Physics, Not Statistics: Kepler's Paradoxical Return to the Equant

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> Since all competent modern physical mathematics is based on the pioneering achievements of Johannes Kepler, the argument to be made, in explanation of the intrinsic incompetence of statistical mechanics for economics, will employ the image of a planetary orbit, as defined by Kepler's uniquely original discoveries, to define a forecastable quality of true long-term cycles in an economy. That lesson, from Kepler, for economics today, is the best source of remedy for the failures intrinsic to the consistently failed methods which have been employed by economics statisticians generally during the recent decades.[1]

Preface: A Dispute on the Equant

A social process, created no later than the summer and fall of 2006, when the LaRouche Youth Movement, following Lyndon LaRouche's guidance, embarked on a mass socialized project to work through Kepler's ***The New Astronomy*** to make the breakthroughs in economic science required to politically organize the rebuilding of the collapsing world physical-economic system, has borne fruit in a new level of discussion, allowing new questions to be developed, and breakthroughs to be made, that would never have occurred among a group of isolated individuals working on discoveries in their bedrooms, or among students listening to a lecture series. Evidence of the successful gestation of this process was borne out in one incident in early December, 2006, at a meeting of the LaRouche Youth Movement in Washington, DC. A question was raised there that was being pondered by an increasing number of members of the LYM around the world, a question that provoked a lively back-and-forth: "Why does Kepler re-introduce the equant in Part III after he has already refuted the possibility of its existence in Part II of *The New Astronomy*?" Follow-up discussions on the question, particularly after Lyndon LaRouche's December 22nd paper, in which he first makes explicit reference to the *equant*,[2] prompted the writing of this article.

> These discovered, universal principles, belong to a category of experience which Kepler was the first to define, through exploring the paradoxical implications of the *equant*, as showing the ontologically infinitesimal reflection of any universal physical principle.[3]

And:

> That function of irony, in language, as in physical science, which distinguishes the creative mental powers typical of the specific notion of the human individual, is the same function associated with the process of discovery of a universal physical principle in physical science, as Kepler's treatment of the fallacy of the *equant*, in proceeding toward the discovery of a universal principle of gravitation, illustrates the existence of the apparent infinitesimal magnitude associated with the quality of action by a universal physical principle of gravitation.[4]

The Equivalence of Hypotheses

Claudius Ptolemy, Nicolaus Copernicus, and Tycho Brahe offered hypotheses for the motions of the planets, hypotheses which, at first glance, appear to be immensely different. Ptolemy has all planets move around the Earth with an equant and an epicycle, Copernicus has all move around the sun with a double epicycle, and Brahe combines the two, allowing the planets to move around the sun which itself moves around the Earth. Kepler, professing himself to be of the Copernican outlook, nonetheless does not begin his ***The New Astronomy*** with a defense of the Copernican hypothesis. Rather, his first task is to demonstrate the *equivalence* of these three seemingly different systems.[5] Kepler proves that all three world systems can have their parameters adjusted in such a way as to completely agree.

If these hypotheses are capable of making *exactly* the same results (within observational precision), that is, if they all "work" equally well, how can one decide which among them is correct? Should "working well" even be the metric of truthfulness?[6]

And, what *is* equivalent about these hypotheses? Certainly not their outward appearances (although they can be used to create equivalent predicted appearances for the planets), but rather their equivalent *assumptions*. All are based on uniformity as a guiding principle of the organization of the universe: both uniform angular motion, and motion of uniform distance (circular motion). They also share a rejection of the

[1] Lyndon H. LaRouche, Jr., "Re-Animating an Actual Economy," **EIR**, August 4, 2006
[2] LaRouche, "What the Congress Needs to Learn: The Lost Art of the Capital Budget," **EIR**, Jan 12, 2007
[3] Ibid.
[4] Ibid.
[5] See http://wlym.com/~animations/part1/index.html for animations of this equivalence.
[6] A society convinced that human beings are evil, which decides to organize itself according to that principle, will achieve results that cohere with that thought. "I know I didn't try to do anything good, but doesn't my failure prove that it was impossible anyway?"

body of the sun playing any role besides celestial décor; instead of the actual sun (the *apparent* sun), they all use a geometrical point near the sun known as the *mean* sun. For Ptolemy and Brahe, this is a point moving around the Earth with the same period as the sun, but, unlike the actual sun, it moves uniformly. Copernicus considered the mean sun to be the center of the Earth's orbit, and he set up the orbits of other planets using this point as his anchor.

