so obviously detrimental to astronomical precision that one involuntarily begins to search for some ulterior motive behind all this, with only two possibilities – either a vain desire to make the catalogue eternal (a non-option due to longitudes, as it turns out), or a deliberate effort of hiding the time when the catalogue was compiled, seeing as how ecliptic latitudes were considered immutable before Newton and Laplace …" ([544], Volume 4, page 201).

This brings us to another obvious question. Since the North Pole's position among the constellation alters visibly with the course of time, is it possible to use this information for the dating of the Almagest catalogue, with the knowledge of the laws that this alteration conforms to?

1.2. The North Star as the first star of the Almagest catalogue

The Almagest catalogue begins with the North Star. This seems to be perfectly natural at first – indeed, given that the catalogue lists the stars of the Northern Hemisphere, it is only natural that the compiler should begin his list of stars in equatorial coordinates from the star closest to the centre of the Northern Hemisphere, or the pole. However, if we are to consider this issue with more attention, we shall come up with a whole range of perplexed questions.

Modern Scaligerian chronology tries to convince us that the Almagest was compiled around II century A.D., or somewhat earlier, under Hipparchus (in the alleged II century B.C., that is). It is easy enough to calculate that the constellation of Ursa Minor remains closest to the North Pole out of all the constellations listed by Ptolemy, and there were no significant alterations in its disposition over the length of the historical interval, or the period of the last 2.500 years. Further on, it is also easy to calculate which of Ursa Minor's stars was the closest to the pole around the beginning of the new era, which is when the Almagest is presumed to have been compiled. This star turns out to be the Beta of Ursa Minor. Moreover, it is marked as a star of the second magnitude order in the Almagest, which makes it brighter than the North Star, marked as the star of the third magnitude order in the Almagest and therefore dimmer than Beta.

Incidentally, it has to be noted that one can find no modern star names in the Almagest (such as Alpha, Beta etc). Ptolemy localises the stars by their disposition towards the constellation figure and by their coordinates. Let us point out that in reality the magnitudes of Ursa Minor's Alpha and Beta are virtually identical – namely, according to the modern photometric data, the magnitude of Alpha equals 2.1, and

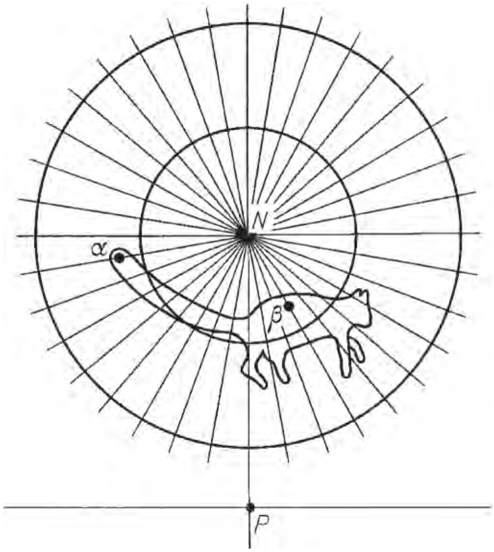


Fig. 11.2. The disposition of Alpha and Beta stars in the constellation of Ursa Minor in relation to the pole for the II century A.D. A fragment of Bode's star chart that he compiled after the Almagest in the XVIII century.

the magnitude of Beta – 2.2, which makes the former a trifle brighter than the latter. However, Ptolemy adhered to the contrary opinion, believing Alpha to be dimmer than Beta ([1339], page 51, Cat # 2).

Calculations demonstrate that in the II century A.D. the distance between the North Pole and Ursa Minor's Beta roughly equalled 8 degrees, whereas the modern North Star, or Ursa Minor's Alpha, was located at the distance of 12 degrees from the pole. Thus, in the II century A.D. the North Star was much further away from the pole than Ursa Minor's beta. The disposition of these stars in the II century A.D. is shown in fig. 11.2, which is a part of the star chart compiled by the famous astronomer Bode in accordance with the Almagest catalogue. The positions of stars and constellations were obviously calculated and indicated for the II century A.D., since Bode appears to have accepted the Scaligerian dating of the "ancient" Ptolemy's lifetime.

