Austrian heliocyclic stars, first part, which is about the phenomena.

Proposition I

Investigating the Austrian stars by means of an optical tube and other procedures.

Not many years ago, a certain tube came out of my beloved Belgium, closed at the top by a convex lens and at the bottom with a concave lens (they call it telescope or dioptre). Through this device, things located far away are much closer. So, it happens that with the help of this tube we can observe many things of the sky unknown in past centuries and, among them, that one which we have proposed to address: Austrian stars. Then, given a tube - AB say - separated at a suitable distance the two lenses A and B, if someone passes through it a solar ray that goes from the convex lens A to the concave lens B, and reflects it at some distance onto a blank piece of paper, the solar disc CDE will appear on the paper, and, at the same time, stars F, G, and others, for example, in the form of blackish and rusty-coloured spots will also be visible inside the disc - if they are present on the Sun at that moment.

Such stars can also be observed on the Sun by bringing the eye closer to the concave lens B. But, in that case, in order for the excessive brightness of the Sun not to irritate and damage the eyes, it will be necessary to diminish the brightness with one or two green lenses or another of rather dark colour, and before directing our eyes to the Sun, we shall have to look edge-wise little by little until our eye gets used to supporting so much light. However, if the Sun is not appreciated, as often happens, due to a dense fog or vapours in the sunrise and sunset, in that case one can observe through the tube with no problem for as long as necessary without the aid of any glass object.

Again, these heliotropes [solar objects] will be observable without the tube if the solar ray received in a clean mirror is conveniently reflected towards a totally dark place; and they are also appreciated when, without any lens, the solar ray is passed through a narrow hole towards a dark place and is reflected, as before, onto a paper. Thus, these bodies are represented in far more successful way using a telescope, without which only the most compact conjunctions of these planets can be perceived, as you yourself can verify by performing an experiment.

It should be kept in mind, however, that when the solar ray passes through the telescope or a narrow hole, everything appears upside down. This is such that the upper part of the Sun (A), and the heliotropes in that position, project onto the lower part of the disk in (D); instead, the lower part of the Sun (C) will be seen in the upper part of the semicircle (E). Indeed, this is dictated by the laws of optics, because the rays that cross the hole or that converge by the effect of the convex lens concur in the vertex of the cone (B) (which we can perfectly call point of concurrence), and in that point intersect; hence the objects located in the upper part are permuted with those in the lower part, and those in the right with those in the left. And it is enough to notice this only once, so that the inexperienced do not take in their observations what is on the right to be what is on the left, or what is above for what is below. Apart from this, the phenomena of these planets that we shall be representing in this work present their real position, the same as they appear on the Sun.

Proposition II

The first form of aiming the telescope at the Sun to determine the movements of the Austrian stars.

Given a column (A), the upper surface (BC) is leveled in such a way that its side (CD) constitutes the angle of elevation of the equator with the line (DE), parallel to the horizon (FG), for example the angle (CDE) with respect to us of 39.5 degrees, and in the middle of this surface, (H) say, is fixed at right angles a circular and firm axis. Likewise, set two planes (KLM) and (KNOP), of which the upper (KNOP) has an angle of maximum inclination, about 23.5 degrees, with respect to the lower (KLM), and inscribe in the upper plane the ecliptic (NOP) divided according to custom into signs and degrees.

