

On *New Astronomy*, Part 1: *Writing Proposal*

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Because I myself have been enjoying a wrestle with the challenge to be able to lead in creating ideas not yet changing humanity, especially now that we have succeeded in freeing Congress from the neoconservative coup, the following is a transformation of my notes which I did not have the leisure to use for a composition.

1 From “Author’s Introduction”

A mathematical point, whether or not it is the center of the world, can neither effect the motion of heavy bodies nor act as an object towards which they tend. Let the physicists prove that this force is in a point which neither is a body nor is grasped otherwise than through mere relation.

It is impossible that, in moving its body, the form of a stone seek out a mathematical point (in this instance, the center of the world), without respect to the body in which this point is located. Let the physicists prove that natural things have a sympathy for that which is nothing.

—J. Kepler

Why does a cause of the bodily domain need to express itself bodily, and, in turn, in the visible domain?

If we look back into final causes and take principles as active on all others, then any bodily cause would have to act on the cause of vision. Therefore, any unknown cause of the creation of visible bodies would

be understood by the senses as an identifiable singularity for the determination of bodily appearances.

2 “Detailed Questions”

2.1 Who does Kepler say referred to a relationship between music and planetary motion before him?

“Hence the Pythagoreans, when they shared out musical tones among the stars, gave the lowest (the ‘**hypate**’ among the strings of the lyre) to the moon, because the motions of both are slowest.” (Ch. 1, p. 116)

2.2 What is the essence of disagreement between mean and apparent sun? How do you calculate the mean sun?

As the ancients found out, if one were to measure the motions of the celestial constellation of stars and of the sun from an earthly fixed position with a unit of motion: the successive risings of a chosen constellational star, one would measure a small difference between these two motions. This would indeed be a non-uniform difference that can be visualized if the sun’s motion is taken with respect to that of the constellation of stars, or, in other words, if the constellation of stars is taken as fixed on a celestial sphere and a period of its motion taken as the rigid i.e. unit motion. The sun’s non-uniform motion appears in a narrow circular band on the sphere of fixed stars with the longitude completing a circle in about 365 units

of motion.

Because this is a small non-uniformity (with its maximum of the order of degrees), and since the reason for our observation of it is our assumption of a rigid celestial sphere and the sun's motion as occurring on it, if we try to replicate our method for knowing the fact of this non-uniformity to know the non-uniformity itself, we would hypothesize a new unit—for knowing it—sharing the rigidity of the previous one.

Although this new unit may have an incommensurable effect (size) of yet unknown origin with the previous one, it has a commensurable (same) rigidity, and thus—a fixed proportional relationship with the previous one.

Because of the shared rigidity, this new unit is a motion traversing the ecliptic uniformly w.r.t. the previous, and it which would complete a cycle together with the sun. The sun's motion periodically deviates from this uniform motion possibly by moving on an epicycle in a manner similar to the sun's deviation from the constellation of stars.

The uniformity of this new motion provides one aspect of the mean sun. The second aspect is the matter of phase synchronization between the mean and the observed (apparent) sun.

If we assume that all physical relationships between physical actions share the same rigidity, or—as some say it—that physical principles are fixed, and that therefore relationships are fundamentally fixed, what else is left to us but to discover or stumble across the geometrical, effectively formal, rules (or their derivatives or equivalents) for reconstructing these fixed relationships? It would also mean that every (cyclical) motion has a fixed relationship to “uniform circular motion”—possibly the simplest motion.

The matter of the sun seems all too easy now. The axiom adopted by Ptolemy & Brahe is that the sun moves on an epicycle with the same uniform motion as that of the epicycle's center around the earth, but in an opposite direction, so that the sun's motion is equivalent to the motion on an eccentric circle with eccentricity from the earth the same as the epicycle's radius. For Copernicus the roles of the earth and the sun are swapped.

The added center of the sun's eccentric, which we

could determine from observations of the apparent sun, gives us the necessary reference point to synchronize mean and apparent suns' phases. At the point at which the apparent sun moves slowest against the fixed stars, its slowness would have to be the optical result of the sun's being at apogee, which means that the radius of the sun's epicycle coincides with the line of vision and adds the largest possible distance to the sun's distance from the earth. As Ptolemy, Copernicus & Brahe did, we could take the crossing of the line from the earth through the sun's eccentric's center as a zero phase for both suns.