Furthermore, the Beta star is located at the centre of Ursa Minor's body, whereas the Alpha is the star at the very tip of Ursa Minor's tail, qv in fig. 11.2. This is precisely how the positions of these stars are described in Ptolemy's Almagest. The North Star, or the modern Alpha, is localised by Ptolemy as "the star at the tip of the tail" ([1339], page 27; also [704], page 224). As for Beta, Ptolemy describes it as "the southernmost star of the rear part" ([1339], page 27), or as "the next star [after Alpha – Auth.] on the tail" ([704], page 224; see also the fragment of Bode's chart in fig. 11.2). As we can plainly see, Beta is located closer to the centre and the back of the figure, which also brings it closer to the top part of the whole figure, if we are to turn Ursa Minor in such a way that it "stands on its feet". Let us now provide a brief review of the above considerations formed into a table.

North Star, or the modern Alpha of Ursa Minor	*The modern Beta of Ursa Minor*
1. Named as a star of the 3rd magnitude order in the Almagest, which makes it dimmer than the Beta. In reality, their magnitudes are almost equal, qv above.	1. Named as a star of the 2nd magnitude order in the Almagest, being one of the constellation's two brightest stars, since only Beta and Gamma were named as stars of the 2nd magnitude order by Ptolemy.
2. In the II century A.D. the North Star lay at a considerable distance from the pole, namely, one of circa 12 degrees.	2. In the II century A.D. the Beta was closer to the pole than the Alpha, and lay at the distance of circa 8 degrees from the pole.
3. The North Star is described as "the star at the tip of the tail" in the Almagest.	3. The Beta tops the back of Ursa Minor – it is located at the very centre of the constellation figure.

Having compared these two columns, we must admit that we believe it to be a psychological impossibility that a catalogue dating from the II century A.D. should begin with the North Star, since there is obviously a much better candidate – namely, the Beta star of the constellation.

N. A. Morozov was perfectly correct to opine as follows: "How can it possibly be true that someone who lived in the second or even the third century, while listing the stars from the north to the south, could begin the list of Ursa Minor's stars with the furthest star from the pole located at the constellation figure's tail, and not the star at the centre, closest to the pole?" ([544], Volume 4, page 202). The situation shall grow

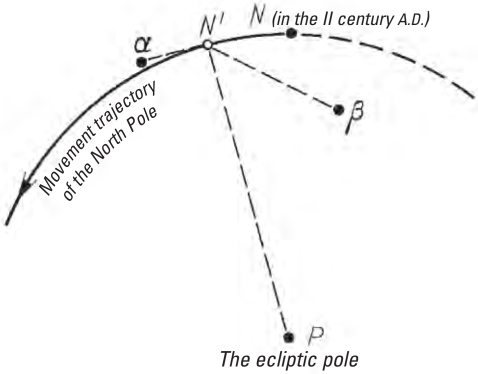


Fig. 11.3. The North Pole moves virtually right towards the Alpha of Ursa Minor, or the modern North Star, moving away from the Beta. The initial location of the North Pole (*N*) is given for the II century A.D.

even stranger if we assume that the star catalogue was compiled by Hipparchus in the alleged II century B.C.

However, everything shall change instantly, with every oddity disappearing, if we abandon the hypothesis that the Almagest was compiled around the beginning of the new era. Let us see whether there are any epochs when it would be perfectly normal for the compiler to begin the catalogue with the North Star. In fig. 11.3 one sees the North Pole (*N*), the ecliptic pole (*P*), and Ursa Minor's Alpha and Beta, as well as the direction of the North Pole's rotation around the ecliptic pole. We disregard the minor oscillations of the ecliptic presently. It is perfectly clear that the situation alters over the course of time. Namely, the Beta star drifts away from the pole, whereas the Alpha star moves in the opposite direction. Fig. 11.3 makes it very obvious that the North Pole moves right towards Alpha, or the North Star, and away from Beta. The initial position of the North Pole (*N*) in the II century A.D. is shown in fig. 11.3. The pole (*N*) rotates around the pole of the ecliptic at the rate of circa one degree per century (the estimate is, of course, rather rough).

