

A preliminary analysis of the Almagest star catalogue

1. THE CATALOGUE STRUCTURE

The Almagest star catalogue comprises its seventh and eighth books. We were using the canonical edition of the Almagest star catalogue for our research, as published by Peters and Knobel ([1339]), as well as the two complete editions of the Almagest translated by R. Catesby Taliaferro ([1355]) and Toomer ([1358]). The first Russian translation of the Almagest came out in 1998 ([704]).

Before we give our characteristic to the catalogue, it would be expedient to remind the reader of a few concepts used in literature on the history of astronomy.

The Almagest star catalogue was compiled in the ecliptic coordinate system. As we mentioned earlier, in most of its editions and copies stellar latitudes are rendered to the epoch of circa 60 B.C. In other words, the initial longitudinal reference point was recalculated by someone to correspond to the position of the sun in relation to the stars as they would appear to the observer from the middle of the I century A.D. on the day of vernal equinox.

Stellar longitudes as indicated in the Almagest catalogue relate to the so-called even Zodiac as counted off the vernal equinox point of a given epoch. Let us explain that the even or “monthly” Zodiac is a mere

division of the ecliptic into twelve equal parts as stipulated by the epoch of observation. It has to be emphasised that (strictly speaking) the even Zodiac is defined by the observable solar trajectory on the celestial sphere and not the zodiacal constellations per se. The ecliptic arc covered by the Sun during the first month of “march” (not the calendar march, but the month that begins on the day of vernal equinox) is commonly referred to as “Aries”. The next “equinoctial month of April” is when the Sun passes through the constellation of Taurus of the even Zodiac. Next come Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and, finally, Pisces. This is how the annual ecliptic circle ends. Thus, the even Zodiac can be regarded as a simple way of dividing the ecliptic into 12 equal 30-degree parts starting with the vernal equinox point for a given epoch. Precession makes this initial point of reference shift along the ecliptic at the rate of circa 1 degree per seventy years. These shifts are significant, but relatively small as compared to the thirty-degree span of a whole sign. Therefore, the even Zodiac, once chosen for its approximate correspondence to the constellations of the Zodiac, retains this correspondence to this day. In other words, if the Sun is in Aries (or March, according to the even Zodiac), it shall be near the zodiacal constellation of Aries. The reverse is possible as well – namely, that the

Table 2.1. Signs of the even Zodiac corresponding to 30-degree arcs (or longitudinal intervals) as counted from spring equinox point of the current epoch.

Latin name of a sign	Abbreviated Latin name	Longitudinal interval
Aries	Ari	0 – 30
Taurus	Tau	30 – 60
Gemini	Gem	60 – 90
Cancer	Can	90 – 120
Leo	Leo	120 – 150
Virgo	Vir	150 – 180
Libra	Lib	180 – 210
Scorpius (Scorpio)	Sco	210 – 240
Sagittarius	Sag	240 – 270
Capricornus (Capricorn)	Cap	270 – 300
Aquarius	Aqu	300 – 330
Pisces	Pis	330 – 360

boundaries of zodiacal constellations were once defined in such a manner as to correspond to the even Zodiac – the visible solar route, or the ecliptic, divided into twelve even parts.

In table 2.1 we cite the complete list of signs (or arcs) that comprise the even Zodiac. All of them are counted off the variable vernal equinox point.

Stellar longitudes were transcribed with the aid of these arc signs (or month signs) in the Middle Ages. For instance, “15°20' in Taurus” stood for 45°20' as counted off the current vernal equinox point (or some other point chosen as referential by the authors of a given catalogue for reasons of their own). It has to be stated that the equinox point didn't always serve the referential purpose in the old catalogues. Let us consider another example: “15°20' in Libra” would mean 225°20' as counted off the point of reference. See table 2.1. This is how the longitudes are transcribed in the Almagest catalogue.

Ecliptic latitudes of stars in the Almagest are indicated according to a simpler principle – namely, they are counted off the ecliptic that corresponds to the latitudinal zero degree and up to the ecliptic pole corresponding to the 90th latitudinal degree. The Alpha of Ursa Minor, for example, has the latitude of

+66°0' in the Almagest. The “+” or “–” here refer to the respective location of the star in the Northern or Southern Hemisphere.

As we have pointed out already, zodiacal signs do not correspond to zodiacal constellations, which is why the stars that pertain to a single zodiacal constellation can wind up in different zodiacal signs.

The canonical version of the Almagest catalogue contained in the work of Peters and Knobel ([1339]) is presented as a table that consists of six columns.