It is upon this use of the *mean* sun that Kepler targets his investigative acumen. Kepler writes that Ptolemy "chose the mean motion, thinking that the difference (if any) between taking the mean sun and the apparent sun could not be perceived in the observations, but that the form of computation and of the proofs would be easier if the sun's mean motion were taken." What, for Ptolemy, was a decision in favor of computational ease, became a physical absurdity for Copernicus and Brahe. Yet, they continued to use it.[7] Kepler's insistence on relating planetary orbits to the apparent sun required that he demonstrate that, unlike the *equivalence* of hypotheses discussed above, the difference between the mean and apparent sun *does* result in incompatible hypotheses. That is, this question *is* something susceptible of a crucial experiment.

Kepler sets out to develop his own tentative hypothesis for the first inequality of the motion of Mars, a hypothesis, which, by its use of the apparent sun, will *not* be equivalent to those of Ptolemy, Copernicus, and Brahe. This tentative hypothesis, based on the use of circular orbits and a point of uniform motion rather than physical considerations, Kepler calls his *Vicarious Hypothesis*.

The Vicarious Hypothesis

Before reading on, be sure to have read *The Fallacy of the Equant* (**Δυναμις**, this issue).

Kepler's *vicarious hypothesis* works better than those of his predecessors, vindicating his use of the apparent sun. However, it is not yet perfect, for its successful application requires the use of a value (the eccentricity of the orbit) known to be false. Furthermore, Kepler proves the *impossibility* of adjusting such a hypothesis to provide a perfect representation of the heavens. Of this constructive failure, Kepler writes in Part II of his ***The New Astronomy***:

> 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.[8]

It would seem that a totally new approach to astronomy is in order. Yet, after his demonstration of the unavoidable paradoxes inherent in approaching astronomy with the assumptions of uniform motion embodied by the equant, and of uniform distance required by a circular orbit, Kepler surprises many readers with what he does next to refute the approaches of Ptolemy, Copernicus, and Brahe. He spends the first half of Part III demonstrating that the motion of the annual orb (the Sun or Earth) is not a simple eccentric, as his predecessors insisted, but that it *does* conform to the equant-hypothesis! That is, it is wrong to say that the annual orb does *not* have an equant in its theory. But, why would Kepler *add* an assumption that he has seemingly just refuted?

A Different Type of Equant

But, before getting into the details, let us review Kepler's mind. In his argument *for* the existence of the equant, from the chapter of ***Mysterium Cosmographicum*** titled "Why a planet moves uniformly about the center of an equant," he says of an equant with bisected eccentricity:

> Therefore at the middle part of the eccentric path where it projects above the concentric circle, the planet will be slower, because it moves further away from the Sun and is moved by a weaker power; and in the remaining part it will be faster, because it is closer to the Sun and subject to a stronger power… Let A be the source of this moving spirit, namely the Sun…. Then, naturally, let the whole universe be full of a spirit which whirls along any stars or comets it reaches, and that with the speed which is required by the distance from the Sun or of their positions and the strength of its power there.[9]

As you can see, Kepler had always considered the equant-model a good *hypothesis* to explain the motion of the planets, not because of a power of uniform angular motion, but because it mimicked a *physical* power, a "moving spirit," whose source is in the Sun. Here we have, over a decade before the printing of ***The New Astronomy***, Kepler's hypothesis of a physical cause! The failure of the vicarious hypothesis in Part II was a successful demonstration that the geometrical mimic can be differentiated from the physical truth.[10]

Note the difference in method: Ptolemy introduced the equant to match the observations, but Kepler, looking back at its introduction, forms a physical hypothesis for *why* the equant appears as a useful geometrical tool. Now, the search for what might ironically be called a *physical equant* can begin!