We now have a general idea of the time period required for the North Pole to get closer to the North Star than to Beta. We did not aim to make any precise calculations here, since we do not consider this an important dating method for the catalogue; the considerations we're voicing presently have an auxiliary nature. A rough estimate demonstrates that 7-9 centuries later (as counted off the II century A.D.), the Alpha star does indeed become closest to the North Pole. Therefore, we come up with the following comparative table for stars Alpha and Beta, covering the period between the IX-XI century A.D. and our days.

North Star (Alpha)	*Beta star*
1. Star of Ursa Minor closest to the North Pole.	1. Lays at greater distance from the North Pole than Alpha.
2. The tail is the part of Ursa Minor's figure that lays the closest to the pole. See fig. 11.3 and Bode's star chart.	2. The body of Ursa Minor, which comprises the Beta, moves away from the North Pole.
3. Alpha is brighter than Beta. The true brightness of Alpha equals 2.1 (as per photometric measurements). Alpha is the brightest star of Ursa Minor.	3. The true brightness of Beta equals 2.2 (as per photometric measurements). Therefore, Beta is dimmer than Alpha, although Ptolemy claims the reverse to be the case.

It is perfectly obvious that any observer who would compile the catalogue in the timeframe between the IX century A.D. and the present day is most likely to choose Alpha as the first star in his list – this is precisely what the compiler of the Almagest has done. Incidentally, in the XV-XVI century, which is when the Almagest manuscripts were published the most actively, the modern North Star was already the closest to the North Pole, the distance between the two equalling a mere 4 degrees. There was no closer star. In 1900 the distance between the modern North Star and the pole equalled 1 degree 47 minutes, and by 2100 it shall equal 28". After that, the distance shall begin to grow.

And so, by beginning with the North Star, the compiler of the Almagest catalogue provides us with some data about the date of his observations – they cannot predate the epoch of the X-XI century A.D.

1.3. Oddities inherent in the Latin (allegedly 1537) and Greek (allegedly 1538) editions of the Almagest

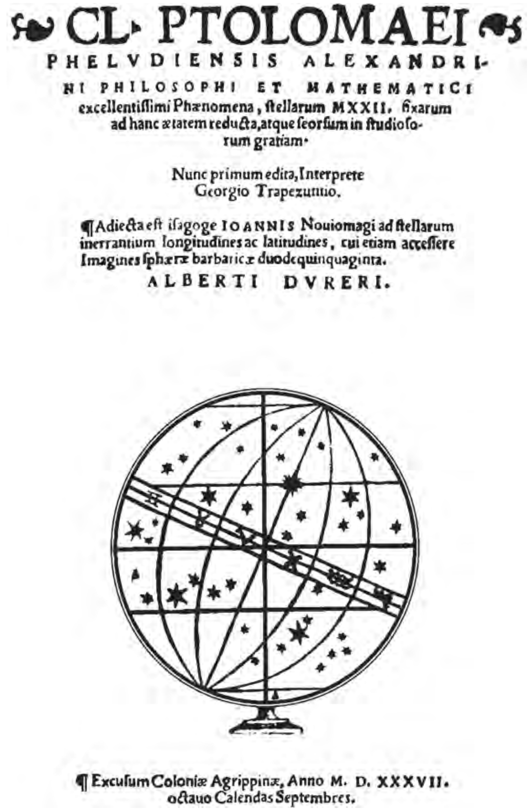
The Latin edition of the alleged year 1537, kept in Cologne, and the Greek edition of the alleged year

1538, kept in Basel, are considered the most important mediaeval editions of the Almagest ([1024]). See also the list of the Almagest's printed versions in [1024]. The title page of the Latin edition tells us explicitly that the edition in question is the "first", qv in figs. 11.4 and 11.5. We read the following (fig. 11.5):

Nunc PRIMUM edita, Interprete
Georgio Trapeuzuntio.