The first column contains the index number of a given star in the Almagest. This numeration was devised by the astronomer Bailey. Surviving manuscripts of the Almagest contain no numerical indexation. Bailey was a famous commentator and researcher of the Almagest. According to Bailey, the sum total of stars listed in the Almagest equals 1028. There are minute discrepancies between the estimates of different researchers, one of the reasons for their very existence being the fact that some stars were listed twice in the Almagest (see [1339] for more details).

The stars are grouped by constellation in the Almagest; each of the constellations has a name. The Almagest lists 48 constellations all in all; we shall cite the actual list below. Some constellations have annexes referred to as “*Informata*” – auxiliary stars that weren't included in the main list of stars comprising a given constellation. The Latin term “*informata*” translates as “shapeless” or “amorphous” (“*informis*”, “*informatitas*” etc). In other words, the main list apparently contains the stars that the ancient astronomer believed to form the “skeleton” of the constellation, whereas the stars listed as “*informata*” provide the “background” of sorts. It is possible that the compiler of the catalogue believed the stars of the *informata* category to be of a lesser importance than the “main” stars. One must bear in mind that the ancient astronomy was closely linked to astrology, where the visual outline of a constellation was of paramount importance. Some of the Almagest constellations have no *informata* whatsoever. A full list of constellations can be found below, in table 2.2.

The second column of the table in [1339] contains a verbal description of the star in question and the part it plays in the general shape of a given constellation. Such descriptions are often rather vague. For instance, the Alpha of Ursa Minor is referred to as “the star on

the tip of the tail” in the *Almagest*. In the canonical version of the *Almagest* ([1339]) verbal descriptions of stars were taken from the Latin edition of 1528 translated by Trebizond. They were verified by the Greek edition. It is believed that the initial language of the *Almagest* was Greek. See Chapter 11 for more details concerning the history of the *Almagest*’s manuscripts and first editions.

The modern names of the stars can be found in the third column of the table in [1339]. Actually, this column contains the names of the *Almagest* stars identified on the star chart of today. Said identifications are the result of much labour performed by the scientists whose research involved the *Almagest*. What complicates such identifications is the rather whimsical nature of the verbal descriptions in question. Moreover, the very figures of constellations could vary from one astronomical school to another over the course of years. Therefore, the identification of the *Almagest* stars as some of the stars that we know today is anything but self-implied. Obviously enough, this is the very first problem to solve before we can proceed to analyse other characteristics of the catalogue.

An enormous body of work was conducted by the XVII-XIX century astronomers in order to identify the *Almagest* stars. The final version can be found in [1339]. We shall forthwith refer to it as “canonical”. The same source ([1339]) contains the table of discrepancies between the opinions of different specialists in re the identification of a given star. This table contains several such identifications of *Almagest* stars.

The fourth column contains the ecliptic longitude of a star as related to the arc (or sign) of the even Zodiac that the longitude value in question falls over.

The fifth column contains the star’s ecliptic latitude.

The sixth column corresponds to the “brightness” (or size) of the star.

2.

THE ANALYSIS OF THE DISTRIBUTION OF RELIABLY AND POORLY IDENTIFIABLE STARS IN THE *ALMAGEST*

The book ([1339]) contains a table entitled “Identification Discrepancies”, which deals with the different identifications of certain *Almagest* stars made by

the following famed researchers: Peters, Bailey, Schjellerup, Pierce and Manitius. Different identifications of certain *Almagest* stars on the celestial sphere of our epoch suggested by said astronomers are also indicated.

We have partially processed this enormous body of material. First of all, it is very useful to indicate the location of the constellations mentioned in Ptolemy’s star catalogue geometrically. Let us use a modern map that specifies constellation boundaries for this end. In fig. 2.1. these boundaries are represented as uninterrupted zigzagged lines. This is an approximated representation, of course, since the ancient constellations had no rigidly defined borders. However, it suffices for a rough estimate, therefore we can assume that fig. 2.1 gives us a correct qualitative representation of how the *Almagest* constellations are positioned on the celestial sphere.

Let us compare this illustration to the star chart (with drawn constellations) from the first editions of the *Almagest* – in Greek and in Latin, dating from the XVI century A.D. In fig. 2.2 we see a star chart of the Northern hemisphere drawn by Albrecht Dürer, and in fig. 2.3 – the chart of the Southern hemisphere by the same artist. Dürer created these maps in 1515 (see [544], Volume 4, pages 204-205; also [90], pages 8-9). Dürer’s map of the Northern Hemisphere was included in the 1527 edition of the *Almagest* ([90], page 8). Dürer’s star chart of the Southern Hemisphere saw another edition in 1527, slightly altered (we reproduce it in fig. 2.4).