But, before moving ahead, Kepler raises an objection to this idea:

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[7] See http://wlym.com/~animations/part1/meanapparent.html for a development of the mean sun and the apparent sun.

[8] Johannes Kepler, ***Astronomia Nova***, trans. William Donahue, pp. 283-284.

[9] Johannes Kepler, ***Mysterium Cosmographicum***, trans. A. M. Duncan, Ch. 22, pp. 217-219

[10] As Kepler says in Chapter 4 of his ***Astronomia Nova***: "The point of the equant… is nothing but a geometrical short cut for computing the equations from a hypothesis that is clearly physical."

> [W]hat explanation will be eventually put forward for the annual motion of the Earth? For it did not need an equant either in Ptolemy's theory or in Copernicus's. Consequently, this is also a doubtful case awaiting the judgment of astronomy.[11]

How can his physical hypothesis be *universal*, if it is not expressed in the motion of the annual orb, which does not have an equant?

A Barrier to Hypothesis

Kepler writes of this mental barrier to consideration of his physical reasoning in the beginning of Part III of his ***The New Astronomy***:

> In chapter 22 of the *Mysterium Cosmographicum*, when I was giving the physical cause of the Ptolemaic equant or of the Copernican-Tychonic second epicycle, I raised an objection against myself at the end of the chapter: if the cause I proposed were true, it ought to hold universally for all planets. But since the earth, one of the celestial bodies (for Copernicus), or the sun (for the rest) had not hitherto required this equant, I decided to leave that speculation open, until the matter were clearer to astronomers. I nevertheless entertained a suspicion that this theory might perchance also have its equant. After I gained the recognition of Tycho, this suspicion was confirmed in me.[12]

Studying the Earth

The study of the annual orb is of particular interest for studying Kepler's *method* of thought. Unlike their theories of the motion of Mars, which, at times, were off by degrees, the hypotheses of Ptolemy, Copernicus, and Tycho for the motion of the annual orb left nothing to be desired: the predicted locations were never found to be at variance with the actual locations of the sun. Upon what grounds might Kepler introduce an equant into the theory of the annual orb, when a simple eccentric already works "perfectly?" We seem to be facing the same problem encountered in Part I of the *equivalence of hypotheses*: were Kepler to show that using an equant for the annual orb gives correct values, could he claim that he is more correct than his predecessors, or only *equivalently* correct? Clearly, a different, active, type of reasoning is required here.

An Irony From Above

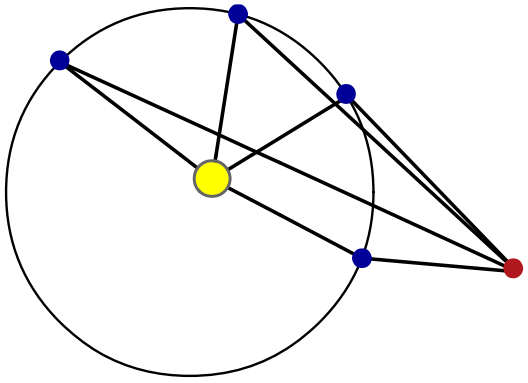
But, how can we begin to study the motion of our home the Earth, when we are moving along with it? This question is akin to the use of *irony* in political organizing.

All humans have assumptions about how the world around them, and the mind within them, operate. These predispositions act upon all that we observe or consider; therefore our observations are shaped by our assumed axioms. Is it possible to examine these assumptions themselves, and, if so, how?[13] How can anyone be made to see their assumptions, if all their perceptions are made according to these very assumptions? How can we see the motion of the Earth while we are moving with it?

Watching the Earth from Mars

Kepler uses an *irony* in the Sun-Earth-Mars relationship to allow this feat of self-reflection, by watching the Earth from the Sun and from Mars. This he does by making Mars remain motionless, an observer of our moving Earth. But, how does he accomplish this?