To place the tube (YZ), arrange a long slat (IT), to which fix three small boards (TVI) forming a right angle. Between the first two there will have to be inserted the telescope (YZ) parallel to the slat (IT), instead the third one will have to be oriented to the solar ray at a due distance, so that our planets can be seen in it, in accordance with what we said in Proposition I. The column (A) must be placed in such a way that the surface (DEFG) is in the plane of the meridian and the angle (CDE) rises in the opposite direction at noon. The planes (KLM), (NOP) and the slat (IT) have to be applied to the axis (H), and the middle of the slat, on which the tube (YZ) rests, must be fixed towards the position of the Sun on the ecliptic (NOP). Once this is done, if the planes (KLM) and (NOP) fixed towards the position of the Sun together with the telescope are rotated towards the axis (H), while the convex lens (Z) is oriented towards the Sun, the solar ray will pass through it and its disk will be shown on the board (I), through whose centre, after drawing the straight line (SX) parallel to the board (IT), will be shown the ecliptic, where, if the heliotropes are visible on the Sun, they will be seen in the opposite position to the one they have in the ecliptic, and in this way, if on the following days their location is recorded on the solar disk (SIX), one will be able to perceive how their trajectory is maintained with respect to the ecliptic, and therefore with respect to the other circles of the sphere.

And although this could be the clearest and most worthy method with which to follow the trajectory of these stars, given my experience in the manufacture and handling of this instrument, which is, to be clear, quite complicated - because if everything is not arranged with the greatest precision and the plane of the ecliptic cannot be turned as smoothly as possible around the axis (H), it will be difficult for the solar ray to pass through the tube and to be reflected as it should on the board (I) - I shall add two other methods of observation, but before this I shall specify some points necessary to bear in mind for the question.

One will have to take care, both in this method of observation and in others, as far as possible to stop any other source of light other than the solar ray from reaching the board (I). For this, the observer's head may be covered with a cloak or some other type of veil, so that the board is covered and at the same time the folds [of the cloak] are gathered together and tightened up close to the board (V), so that no external light can reach the board (ISX), as the facts themselves will reveal.

Then you will discover the following: if the same distance of the tube with respect to the board (I) is conserved for a whole year, the solar disk will be projected in a larger size in winter than in summer, as the laws of Optics postulate. As in winter the Sun is at perigee and is closer to us, it must present a greater dimension than when it is at apogee, at around the summer solstice. So, if you intend to fix in your observations exactly the same magnitude of the disc (which in my opinion is convenient for a satisfactory practice of observations), you will have to place the tube in summer at a slightly greater distance from the board (I) than in winter. The demonstrations of Optics also postulate that for a distinct representation of a nearer object the distance from the convex lens (Z) to the concave (Y) is greater than for the representation of a farther object. Hence, for a more accurate investigation of the particles of these heliotropes, the tube should be reduced a little in summer, and, on the other hand, should be extended in winter; although the difference is small and it is hardly noticeable (unless the tube is of considerable dimensions).

Proposition XVI

Phenomena of the Austrian stars towards the ecliptic from the section of the ecliptic itself with the vertical.

In the following figures of phenomena, the straight line (AB) is the ecliptic, the upper or boreal part of the Sun is (C), the lower is (D). The points indicated by numbers express the place where the heliotropes are seen or, if they appeared in a cumulus, the main part of the cumulus. And, as I already mentioned, I did not consider it necessary to draw all the particles; in addition, when many times several cumuli appear and moreover far from each other, I have represented here the trajectory for only one.

The upper series of numbers indicates the day of the month, the lower, the time at which the observation was made; sometimes also the altitude of the Sun, as will be noted in the corresponding place. Days often appear discontinuously, not because there were no spots on the Sun, but because we did not observe them, since the sky is not always favourable.

Also, as I think that to investigate the assumptions around these phenomena it would be of great help to offer the path of these stars with respect to the ecliptic according to the order of the months, and by not having notable and sure phenomena of a single year month-to-month, I chose to follow the natural order of the months and to represent the most striking observations of several years, even if they do not follow an annual order.

Page 67 (January 1619). This spot was on the 14th; it was a long line of many tiny spots, which were then divided into two cumuli; however, on the 20th one cumulus only was left. The following days the sky was not favourable.

Page 68 (February 1620). In February, there was this dense cumulus, which we could distinguish with attention when the sky allowed it. At its entrance, on the 17th, faculae appeared behind as often appear around other cumuli at the entrance and exit. This cumulus remained compact throughout its trajectory on the Sun.