This leads us to a perfectly justified question. How reliable are the datings of the manuscripts that served as prototypes for the edition of the alleged year 1528 (Trebizond, #36 in the list from [1339], qv below) and the edition of the alleged year 1515 (#35 in the list from [1339]), considered exceptionally rare today? To the best of our knowledge, there is another edition, allegedly dating from 1496, which contains no star catalogue at all. The date indicated on the title page of the Latin edition allegedly dating from 1537 is transcribed as follows: M. D. XXXVII (see fig. 11.4). Pay attention to the dots that separate the Latin letters M and D from the rest. As it was pointed out in CHRON1, this transcription can be interpreted in a variety of ways, such as "Magnus Domus XXXVII", or "Magn Dome XXXVII" – "Year 37 of the Great House", in other words. Therefore, we might as well also enquire about the actual dynasty (or Great House), whose reign the mediaeval publisher used for chronological reference.

N. A. Morozov describes the oddities that he had discovered, which made him question the consensual dating of the Almagest, in the following manner: "I … started to compare the latitudes I found [in the Latin book of the alleged year 1537 – Auth.] to their modern equivalents, converting direct ascensions and declinations of stars taken from the Astronomischer Jahrbuch of 1925 into longitudes and latitudes for this purpose. The very first calculation that I had performed for Regulus flabbergasted me completely: the position I came up with corresponded to the XVI century A.D. and not the II – the epoch when the book under study was published, in other words. I proceeded with Virgo's Ear of Wheat and three other bright stars. The result was the same – Ptolemy's longitudes corresponded to the XVI century! … I thought to myself 'How can this be? After all, Bode (whom I still hadn't read in the original) and a host of other astronomers, such as Abbot Montinho, date this book to the second century' … The very next morning … I went to the Pulkovo Observatory in order to compare these amazing results to the first editions of the Almagest kept there … I took the first Greek edition [of the alleged year 1538 – Auth.] off the shelf, and


CL. PTOLOMAEI
PHELVDIENSIS ALEXANDRINI PHILOSOPHI ET MATHEMATICI
excellentiſſimi Phænomena, ſtellarum MXXII. fixarum ad hanc ætatem reducta, atque ſeorſum in ſtudioſorum gratiam.

Nunc primum edita, Interprete
Georgio Trapezuntio.

¶Adiecta eſt iſagoge IOANNIS Nouiomagi ad ſtellarum inerrantium longitudines ac latitudines, cui etiam acceſſere Imagines ſphæræ barbaricæ duodequinquaginta.
ALBERTI DVRERI.

¶Excuſum Coloniæ Agrippinæ, Anno M. D. XXXVII.
octauo Calendas Septembres.

Fig. 11.4. The title page of a Latin edition of the Almagest, allegedly dating from 1537.

Nunc primum edita, Interprete
Georgio Trapezuntio.

¶Adiecta eſt iſagoge IOANNIS Nouiomagi ad ſtellarum inerrantium longitudines ac latitudines, cui etiam acceſſere Imagines ſphæræ barbaricæ duodequinquaginta.
ALBERTI DVRERI.

Fig. 11.5. A fragment from the inscription on the title page of an edition that allegedly dates from 1537.

was amazed to discover that all the longitudes it contained were reduced by the shift on 20 degrees (give or take 10 minutes) as compared to my Latin book; therefore, the time of the catalogue's compilation was shifted backwards by fifteen hundred years, if we are to count the respective longitudes from the point of vernal equinox … My amazement was no longer: Bode had used the Greek edition of 1538 for his calculations, whereas I referred to the earlier Latin edition of 1537. However, I started to wonder about the following: isn't it odd that precession would cover precisely 20 degrees over the period of time that passed between the alleged epoch of Ptolemy and the Greek edition of his book – not 15, 16, 17, 18 or some such, but a whole 20 degrees, with the same variation of give or take 10 arc minutes?" ([544], Volume 4, pages 178-179).

Bode's position is perfectly clear: why would one analyse the Latin "translation" if one had the original (as Bode believed) text in Greek? It was only later that N. A. Morozov first voiced the suspicion that the Latin text of the alleged year 1537 might be the original in reality, the Greek text of the alleged year 1538 being a derivative thereof. Scaligerian chronology claims the reverse to be true.

