The Fallacy of the Equant

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Typically, actually scientific method, as teams of the LaRouche Youth Movement (LYM) have experienced this for themselves, is the crucial example, demonstrated by Johannes Kepler, of the problematic attempt to define Solar orbits in a manner congruent with the notion of an *equant*. All comprehensive notions of a competent modern physical science are implicitly embedded in the implications of the problematic nature of the assumption of the *equant*. It is this discovery by Kepler, which provided modern science with a rigorously defined notion of the ontologically efficient actuality of what is rightly considered a universal physical principle, such as gravitation. It was Kepler's recognition of the fallacy of the *equant* which, according to Kepler's account, prompted Kepler's conception of the infinitesimal reflection in the very small, by a universal principle in the very large. All competent modern science is premised on an apriorism-free notion of a universe defined by a process of development among a set of universal physical principles of the same, experimentally defined, ontological quality, in themselves, as Kepler's notion of universal gravitation.[1]

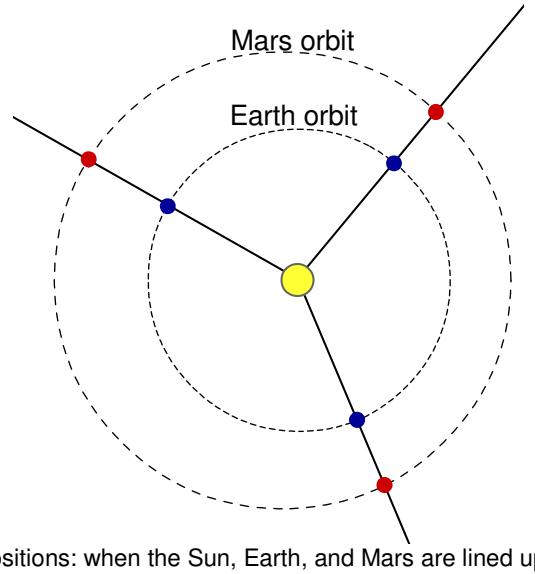
The Fallacy of the Equant

Moreover, it is no less false that the center of the world is within the earth than that it is outside the earth; nor does the earth or any other sphere even have a center. For since the center is a point equidistant from the circumference and since there cannot exist a sphere or a circle so completely true that a truer one could not be posited, it is obvious that there cannot be posited a center [which is so true and precise] that a still truer and more precise center could not be posited. Precise equidistance to different things cannot be found except in the case of God, because God alone is Infinite Equality. Therefore, He who is the center of the world, viz., the Blessed God, is also the center of the earth, of all spheres, and of all things in the world. Likewise, He is the infinite circumference of all things.[2]

In Part II of his *The New Astronomy*, Kepler takes up the motion of Mars, having identified two *a priori*, axiomatic assumptions which had bounded the investigations of astronomy up to that time: that the planets move in perfect circles, and that an equant point can be found for the orbit – a point from which the planet could be observed to move at a constant speed, traversing equal angles in equal times – a point of uniformity. Rather than this approach to investigating the apparently irregular motion of Mars, Kepler's healthier mind posed the question: what are the characteristics of change of Mars's apparent motion?

Investigating Mars

The motion of the planets were seen to have one periodicity and movement through the zodiac proper to themselves, and a *second* movement related to their apparent proximity to the sun. Kepler's predecessors Claudius Ptolemy, Nicolaus Copernicus, and Tycho Brahe offered hypotheses for these two actions.[3] To investigate a planet, it is first necessary to untangle these two motions. Using the Copernican model, the second *inequality*, as it is called, does *not* reflect a change in the motion of Mars, but rather reflects the motion of our Earth, from which we observe it. This inequality can be removed by using specific observations: those taken at *opposition*. If we see the Sun and Mars at *opposite* sides of the horizon (one setting while the other rises), then the Sun, Earth, and Mars lie on a straight line, and the sun "sees" Mars in the same direction that we on the Earth observe it. Thus, while making observations as we stand physically on the Earth, our mind's eye is transported to the sun, from which we can watch Mars.



Oppositions: when the Sun, Earth, and Mars are lined up, the Earth sees Mars in the same direction as does the Sun.

Having eliminated the effect of our moving Earth on the observations of Mars, the *first inequality* still remains; Mars's motion, freed form the *second inequality*, is determined to have one position on the zodiac at which its motion is fastest,

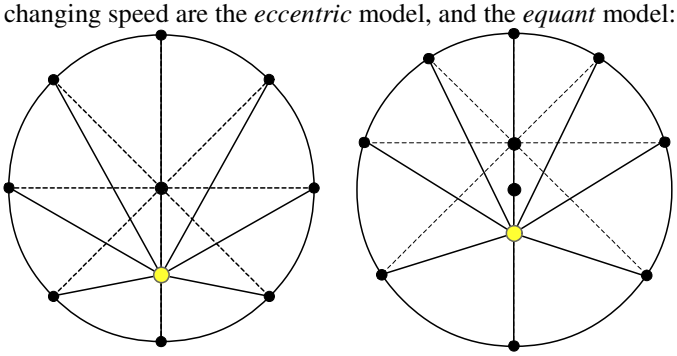
[1] Lyndon H. LaRouche, Jr., "The Dance of the Bio-Fools," **EIR**, Feb 2, 2007

[2] Nicolaus of Cusa, ***De Docta Ignorantia***, trans. Jasper Hopkins

[3] See Vander Nat's "De Astronomia," **Δυναμις**, this issue.

and another where it is slowest. How can this changing speed be understood?