It is the maltreatment of creativity by adopting the axioms resulting from the assumptions underlying the second aspect of constructing the mean sun, as pointed out above, which is essentially what disagrees with what Kepler is willing to adopt.

2.3 Why were epicycles hypothesized?

What I have been able to understand about the development of the hypothesis of epicycles is incorporated in my answer to question 2.

2.4 What paradoxes in the observed sky did ancient man have to consider to hypothesize the different celestial motions?

I hypothesize the following development.

The sky appears still and quiet at night. However, if you identify an intriguing feature of the night sky and try to show it to your friends 5–6 hours later, you would find that that feature's position has a different relationship to the features on the earth than before.

The sun also appears still, but its position in the sky changes like night and day.

Repeated observations and possibly even measurement demonstrate an unchanging arrangement of stars.

However, over a longer period of time it appears that the sky's relationship to features on earth changes over a number of nights.

The moon appears to change its relationship to the rest of the stars. Part of it, also, becomes dark periodically, and progressively.

The sun's path in the sky appears to change from day to day over a longer period of time. Also, the sun's projected position among the stars changes over a longer period of time.

One could see a bright star at dawn—the morning star. After a number of weeks of rising closer and closer to the sun, it is finally lost in its light.

There are other stars that travel among the constellations like the morning star which accompany the sun along its path.

Sometimes the moon covers the sun almost exactly for a short part of the day. The sun, the moon and the other moving stars travel along the same circular band of the sky among the constellations over long periods of time where they eclipse each other. Call this region of the sky the ecliptic (circle?).

There is also an evening star that accompanies the sun for a number of weeks.

The moving stars, the sun and the moon travel among the constellations non-uniformly.

The small moving stars retrogress. Call these wandering stars planets.

Three of them are always in the middle of retrogression when they appear opposite the sun in the sky.

Planets appear to be brighter, closer to the ecliptic, and to move faster among the fixed stars as their separation from the sun in the sky diminishes. The arcs and times between oppositions, and brightness of the planet during opposition increase with their separation from a specific point among the fixed stars.

Each planet starts retrogressing at about the same separation from the sun every time.

2.5 How do you determine a line of apsides with respect to the mean and to the apparent sun?

For the astronomers before Kepler the line of apsides is the line through the equant of the motion on the circle which determines the first inequality—the orbit of a planet's (small) epicycle's center,—and a pivotal

position.

For Ptolemy the pivotal position is the earth (its center), for Copernicus—the center & equant of the earth's orbit, and for Brahe—the mean sun (the line of apsides travels together with the mean sun) which moves on a concentric of the same size as the eccentric of the apparent sun.

A moving celestial body's eccentric and its equant and center are found by comparing the angles with the time intervals between observed positions of the body.

After finding the pivot position, it would be necessary to determine a planet's eccentric and its center.

If we take the mean sun as the cause for the second inequality, then the position of the center of the planet's epicycle would be on the line of vision from the earth to the planet when the planet is at opposition to the mean sun, and it would be from the comparison between angles and periods of time between those observations that the planet's eccentric would be determined.

If we take the apparent sun as bearing the cause for the second inequality and use apparent oppositions to determine a planet's eccentric with its center and equant, we would also have a new pivot for Copernicus's and Brahe's hypotheses, for which we would need to take the sun's body as a pivot, instead of the mean sun (the center of earth's circle).

However, Kepler showed that to within about 1° of precision, you can keep the eccentric's size and for Copernicus & Brahe also equant, and for Ptolemy—adjust the equant only to account for the different phase of the planet on the epicycle.

2.6 What is Kepler saying about the problem of solid orbs and the physical hypothesis of Copernicus?

The problem with solid orbs is that Brahe observed comets that passed through what must have been these solid orbs. Also, just the explanation of the execution of motions with the limits of the solidity of orbs and the moving power of animal souls, does not explain the generating power of the proportions *be-*

tween these solid orbs and between the animal souls.

If solid orbs be denied, then the execution of epicycles involves the motion of attention-attracting power which subsists in no body and lacks any method for physical transportation and for attraction of attention. The execution of eccentrics, also, involves attention to a point which subsists in no body. In both cases, also, the guiding minds of the animal souls need to pay attention to a number of various things at once to achieve synchronization.