It could be that the author of the XV, XVI or even early XVII century, who published the alleged "Latin translation" first, hadn't bothered to account for the effect of precession. When it was pointed out to him, he introduced the corrections into the "Greek original", shifting it backwards in time to the II century A.D.

Let us cite the table compiled by N. A. Morozov, which demonstrates the 20-degree longitudinal shift between the Latin and the Greek editions of the Almagest in all clarity, using the Cancer constellation as an example ([544], Volume 4, p. 180). See table 11.1.

However, we may yet encounter objections against the originality of the Latin text allegedly dating from 1537. Our opponents might suggest that in the XVI century Ptolemy's book wasn't published as a document important for the history of sciences, but rather a scientific tractate for immediate use by the scientists and students of astronomy. This application was however hindered by precession, which had rendered the data contained in the "old" catalogue obsolete. Therefore, the translator brought the catalogue "to date", introducing the latest data available in his epoch, or the astronomical data of the XV-XVI century. As for the publisher of the Greek text, which came out the very next year, allegedly in 1538 – he may have decided that the Greek text was no longer needed as a textbook after the publication of the Latin

Ptolemy's star names	*Modern star names*	*Stellar longitudes calculated for 140 A.D. Parentheses contain longitudes from the Almagest version referred to in [1339]*	*Stellar longitudes indicated in the Greek edition of the Almagest allegedly dating from 1538*	*Stellar longitudes given in the Latin edition of the Almagest allegedly dating from 1537*	*Difference between the Latin longitudes and their Greek counterparts*
1 (Manger)	41ε	Cancer 10° 19' (10° 20')	Cancer 10° 20'	Leo 0° 10'	20° (–10')
2	33η	Cancer 8° 18' (7° 40')	Cancer 7° 20'	Cancer 27° 30'	20° (+10')
3	31θ	Cancer 8° 38' (8° 0')	Cancer 8° 0'	Cancer 27° 50'	20° (–10')
4 (Ass)	43γ	Cancer 10° 26' (10° 20')	Cancer 13° 0'	Leo 2° 50'	20° (–10')
5 (Jennet)	47δ	Cancer 11° 36' (10° 20')	Cancer 11° 20'	Leo 1° 10'	20° (–10')
6	65α	Cancer 16° 0' (16° 30')	Cancer 16° 30'	Leo 6° 20'	20° (–10')
7	48ι	Cancer 9° 13' (8° 20')	Cancer 8° 20'	Cancer 28° 10'	20° (–10')
8	10μ	Cancer 2° 21' (2° 40')	Cancer 2° 20'	Cancer 22° 30'	20° (+10')
9	17β	Cancer 7° 10' (7° 20')	Cancer 7° 20'	Cancer 27° 0'	20° (–20')

Table 11.1. The table compiled by N. A. Morozov ([544], Volume 4, page 180). The table demonstrates the shift of longitudes by 20 degrees that makes the Latin edition of the Almagest differ from the Greek, using the constellation of Cancer as an example. In order to render the coordinates to their ecliptic equivalents, one has to bear in mind that the sign of Cancer begins at the 90th degree of longitude in the even Zodiac, and Leo – at the 20th degree, qv in table 2.1.

translation, restoring the initial data introduced by the "ancient" Ptolemy, which date the catalogue to the beginning of the new era. This theory appears to be supported by the title page of the Latin edition of 1537, which bears the legend "rendered to the present moment for the sake of the students" (*ad hanc aetatem reducta, atque seorsum in studiosorum gratiam*) – see fig. 11.4.

This line of argumentation acknowledges the apocryphal nature of the Latin edition (inasmuch as the star catalogue is concerned, at least), but denies the possibility that the Greek version may be apocryphal as well.