In figs. 2.5 and 2.6 we see two more star charts included in another edition of the *Almagest* (dating from 1551). It is very peculiar that although the “ancient” Ptolemy is supposed to have lived in the II century A.D., some of the constellation figures are dressed in mediaeval attire ([543], pages 216-217).

In figs. 2.7 and 2.8 we also reproduce the maps of the Northern and Southern hemisphere compiled in accordance with the *Almagest* by the astronomer Bode in the XVIII century.

Dürer’s star chart does not contain any precise borders of *Almagest* constellations. The matter is that Dürer merely drew the symbolic figures of zodiacal constellations – Hercules, Pegasus etc. Nevertheless, a comparison with the modern star chart demonstrates that modern constellation borders are in good

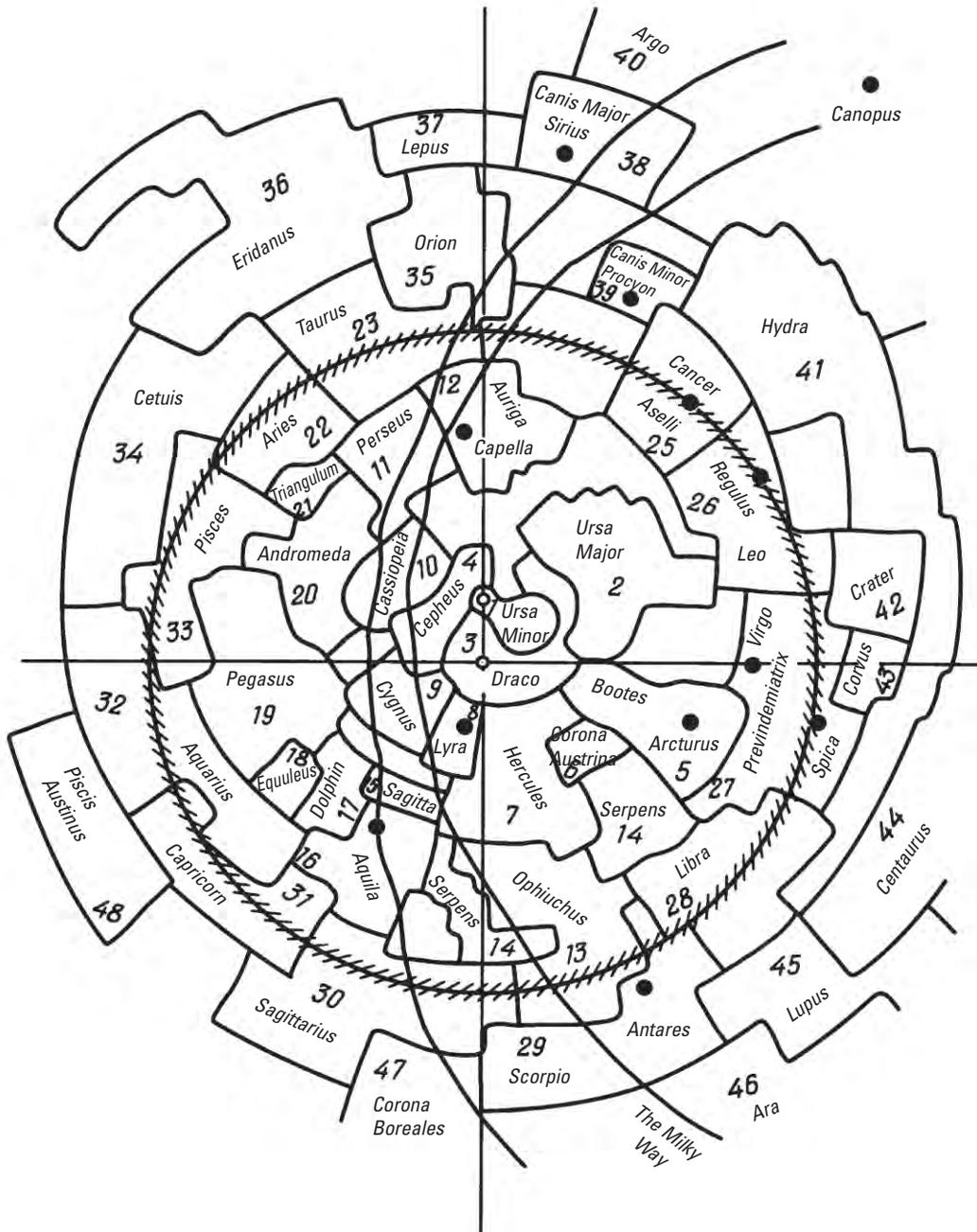


Fig. 2.1. Modern boundaries of the constellations mentioned by Ptolemy in the Almagest.