Mars has its year just as does our Earth. In the same way that the sun appears at the same location in the zodiac each Earth year (keeping in mind the precession of the equinox), Mars is in the same position with respect to the sun after each of its years. But, our Earth is *not* in the same position after one of Mars's years. Therefore, the motionless Sun and Mars are Kepler's two celestial eyes, watching our Earth in its course through the heavens.[14]

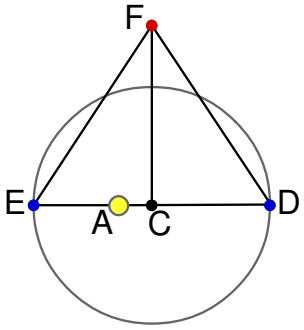


Four different positions of the Earth, with the Sun and Mars always at the same positions.

Just as in Part II, where a dialogue involving the Sun and the Earth was used to determine the path of Mars by using observations taken at opposition, Kepler again allows Sol, Earth, and Mars to work in harmony to determine their relationships. So, armed with this tool of creating *irony*, we can retrace Kepler's footsteps as he demonstrates conclusively that the Earth (or Sun) does *not* move on a simple eccentric.

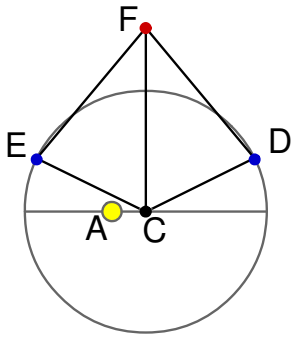
[11] Kepler, ***Mysterium Cosmographicum***, p. 219
[12] Kepler, ***Astronomia Nova,*** pp. 305-306
[13] Kant believed this to be impossible; he writes of one such unquestionable assumption in his ***Critique of Pure Reason***: "Not only in judgements, however, but even in conceptions, is an a priori origin manifest. For example, if we take away by degrees from our conceptions of a body all that can be referred to mere sensuous experience—colour, hardness or softness, weight, even impenetrability—the body will then vanish; but the space which it occupied still remains, and this it is utterly impossible to annihilate in thought."
[14] See http://wlym.com/~animations/part3/24/index.html.

Let us create a very specific *irony*, to directly examine the assumption of a simple eccentric. Allow the position of Mars, to which it returns each Mars-year to be perpendicular to the Earth's line of apsides, and, in fact, to be on a perpendicular raised from the point of uniformity of the Earth's motion (which is also the center, according to those who came before Kepler).

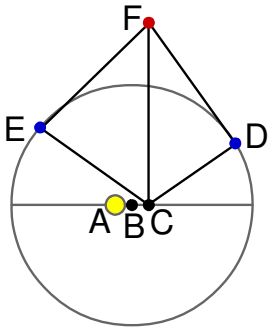


Here, A is the sun, C the point of uniform motion (both the equant and the center, assuming a simple eccentric), E and D are two positions of the Earth looking at Mars at the same position F. The motion of the planets did not provide Kepler with the good fortune of angles FCE and FCD being exactly 90°, but he did get both to be equal to 64°23'30".

By the hypothesis of the simple eccentric, this orientation should be symmetrical:



However, observed angles CEF and CDF do *not* come out equal. Working from the location of Mars, the angle Earth moves around the equant, the observed positions of Mars, the orientation of the line of apsides for the Earth, and, finally, the assumption of a circular orbit, we arrive at this unsymmetrical result, indicating that C is *not* the center of the Earth's orbit. Thus the *mean sun* is not the center of the Earth's orbit it all, but is actually its equant. How much more absurd it now appears to set up planetary hypotheses using the mean sun!



B is introduced as the center of Earth's orbit, distinct from C.