The refutation of the above is as follows. All the latitudes contained in the Greek edition of the alleged year 1538 have been made greater systematically, the precision margin turning out 25 minutes higher than that of the Latin edition allegedly dating from 1537, or simply corrected for more precise values. Precession has got nothing to do with it, since it does not affect latitudes whatsoever. The correction is of a circular nature, which means that the entire ecliptic was shifted towards the South by nearly the entire diameter of the Sun. The ecliptic of the Greek edition would thus assume its normal astronomical position, since its plane virtually intersects with the centre of the coordinate system, qv in fig. 11.6. The ecliptic was still "fitting poorly" in the earlier Latin edition of the alleged year 1537, meaning that its plane did not intersect with the centre of the celestial sphere. Thus, the ecliptic was measured poorly in the Latin edition, and much better so in the subsequent Greek edition. What we see is obviously a revision of the Latin original.

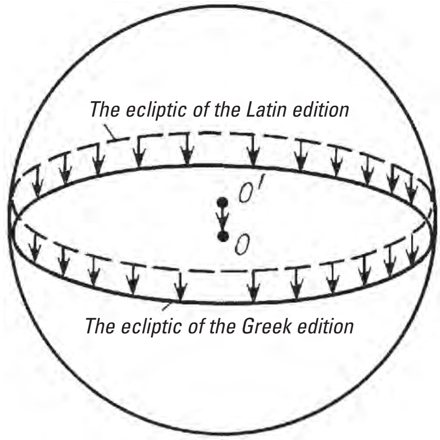


Fig. 11.6. The disposition of the ecliptic in the Greek edition of the Almagest allegedly dating from 1538, as well as the preceding Latin edition allegedly dating from 1537.

Let us provide the following explanatory remark for the attentive reader. The ecliptic of the Latin edition is shown in fig. 11.6 as a dotted circle, and that of the Greek edition – as a simple circle. The "Latin ecliptic" obviously fails to cross the centre of the sphere. The "Greek ecliptic" already occupies a more

Number of Ursa Minor star in the Almagest. Modern names of the stars are given in parentheses	*Latitude indicated in the Latin edition*	*Latitude indicated in the Greek edition. Variants from [1339] are given in parentheses*	*The discrepancy: Greek latitude value with the Latin latitude value subtracted*
1 (1α Ursa Minor)	65° 35'	66° 00'	+25'
2 (23δ Ursa Minor)	69° 35'	70° 00'	+25'
3 (22ε Ursa Minor)	73° 55'	74° 20'	+25'
4 (16ζ Ursa Minor)	75° 15'	75° 20' (75° 40')	+5'(+25')
5 (21η Ursa Minor)	77° 1'	77° 20' (77° 40')	+5'(+25')
6 (7β Ursa Minor)	72° 25'	72° 50'	+25'
7 (13γ Ursa Minor)	74° 25'	74° 50'	+25'
8 (5*A* Ursa Minor)	70° 45'	71° 10'	+25'

Table 11.2. A comparison of the Latin and Greek ecliptic latitudes of Ursa Minor, the first constellation of the Almagest. In the second column one finds the latitudes from the canonical edition, allegedly dating from 1537, and in the second – those taken from the Greek edition of 1538 (presumably), as well as their variants from the canonical version of the Almagest ([1339]) and Toomer's translation ([1538]). The last column contains the difference data for both latitudes.

correct astronomical position, since it is shifted downwards by 25' and made parallel to the "Latin ecliptic". It is possible that the error inherent in the Latin edition was made due to the rough nature of the instruments used for measurements or insufficient accuracy in the conversion of equatorial coordinates into their ecliptic equivalents.

Let us also cite the comparative table of Greek and Latin latitudes (table 11.2) – for example, the ecliptic latitudes of the Almagest's first constellation, namely, Ursa Minor. In the second column we cite the latitudes of the Latin edition allegedly dating from 1537, and in the third – those contained in the Greek edition allegedly dating from 1538, as well as their variants from the canonical version of the Almagest ([1339]) and Toomer's translation ([1358]). The last column contains the values of the discrepancies between latitudes (more specifically, Latin latitudes are subtracted from the Greek).

It is thus quite obvious that the discrepancy between the latitudes indicated by the Latin and the Greek versions (see also the canonical version in [1339] and [1358]) is precisely equal to 25' for every star of Ursa Minor. This is very clearly a shift of 25'. The values of Greek and Latin latitudes were taken from the table cited in [544], Volume 4, page 198.