Kepler also seems to have in mind a disagreement with the supposition that each planet has its own voluntary mind guiding it, rather than having what could be expressed as the planets' motion being the intersection of an idea with other active ideas the way the motion of someone's hand is an intersection of ideas, the hand and whatever else it is moving not having minds of their own.

See also question 10.

2.7 Why is Kepler saying that whether the mean or the apparent sun is the source of motive power cannot be determined by looking at only the first inequality?

Indeed Kepler does demonstrate in Ch. 5 that according to Ptolemy, Copernicus & Brahe's hypotheses there are some physical aspects of the motion of the first inequality, observable because of the motion's non-uniformity, which are independent of the optical effects of the mere position of the observer. The observational difference of those aspects between the possibility of the apparent sun as the location of motive power, and that of the mean sun as this location, however, is demonstrated by Kepler to be within 5' and possibly much less.

However, it should be noted that these three hypotheses all share the same core hypothesis about the relationship between the mean sun and a planet's motion, which hypothesis is based on the same hypothesis about the human mind that leads to the effort to explain observed qualities of a process by arbitrary non-physical, geometrical conjectures. There-

fore, since the 5' or less difference is virtually not a qualitative difference, the quality of the motive power's location as in the present case is not regarded by the Ptolemeic-Copernican-Brahean hypothesis.

In addition, the orbit of the first inequality is in a sense taken as independent of the location of the motive power. The relationship is determined by the use of the location of the motive power to separate the effect of the second inequality on a planet's motion. The resulting separated motion of the first inequality was taken by these astronomers as merely *measured* certainty.

2.8 Why and in what way does Kepler think he can test his hypothesis, even though the three fabled astronomical models in his time all predict the determining positions of Mars actually observed within observable bounds?

It is true that Kepler found a way to disprove the astronomical hypotheses used during his time by observing effects not allowed by the corresponding models of planetary motion. However, even before he obtained Brahe's data that allowed him to discern such effects, and before he achieved a number of discoveries crucial for constructing his idea of the activity of the solar system, during his composition that became known as *The New Astronomy* Kepler trusted enough in the hypothesis for the planetary motions to invest years' labor since at least his *Mysterium Cosmographicum*, starting with his hypothesis and using recalculated observations from the physically observed sun.

That cannot have been a "whatever pops in my mind" hypothesis. What gave Kepler the moral strength for decades' pursuit of that hypothesis and the ability to not only refute, but also actually know and construct a truthful hypothesis was an honest faith in the unknown—that the unknown is not evil, but rather good.

Kepler must have known that whenever an important hypothesis is created its truthfulness must be knowable by the human mind, since that is what gives

it power to affect the universe. On the other hand, what would be the use of a hypothesis whose truthfulness is unknowable? Wold God have sufficient reason to create the possibility of it?

Therefore, the knowledge of the truthfulness of a hypothesis is expressed (observable) as its effect on the improvement of the universe.

And since not we, but God, created the principles that govern the action of hypotheses in the universe, our only job as human beings, as Kepler boldly and heartily took that job, is to create them as poets and in the willing of good. That is what will drive us to turn our lives to the pursuit of truthfulness and not to leave what we know we can perfect imperfect.

2.9 Why does Saturn begin to retrogress at 90° or beyond with the sun, Jupiter—at 120° , Mars—at 144° or before 135° ? Would the inferior planet Venus retrogress?

Now let us look into the business of retrogression first in what has sometimes been referred to as the Copernican form.

Let us take the earth, which is assumed to move according to perfect uniform circular action, and a superior planet such as mars, assumed to travel on an eccentric larger than earth's circle with a shorter period than that of the earth.

Retrogression begins and ends at the points where the planet appears stationary with respect to the fixed stars. That happens when the motion that the planet would have to perform to appear stationary from the earth coincides with the Copernican motion of the planet. (Fig. 1)

Since we are only considering appearances and the only way a motion with a definite trajectory can differ in appearance is by what we call swiftness, that is the characteristic we need to take for comparison. Since we can only compare the ideas (principles) of differnt actions only by the ideas of their effects—which are their interaction and which define the necessity for their relationship—we can employ what is used customarily: the geometric effect of the motion at a rigid swiftness during a rigid unit of time.