Page 69 (March 1618). With great care I wrote down many particles of spots, variously scattered, like one sees most of the times. Otherwise, these cumuli are more developed in the central part, and more contracted at their extremes, as you see also occurs in this case.

Page 70 (March 1618). One can see the observation of our previous spot, at a smaller size, taken in Ingolstadt in Bavaria, and in Kalisz in Poland. The one of Kalisz represents only the distance of the spot from the centre on a single day; instead, the Ingolstadt observation collects the trajectory of the spot in the direction of the ecliptic (AB). Neither observation was capable of appreciating the tinier particles of this cumulus on such a small solar disk.

Page 71 (April 1620). In April, there was this spot of medium size, but clearly weakened, which kept its compact form throughout its trajectory. The lower series of numbers indicate the altitude of the Sun, "m" for morning, "p" for afternoon.

Page 72 (May 1625). The observation of the month of May was attentive, although taken from a smaller disk. And there was a dense cumulus, even though half of it was divided into three or four parts. On the 22nd, at the exit, the oval-shaped spot was longer than wide, as often happens in other cases when larger cumuli enter or exit.

Page 73 (June 1618). In June, we observed this cumulus which was quite clear to see, and remained compact throughout its trajectory.

Page 74 (July 1618). I have represented the shape of this cumulus, in order to be able to compare it with the observation of Kalisz in Poland, which I shall include below.

Page 75 (July 1618). This is the same spot of the month of July, which I already indicated from my observations. This observation was taken at Kalisz in Poland by Simon Perovius, a member of our Society and a mathematician in that city. It is not oriented towards the ecliptic; even so, it is notable how they coincide in their distance from the centre, especially on the 13th, when at almost the same time and from places so far apart, the spot was observed close to the centre.

Page 76 (August 1619). In August, this cumulus had a few tiny spots and some days it had a larger one next to it.

Page 77 (September 1621). This conjunction of Austrian stars moved away from the centre and, on the 6th, it had behind it a succession of a few tiny spots in a straight line; however, on the 11th and successive days, this first cumulus was followed by two other spots at a large distance. This same spot was observed in Coimbra, Portugal, by Guillermo Wely, member of our Society and professor of Mathematics in that city, and who indicated that, on the 13th, it moved away from the exit in thirteen parts, whose semi-diameter of the circle is 40; instead, on the 14th, it went away in ten parts, on the 15th in four parts, on the 16th in one part. All this, as you yourself can verify, coincides with our observations of those same days.

Page 78 (October 1620). This spot of the month of October also moved away from the centre, and had behind a cumulus of tiny spots, which however had disappeared on the 30th. It was also observed in Coimbra, where, on the 21st, it had moved away from the limb in three parts, the 22nd in seven parts, the 24th in fifteen parts, the 26th in twenty-four parts, the 27th in twenty parts, the 28th in fifteen parts, the 29th in ten parts, the 30th in six parts, the 31st in two parts, again in agreement with our own observations, as can be seen in our study of those same days. However, there may be some difference in the hours, since Wely did not record the time of his observations. In addition, he acknowledged that he had not been too exact in his observations.

Page 79 (November 1621). In the month of November, this cumulus presented on the 20th four small spots joined in a straight line, and a fifth under the third; on the following days, however, they had merged into two or three cumuli, and these separated from each other. On the 30th, however, only one spot remained.

Page 80 (December 1620). On the 2nd of December, there was a single spot; on the 7th, instead, it had another small one joined to it, and two finally at its exit, as shown in the figure. In Coimbra, on the 2nd, this spot had moved away from its entrance in one part, on the 3rd in four parts, on the 4th in 10 parts, on the 5th in sixteen parts, on the 7th in thirty parts, on the 11th it had moved away from its exit in ten parts, on the 12th in five parts, on the 13th in one part. One can see that its entrance and exit coincide with ours; on the 7th, however, one perceives a great difference with respect to our observations, unless there is some error in the numbers.