So, the publisher of the Greek text was "reconstructing Ptolemy's old data" and simultaneously correcting them for greater precision. This contradicts the hypothesis that the Greek text of the alleged year 1538 is the original.

1.4. The star charts of the Almagest

All the Almagest stars are localised in relation to the constellation figures presumably drawn in the sky. In order to use the catalogue, the astronomer must first locate a certain constellation figure in the sky, and then turn to the catalogue in search of a description such as "star at the tip of the tail". In the present example the star in question can be identified as the modern North Star ([704], page 224). "The star above the right knee" in Ursa Major is another example ([704], page 225). And so on, and so forth. We cannot locate any star at all without referring to a star chart with constellation figures drawn upon it. Obviously enough, one might use the numeric coordinate values in order to locate a given star with the aid of measurement instruments; however, this de facto spells as performing the entire measurement process in reverse in order to locate a star by its coordinates. This is a complex and lengthy procedure. It is quite clear that the catalogue was made for the purpose of quick location of stars on the celestial sphere and not the lengthy "restoration procedure" involving reverse calculations.

In this case, two different astronomers referring to the catalogue must possess two perfectly identical star chart copies in order to reconstruct the initial position of "the star above the right knee", for instance, without any ambiguity. If the knee is drawn differently on another copy of the star chart, it is easy to make a mistake. Precise location of stars by body parts of imaginary animals, maintained as a tradition in many countries for many centuries without confusion in actual observation, sans drawn limbs, is only possible insofar as the stars of the first and second magnitude order are concerned – bright stars, that is. Stars of the third magnitude order would already be afflicted by confusion, due to the different astronomers' heterogeneous ideas concerning the shape of the imaginary animals' limbs. Thus, the drawings of animals on star charts played the part of a curvilinear coordinate grid that allowed to define the positions of stars.

At any rate, an astronomer endeavouring to compile a catalogue with the precision margin of 10 minutes, such as the Almagest, must be aware of the paramount importance of using identical constellation figures for different copies of the chart. These copies would be sent to the apprentices and colleagues. As it is stated in the title page of the Almagest's Latin edition, the latter is complemented by 48 star charts engraved by A. Dürer, qv in fig. 11.4. Before the printing press, star charts only contained the brightest stars, and their disposition in relation to the constellation figure varied from one chart to another. It was only after the invention of the engraving technique that a large number of identical copies of a detailed star chart could be manufactured for use by a host of astronomers from different countries.

However, such star charts were right out of the question up until the invention of the mechanical reproduction method in the XV century. Only mass production of absolutely identical copies could jus-

Fig. 11.7. Star chart of the Northern Hemisphere by Albrecht Dürer (1471-1528), allegedly dating to 1527. Taken from [90], page 8.

tify the labour involved in detailed representation of stars up to the 3rd and 4th degrees of magnitude, as is the case with the Almagest. Even if somebody would indeed decide to tackle the Gargantuan job of making a single copy of such a chart before the invention of the printing press, it could never survive for too long – suffice to mention the short lifespan of paper and parchment. The reproduction of such a chart performed with precision sufficient for practical use would mean doing the whole job again from scratch. Albrecht Dürer's star charts are actually the first ones made in great enough detail. In figs. 11.7 and 11.8 we reproduce Albrecht Dürer's star charts of the Northern and the Southern hemisphere allegedly dating