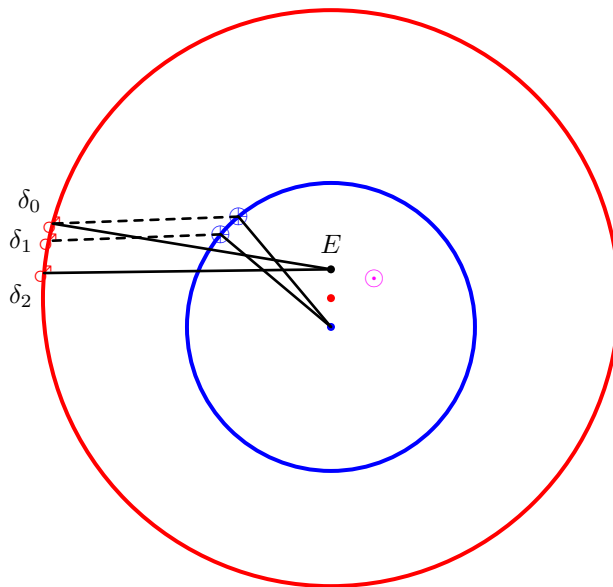


Figure 1: When retrogression starts or ends

In this case those effects are two arcs that start at the position (δ_0) of the observed planet at the time of comparison. One ends at the position (δ_1) the planet would be observed to be at from the earth if it remained in the same sidereal position after the earth traveled for a unit of time.¹ The other one ends where the planet would reach to (δ_2) after it travels for a unit time at a swiftness rigidly the same as that of the planet at the beginning of the arc.

Since if a circle's chord is cut off by two parallel lines, the distance between the two lines is the cosine in the circle of rotation of the chord around any of its endpoints of the angle which is the rotation between the radius bisecting the chord (and its arc) and the two parallel lines, and since half the chord is the sine of half the chord's arc in the original circle, the distance between the parallel lines is the cosine of the radius, which is the sine of the radius which is the diameter of the original circle traversing half the arc

¹We adopt the customary assumption that the fixed stars are so far away from the solar system that the paralax resulting from motion within the solar system is not observable. Hence, the lines from any point in the solar system to a fixed star are taken as paralel.

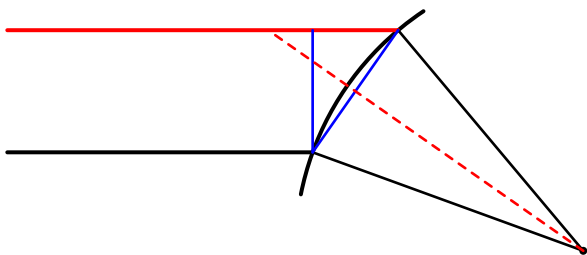


Figure 2: Circle parallel cut

of the chord, traversing the rotation from the radius bisecting the chord to the parallel lines. (Fig. 2)

Therefore, retrogression will start when the products of the cosine of the complimentary angle to the planet's separation from the mean sun and the sine of half the infinitesimal effect of the angular speed around the orbit's center create the same proportion as the radii of the orbits. Because this angular speed for the observed planet depends on the distance of the planet from the equant, retrogression will start at different sprataions from the mean sun, depending on where it is seen among the fixed stars.

Remark now that God has been generous in giving us more fruit than we have asked for!

Because we can construct the separation from the mean sun and the angular speeds from the centers of the earth's and of the planet's orbits as was described in the answers to questions 2 and 5 from observations, the measurement of separation at the beginning of retrogression allows us to know the relationship between the orbits' sizes.

The phenomenon of retrogression can be recognized in what has been referred to as the Ptolemaic form if it be witted that the same two circles which were concentric in the Copernican form are now an eccentric and an epicycle, connected with the same two parallel lines.

For the Brahean form invert the Ptolemaic.

The observation of Venus's retrogression has already been mentioned in the answer to question 4 as the implicit relationship between the morning and the evening star (the unity of which has been reported to have been discovered by the Platonic movement).

The observed motion of an inferior planet has the same characteristics as those of the motion of the earth as observed from a superior planet like mars. The retrogression of mars is determined by the change of course of the line of vision from the earth to mars, which change does not depend on the end of the line from which you are observing.

