ASTRONOMIA NOVA
ΑΙΤΙΟΛΟΓΗΤΟΣ,
SEV
PHYSICA COELESTIS,
tradita commentariis
DE MOTIBVS STELLÆ
MARTIS,
Ex obſervationibus G. V.
TYCHONIS BRAHE:

Juſſu & ſumptibus
RVDOLPHI II.
ROMANORVM
IMPERATORIS &c:

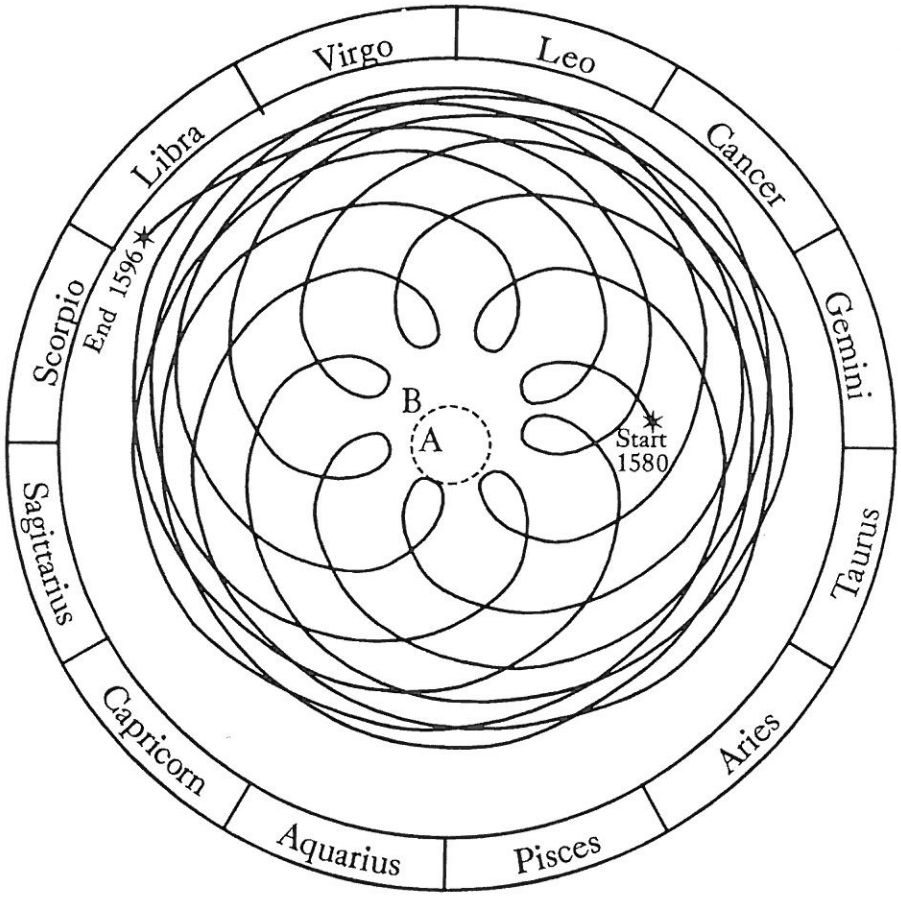
Plurium annorum pertinaci ſtudio
elaborata Pragæ,

A Sæ. Cæ. Mtis Sæ. Mathematico
JOANNE KEPLERO,

Cum ejusdem Cæ. Mtis privilegio ſpeciali
ANNO æræ Dionyſianæ CIↃ IↃC IX.

believe that the sun really moves through the zodiac in the space of a year, as Ptolemy and Tycho Brahe believed, he would then have to grant that the circuits of the three superior planets through the ethereal space, composed as they are of several motions, are real spirals, not (as before) in the manner of balled up yarn, with spirals set side by side, but more like the shape of pretzels[5], as in the following diagram.

4 This is the accurate depiction of the motions of the star Mars, which it traversed from the year 1580 until 1596, on the assumption that the earth stands still, as Ptolemy and Brahe would have it. These motions, continued farther, would become unintelligibly intricate, for the continuation is boundless, never returning to its previous path. Take note, too, that since the circle of Mars requires such a vast space, the spheres of the sun, Venus, Mercury, the moon, fire, air, water, and earth, have to be included in the tiny little circle around the earth A, and in its little area B. In addition, the greatest part even of this little space is given to Venus alone, much greater in proportion than is given to Mars here out of the whole area of the diagram. Moreover, we are forced to ascribe similar spirals to the remaining four planets if the earth stands still, and Venus's spiral would in fact be much more complicated. Ptolemy and Brahe



[5] The Latin is *panis quadragesimalis,* that is, 'bread of the forty [days]', or lenten bread. Pretzels were invented by monks of southern Germany, who adopted the practice of giving them to children as treats during lent.

offer explanations of the causes, order, permanence, and regularity of these spirals, the former using individual epicycles carried around on the eccentrics of the individual planets, in imitation of the sun's motion, and the latter by having all the eccentrics carried around upon the single orb of the sun. Nevertheless, both leave the spirals themselves in the heavens. Copernicus, by attributing a single annual motion to the earth, entirely rids the planets of these extremely intricate spirals, leading the individual planets into their respective orbits, quite bare and very nearly circular. In the period of time shown in the diagram, Mars traverses one and the same orbit as many times as the 'garlands' you see looped towards the centre, with one extra, making nine times, while at the same time the earth repeats its circle sixteen times.

Again, however, it was noticed that these loops in each planet's spirals are unequal in different signs of the zodiac, so that in some places the planet would retrogress through a longer arc of the zodiac, at others through a shorter, and now for a longer, now for a shorter time. Nor is the increment of brightness of a retrograde planet always the same. Also, if one were to compute the times and distances between the midpoints of the retrogressions, neither times nor arcs would be equal, nor would any of the times answer to its arc in the same proportion. Nevertheless, for each planet there was a certain sign of the zodiac from which, through the semicircle to the opposite sign in either direction, all those things successively increased.

The sun has only a single inequality, with respect to the time within which it is completed. But as for the causes of this inequality, the same two factors combine as much for the sun as for the other planets, as will be explained below.

From these observations it came to be understood that for any planet there are two inequalities mixed together into one, the first of which completes its cycle with the planet's return to the same sign of the zodiac, the other with the sun's return to the planet.

Now the causes and measures of these inequalities could not be investigated without separating the mixed inequalities and looking into each one by itself. They therefore thought they should begin with the first inequality, it being more nearly constant and simple, since they saw an example of it in the sun's motion, without the interference of the other inequality. But in order to separate the second inequality from this first one, they could proceed no otherwise than by considering the planets on those nights at whose beginning they rise while the sun is setting, which thence were called ***akronychioi***, or
5 night rising. For since the presence and conjunction of the sun makes them go faster than usual, and the opposition of the sun has the opposite effect, before and after these points they are surely much removed from the positions they were going to occupy through the action of the first inequality. Therefore, at the very moments of conjunction with and opposition to the sun they are traversing their own true and proper positions. But since they cannot be seen when in conjunction with the sun, only the opposition to the sun remains as suitable for this purpose.