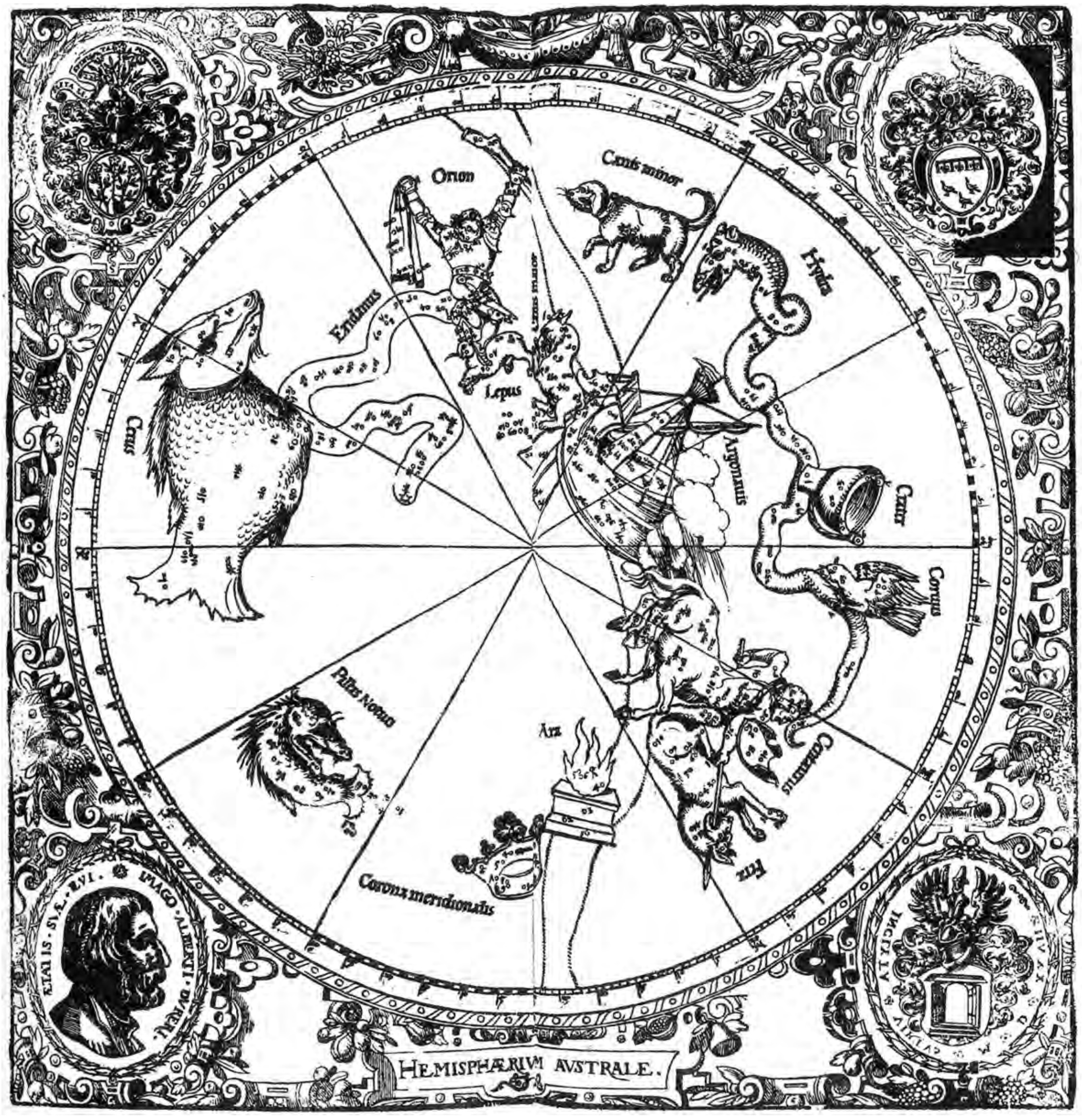


Fig. 11.8. Star chart of the Southern Hemisphere by Albrecht Dürer (1471-1528), allegedly dating to 1527. Taken from [90], page 9.

from 1527. For comparison, in figs. 11.7 and 11.8 we cite the same charts taken from the edition of the Almagest published in the alleged year 1551. It is most noteworthy that the two "Almagest charts" differ from each other – for instance, some of the "ancient" characters are wearing mediaeval clothes in the illustrated maps from the alleged 1551 edition.

Obviously, Dürer's famous star charts, which were engraved in 1515, according to the Latin legend on the engraving, ended up as part of the first Latin edition of the Almagest in the alleged year 1537, long after they were distributed to the Western astronomers as engravings. History of technology tells us that the engraving technique was introduced in