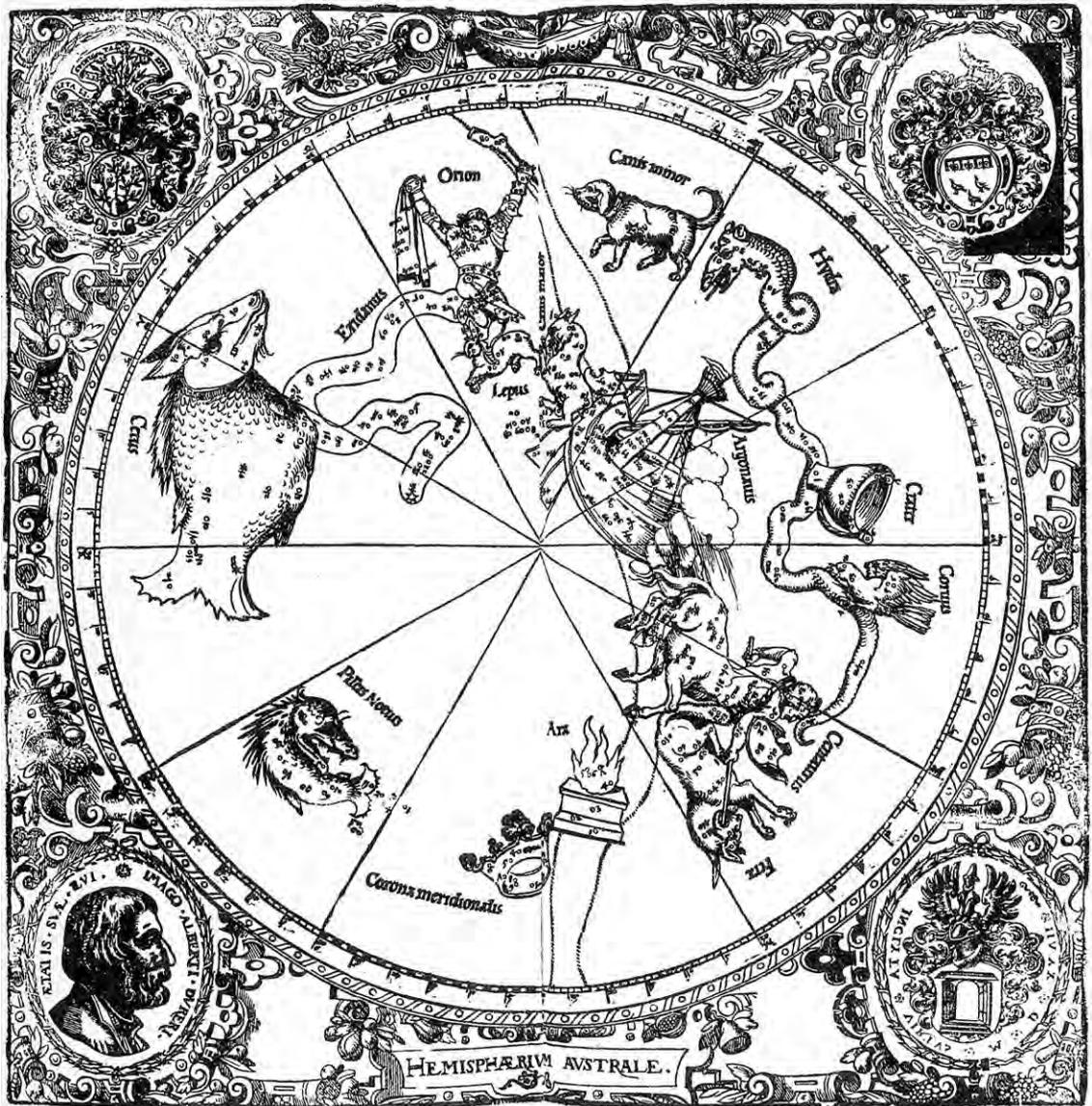


Fig. 2.4. Dürer's star chart of the Southern Hemisphere, published once again in 1527 – this time somewhat altered. According to the commentators, “the decorative framing was added subsequently, and includes a portrait of the painter” ([90], page 9). There was nothing of the kind in the map of 1515. Taken from [90], page 9.

correspondence with the figures from Dürer's star charts in the *Almagest*.