Two geometrical hypotheses that cause an apparently changing speed are the *eccentric* model, and the *equant* model:



Eccentric motion (left) and equant motion (right)

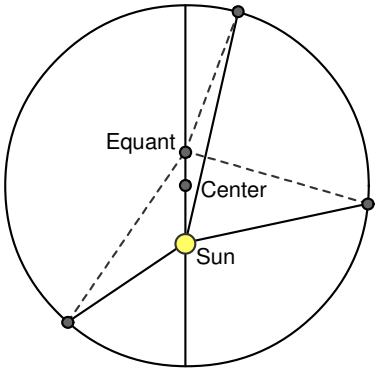
In the eccentric model (left), the planet moves uniformly around the center of its orbit, but is seen from a point off-center. This causes the *apparent* speed of the planet to change based on how close it is to the observer. (Remember, we are still "observing" from the sun by using opposition observations.) In the equant model (right), there are *two* centers: 1. a center of motion, the *equant* (top point), around which the planet describes equal angles in equal time, and 2. a center of location, from which the planet maintains a constant distance, simply called the *center* (middle point). In the equant model, the planet actually does change its speed, a physical change, whose appearance is further affected by its changing distance from the observer (bottom point). Ptolemy introduced the equant, rather than the simple eccentric, because he found it to better represent the motion of the planets.[4]

From Ptolemy through Kepler, the aprioristic assumption of a principle of uniformity acting efficiently in the universe, was unchallenged.[5] For what alternate cause of motion could be said to exist?

Kepler's Model

Before directly challenging the assumptions of the equant and of circular orbits, Kepler aims to vindicate his use of the *apparent sun* (the one we see in the sky) instead of the *mean sun*, an imaginary point near the real sun used by Ptolemy, Copernicus, and Tycho to set up their planetary hypotheses. To do this, Kepler uses opposition observations made with respect to the *apparent* sun, rather than the *mean* sun oppositions used by his predecessors.[6] With twelve observations of Mars at opposition at his disposal, Kepler selects four with which he works out a planetary hypothesis using an equant and a circular orbit.

From the observed distance along the zodiac between one observation to the next, we know how far Mars has moved as seen by the sun (apparent longitude). From the *time* between the oppositions, we know how far Mars has moved as seen by the equant (mean longitude), since the equant is the hypothesized point around which Mars moves at a constant angular speed. With four observations, and an incredible amount of time spent on a difficult procedure, Kepler determines the best alignment of the sun, center, and equant with respect to orientation and distances. He calls this model his *vicarious hypothesis*.



The *Vicarious Hypothesis* (not to scale)

Kepler remarks that the *solar eccentricity* of this model (the distance from the sun to the center) is 11.3% of the radius of the orbit, a value determined not by finding the center as the midpoint between Mars locations, but as the best value to use to make his model "work." To test this model, simply determine the angles around the equant corresponding to the times of the other oppositions, draw lines from the equant to the orbit at those angles, and see where the sun would see those planetary positions.

His *vicarious hypothesis* is a success! Among the twelve oppositions, the largest disparity between his model and the observations is only about 2' (two minutes of arc), [7] which is the margin of observational error in the measurements themselves. Thus, he can conclude that his model works "perfectly" all around the zodiac. This is better than the models of his predecessors, all of whom had used the *mean* sun rather than the apparent. Some might now rest from their labors, content at

[4] For a comparison of the two types of models, see http://wlym.com/~animations/part2/16/aside.html and http://wlym.com/~animations/part2/21/index.html.

[5] Copernicus writes: "We must however confess that these movements are circular or are composed of many circular movements, in that they maintain these irregularities in accordance with a constant law and with fixed periodic returns: and that could not take place, if they were not circular. For it is only the circle which can bring back what is past and over with; and in this way, for example, the sun by a movement composed of circular movements brings back to us the inequality of days and nights and the four seasons of the year. Many movements are recognized in that movement, since it is impossible that a simple heavenly body should be moved irregularly by a single sphere. For that would have to take place either on account of the inconstancy of the motor virtue -- whether by reason of an extrinsic cause or its intrinsic nature -- or on account of the inequality between it and the moved body. *But since the mind shudders at either of these suppositions,* and since it is quite unfitting to suppose that such a state of affairs exists among things which are established in the best system, it is agreed that their *regular* movements *appear* to us as irregular…" (***De Revolutionibus***, I.4)

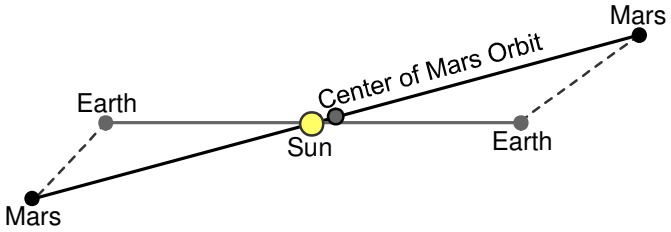
[6] See http://wlym.com/~animations/part1/meanapparent.html.