Because a planet is inferior, however, it has a limit on its separation from the sun, determined by the relative size of the inferior orbit. This limit, also, happens to be the separation of a planet at the beginning or end of a retrogression.

2.10 How would Ptolemy explain the observed proper motion of Venus?

Because in the middle of retrogression inferior planets like Venus appear in conjunction with the sun, if we subtract the effect of a Ptolemaic first inequality circular motion, we would be left with an epicycle, such that when its center must be at opposition, the planet on the epicycle must be in conjunction. That necessitates an epicycle larger than the planet's eccentric. This, however, would mean that the epicycle's orb would have to intersect the orb of the sun which would break Ptolemy's physical hypothesis.

2.11 If Mars's synodic period is about 780 days, but the period of its first inequality—approximately 687 days, how come for Ptolemy “epicycle's motion about its center is faster than the motion of its center about the earth”?

Since, as Ptolemy's model ‘happened’ to do to him, the motion of each planet on its epicycle equalled that of the mean sun, the effect of the sun's motion is already expressed in the motion of the planet: as Ptolemy himself recognized, the planet's opposition to the (mean) sun occurs when the planet and the center of its epicycle appear on the same line of vision from the earth.

As the center of the epicycle travels an angle on the eccentric, the angle from the radius of vision changes by the same angle (in what we can call an opposite direction). Also, as the planet travels an angle on the epicycle in the direction opposite that of the epicycle's center's motion, the angle of the line to the planet from the line of vision changes by the same angle, but in a direction opposite that of the previous change. Therefore, the total angular change of the two rotational motions (on the eccentric and on the epicycle) is the difference of the individual rotational changes. Since, as was mentioned in the answer to question 9, arcs of rotation express the instantaneous angular velocities, so will the angular velocity of the change of angle between the line to the planet and the radius of vision be the difference between the angular velocity of the motion of the epicycle's center on the eccentric and that of the planet on the epicycle.

That angular velocity for mars will be $\frac{1}{365} \text{ rot/day} - \frac{1}{687} \text{ rot/day} = \frac{322}{250755} \text{ rot/day} \approx \frac{1}{799} \text{ rot/day}$. Not that far from a synodic period of 780 days.

3 Initially & Finally

On the remaining aspects of

As the following detailed questions imply, what are the key points of investigation or arguments Kepler had to consider in Part 1 of the *New Astronomy*? Why were these necessary? How and why was Kepler able to test the truthfulness of hypotheses?

Finally, and for future investigation: why does Kepler create the hypothesis he is trying to test in Part 1? What other hypotheses does it necessitate him to create and why? What is the actual hypothesis Kepler is investigating?

As Kepler himself expresses, the truthfulness of a hypothesis has an indirect relationship to the intention of its creation. As the case of the creation of the ability to travel on the high seas by knowing the relationship between the motion of the heavens and the 'fixed' places on earth under the ancient hypotheses

of uniform epicyclical circular action demonstrates, a false hypothesis can increase the potential of human action on the basis of its truthful relationship to the effects of physical occurrences through approximation. It is also possible to hold a true hypothesis under an evil intention. It is for the former that Kepler writes "My aim in the present work is chiefly to reform astronomical theory (especially of the motion of Mars) in all three forms of hypotheses, so that our computations from the tables correspond to the celestial phenomena." (Introduction.)

But it is the second part of "the twofold aim of the work"—"the physical causes of the motions"—which expresses the higher standpoint of Kepler's work. What made it possible to know the truthfulness of the ancient hypotheses and create a truthful one, if ancient society could not do that? Is it not the effects of the intention of the creation of those ancient hypotheses, such as agriculture, seafaring, the increased geometric knowledge of physical action and, most of all,—of the human mind's ability to cause that change? But those effects come among human beings only as sovereign creations. And what can human beings create but the discovery of the true qualities of the universe?

Why was it necessary for Kepler to demonstrate about his hypothesis "in the first part of the work that exactly the same things can result or be presented by this new method as are presented by their ancient method."? Kepler's work is the ancients' discovery of what they used to change humanity so that the possibility of that discovery can be created. It is this that Kepler has taken up: to know the truth, to know what could not be known by humanity before, to thus make humanity what it could not be in the universe before, to cause the principles of the universe to act with a new quality, such that the universe would create this new process of humanity.