In fig. 2.9 we reproduce a page of the star catalogue from an edition of the *Almagest* that dates from 1551. In fig. 2.10 one sees a page from the Greek version of the *Almagest* that was written in the IX century ([1374], page 143). A page from another version of the *Almagest* (in Latin, dating from the XIII-XIV century) is reproduced in fig. 2.11. In fig. 2.12 we see a page from George Trebison's Latin version of the *Almagest* (circa 1481 A.D. – see [1374]). It is most likely that all these editions hail from the XVI-XVII century the earliest. We shall consider the issue of their dating in the chapters that follow. Let us return to the *Almagest* star catalogue.

In fig. 2.1 the shaded circle represents the ecliptic. The wide vertical stripe curved leftwards is the Milky Way. Of course, its borders are defined rather approximately and demonstrate the distribution of the densest parts of the Milky Way. Inside the regions that correspond to constellations we have indicated their names and numbers in accordance with the *Almagest*. For example, Ursa Minor is the first constellation listed in the *Almagest*, Ursa Major is the second, Draco is the third etc.

The *Almagest* contains twelve named stars, or stars that possess proper names. Verbal description of such stars always contains the formula “*vocatur*” (which translates as “named”). Thus, “*vocatur Arcturus*” stands for “star named Arcturus”. All these stars are represented as large black dots in fig. 2.1. They are as follows: Arcturus, Previendematrrix, Spica, Regulus, Acelli, Sirius, Procyon, Lyra = Vega, Cappella, Aquila, Canopus and Antares. We see that most of them happen to be located to the right of the Milky Way, on Milky Way or in its immediate vicinity. Canopus is de facto located outside of the star chart, since the star in question lies very far in the South.

Let us enquire about the order of constellations in Ptolemy's list. This purpose stipulates the compilation of a new chart where every constellation is replaced by the symbolic representation of its centre (a light circle, qv in fig. 2.13). Obviously enough, constellation centres can only be defined approximately, but no great precision is needed here, since we are only interested in a rough qualitative picture. Let us then draw arrows to link adjacent constellations together.

We shall end up with a curve whose motion from one constellation to another reflects the order of constellations in Ptolemy's list. It is remarkable that the resulting curve attains the shape of a spiral that begins with Ursa Minor and goes clockwise, up to the very end of the *Almagest* list. This is precisely where the celestial pole is, qv in fig. 2.1. Right next to it, in Draco, we have the North Pole as well as the pole of the ecliptic. Let us follow the order of Ptolemy's motion across the celestial sphere as he lists the constellations (see the curve in fig. 2.13).

The curve will obviously be divisible into several parts. First Ptolemy lists all the constellations numbered 1-8, namely, the constellations of Ursa Minor, Ursa Major, Draco, Cepheus, Boötes, Corona Borealis, Hercules and Lyra. They are located in the area bordered by the zodiacal belt on the right and the Milky Way on the left.

Then the curve proceeds across the Milky Way. Ptolemy lists all the constellations included in the Milky Way or overlapping with the latter to a great enough extent. Those are Cygnus, Cassiopeia, Perseus, Auriga, Ophiuchus, Serpens and Sagitta (numbered 9-15).

Next Ptolemy deals with the area that lays to the left of the Milky Way (its left borderline is defined by the Zodiacal belt, qv in fig. 2.13). He consecutively lists the constellations of Aquila, Delphinus, Equuleus, Pegasus, Andromeda and Triangulum (numbered 16-21).

After that the curve moves on to the Zodiac and goes around the centre of the star chart. Ptolemy provides a list of all twelve Zodiacal constellations, namely, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces (numbered 22-23).

Finally, Ptolemy leaves the Northern Hemisphere, crosses the Zodiacal Belt and moves towards the Southern Hemisphere, listing the constellations in the following order: Cetus, Orion, Eridanus, Lepus, Canis Major, Canis Minor, Vela, Hydra, Crater, Corvus, Centaurus, Lupus, Ara, Corona Australis and Piscis Austrinus (numbered 34-48). This is where the *Almagest* star catalogue ends.

Thus, Ptolemy's order of constellations is based on a very obvious principle – the self-implied division of the star chart into several regions.

We shall refrain from delving deep into the reasons why the author of the catalogue chose to list the con-