Proposition XVII

Phenomena of the Austrian stars towards the ecliptic from the section of the ecliptic itself with the hourly circles.

Page 81 (January 1626). The observation of this spot in January, which took place in Rome, on a larger and beautifully engraved bronze disk, was shared with me by Father Christoph Scheiner, with whom I have also shared a certain number, and we were able to verify that the observations of both of us coincided exactly.

Page 82 (February 1626). This spot of the month of February was of medium size although it remained unchanged and did not split into parts that were more apparent. Even so, on the 12th it decreased a lot.

Page 83 (March 1626). In the month of March this spot was observed alone on the 19th and 21st. However, on the following days, many others were observed above and below, and it split into many tiny spots from the 26th onwards.

Page 84 (April 1626). In April, this visible cumulus of Austrian stars was appreciated, as clearly as can be seen in the figure, except that on the 11th and 12th there were two small spots next to it instead of one. Under this cumulus, two small spots followed its same path, in parallel, as usually occurs many other times.

Page 85 (May 1626). This cumulus observed in May was not large. On the 29th and the following two days, it split into two. Later, one of them had disappeared.

Pág. 86 (June 1626). This cumulus of the month of June was notable and dense and, from the 22nd, it had around it a lot of very tiny spots.

Page 87 (July 1626). This cumulus of the month of July remained constant, except for the 9th, when it split into two touching each other, and the same on the 13th.

Page 88 (August 1626). In the month of August, this cumulus did not present anything around it until the 28th. From that day onwards, it split into two or more, which looked larger but with a duller colour. On September 3rd, there remained some of this cumulus in the very margins, which is not represented in this figure.

Page 89 (September 1626). In the month of September, there presented this cumulus diluted into numerous particles, especially from the 6th onwards. Hence, its position could not be indicated exactly.

Page 90 (October 1625). In October of the year 1625, this quite scattered cumulus was observed, which already split into two parts from the 1st onwards. We have tried to note here the location of the main part.

Page 91 (November 1625). In the month of November, two small spots separated by a fairly wide distance followed the present trajectory. We have noted in this figure the position of the one that was higher and closer to the ecliptic. On the 17th, coinciding with their exit, many faculae appeared next to the ecliptic.

Page 92 (December 1626). In the month of December 1626, this dense spot of an adequate size was observed. On the 20th, it had a tiny spot at its side, it had two on the 23rd joined to it from behind.

Proposition XXXV
Explaining some common phenomena.

Sometimes it happens that the spots deviate to one side of the trajectory they have started or give the impression that they are moving faster or slower than normal. These phenomena, if they are not attributed to a failure in the observations (because it is easy to miss some error one makes in observing, or because the spots are moving aside from their true position because of the refraction of the lens or air, especially when the solar ray does not impact directly on the centre of the concave lens), one will have to attribute them to the movements of the epicycles and other spheres, although we have not yet investigated their number or their movement. It can also happen that a spot is swallowed up by another, as when a recent one merges with another previous one that has dissipated.

Because, if today, for example, a spot A appears, another B may escape from view as being too dissipated. And it can also happen the other way round: spot B becomes visible tomorrow and instead spot A disperses and cannot be distinguished. One might think that spot A has advanced more than normal from A to D in the space of a single day. On the contrary, if spot B, now visible, dissipates before tomorrow and in its position spot A, not seen before, is observed, one could well think that spot B has not moved from its position, or even that it has retreated. That is, in my opinion, what happened in the year 1620, on June 6th, when a spot was observed about 50 degrees in longitude and 30 degrees south in latitude, and the following day it seemed that it had retreated, and I could not see that spot on any more than those two days. It is credible, as I say, that a spot is confused with another or that an error occurs in the annotation of the date, because until now I have not seen a spot that goes backwards or even remains immobile.