[7] An arc of 1' is one-sixtieth of a degree of the nighttime sky, and is about the width of a pencil lead held eight feet away from you.

having developed the world's best method for determining the position of Mars, but not Kepler. He poses the question: just because any possible error in his model is too small to be observed, does this necessarily mean that he has found the truth? And how can we settle the debate between Ptolemy, Copernicus, and Brahe – Kepler's *vicarious hypothesis* could be implemented equivalently in any of the three world-views, if the *apparent* sun be used.

Another Determination of Eccentricity

Kepler then sets out to check this eccentricity, by determining it directly, rather than the indirect method used in the *vicarious hypothesis.* Kepler will use measurements of latitude, rather than longitude, and find the physical distances of Mars from the sun at opposite points of its orbit, as a way of finding the center of the Mars path.

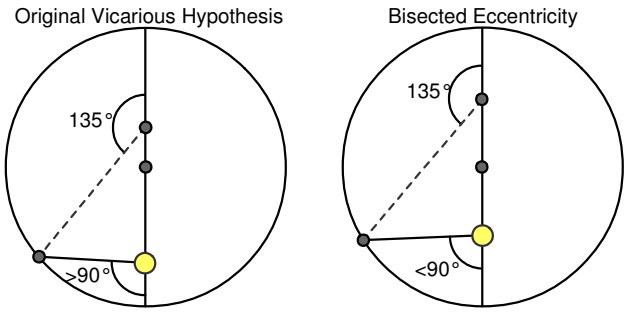


By observing the latitude of Mars north and south of the *plane of the ecliptic* – the plane of the Earth's motion around the sun – and using some trigonometry, Kepler determines how far Mars was from the sun. Doing this at nearly the closest and farthest parts of the orbit means that the mean between these two gives the radius of the orbit, and the distance of the center from the sun – the *solar eccentricity*. With this method, Kepler determines this eccentricity to be 8.0% - 9.9% of the size of the orbit, which does *not* match the eccentricity determined by the vicarious hypothesis (11.3%).

A paradox emerges: how can Mars have one required eccentricity according to his longitude model, and another when investigated directly according to latitudes? What can be said of a model that gives correct results while using a parameter known to be false?[8]

A Crack

In an attempt to reconcile these two eccentricities, Kepler adjusts his vicarious hypothesis to have an eccentricity in keeping with that determined by his study of latitudes. The *total eccentricity* of the vicarious hypothesis – the distance from the equant to the sun – is 18.6%, of the radius, whose half, 9.3% does fit in the range of 8.0-9.9% required by latitude observations. So, if he *bisects the eccentricity*, moving the center to be in the middle between the equant and the sun, he can apply the eccentricity determined by latitudes to the functionally perfect vicarious hypothesis model. This also agrees with Ptolemy, who assumed a bisected eccentricity when working out his model.



In this diagram with greatly exaggerated eccentricity, the sun's perception of Mars changes when the eccentricity is bisected. After a time of 135° from aphelion, measured by the equant, the angle between Mars and the perihelion is *greater* than 90° in the vicarious hypothesis, and *less* than 90° in the bisected version.

Changing to the bisected eccentricity alters the vicarious hypothesis, and this change is significant: the perfection of the vicarious hypothesis is lost when the bisected eccentricity determined by latitudes is introduced. When drawing lines from the equant at angles determined by the times of opposition, Kepler finds a gap: the bisected model is now 8' off for the opposition of 1582. This difference is *not* within observational margins of error.

Thus, his model cannot both give correct positions of Mars (original vicarious hypothesis) and incorporate the true eccentricity (bisected) at the same time. There is therefore no possible way of adjusting it to make it work. Kepler writes:

> Therefore, something among those things we have assumed must be false. But what was assumed was: that the orbit upon which the planet moves is a perfect circle; and that there exists some unique point on the line of apsides at a fixed and constant distance from the center of the eccentric about which point Mars describes equal angles in equal times. Therefore, of these, one or the other or perhaps both are false, for the observations used are not false…
>
> Now, because they could not have been ignored, these eight minutes alone will have led the way to the reformation of all of astronomy.

The statistical approach to astronomy, the attempt to understand the heavens by making models of the footprints of a cause of motion, has not only failed so far to achieve perfection; Kepler has proven, conclusively, the *impossibility* of creating a perfect model with this approach.

What is the implication of this new category of experience for the practice of Man's mastery over nature? Kepler has demonstrated the *required* existence of a universal, *physical* (not geometrical) principle. The unavoidable, paradoxical implications of the equant, force the mind to a new sort of wonder.

To attempt to present Kepler's discovery of universal gravitation, without a thorough working-through of the paradox of the equant, were to proffer an answer to an audience incapable of posing the right question.

[8] Here, too large an eccentricity.