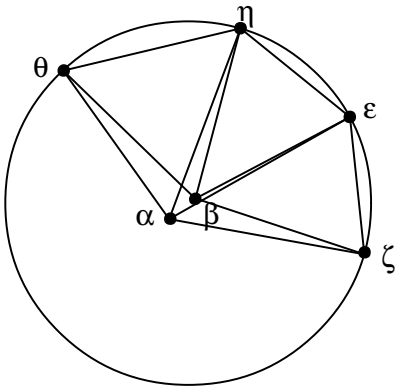
With this result, Kepler, using beautiful insight into triangles, is able to determine the distance BC to be around 1837, which is almost exactly half of the distance AC, which was taken to be 3584 (whose half is 1792); this appears to be a bisected eccentricity! Kepler is emboldened to move ahead with his physical hypothesis from his ***Mysterium Cosmographicum***:

> Such, then, was the beginning of this enquiry, timid and encumbered with such concern that the anomaly of commutation be equal on both sides [that the diagram work out to be symmetrical].
>
> Now that we have once made a hazard of this, we are buoyed by audacity to sally forth again more freely onto the battlefield. For I shall seek out three or more observed positions of Mars with the planet always at the same eccentric position, and from these find by trigonometry the distances of that number of points on the epicycle or annual orb from the point of uniform motion [equant]. And since a circle is defined by three points, I shall use three such observations to find the position of the circle, its apsides (previously taken as a presupposition), and its eccentricity with respect to the point of uniform motion. Should a fourth observation be at hand, it will serve as a test.[15]

Now that Kepler has shown a *paradox*, a crack in the results he obtains from using Tycho's assumptions, he is able more freely to investigate what is *really* happening, no longer in terms of why others are wrong, but to find what is right.

Watching the Dance

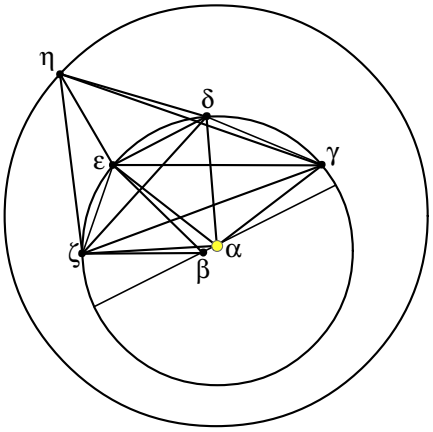
Rather than using two observations, let us use four: three to define a circle, and a fourth to test. To avoid the objections of those who suspect novelty in his introduction of the apparent sun, Kepler first does this using the hypothesis of the mean sun, finding the distance between the center of the annual orb and its equant to be around 1530, very close to the 1800 required by a bisected eccentricity.



In Chapter 25, Kepler finds the distance of the center of the annual orb (β) from the point of uniform motion (α). An animation of a similar process is at http://wlym.com/~animations/part4/41/index.html.

[15] Kepler, ***Astronomia Nova***, p. 316

Kepler next switches his anchor to the apparent sun, and finds the distance between Sol and the center of Earth's path. He does this in chapter 26 using the vicarious hypothesis for the position of Mars as seen from the sun, and then proceeds without this assumption in chapter 27. He finds an eccentricity of 1800 in chapter 26, and 1653 in chapter 27.



Kepler uses the Sun (α) as his anchor, and finds the distance between it and the center of the Earth's orbit (β), again finding a bisection of the total eccentricity used by Tycho Brahe.

To confirm this bisected eccentricity, Kepler assumes it is true, and then devises a method of determining Mars's position based on positions of the Earth using this assumed eccentricity. His concluded positions of Mars as determined from several Earth positions agree among themselves, and with his vicarious hypothesis. Thus, he has concluded the bisection of the eccentricity in the annual orb by four different methods.

Effects on Observations

Despite these demonstrations using observations of Mars, some might object to Kepler that since Brahe's tables based on a simple eccentric never reveal an error with respect to observations of the sun, that introducing an equant could only serve to add an error to the theory. Kepler writes: "Brahe feared that if I bisected the sun's eccentricity I would vitiate his equations of the sun's motion." To test this, Kepler simply calculates the maximum difference between the eccentric-model and his equant-model for the annual orb, and finds this maximum difference to be on the order of seconds of arc – too small to be observed: the equant does not vitiate the equations.

A remarkable consequence of this is that simply observing the sun would *never* have generated an irony *requiring* the equant. Since the two models are indistinguishable by solar observations, this question could have met the same fate as the debate between the *equivalence of hypotheses* of Ptolemy, Copernicus, and Brahe addressed in Part I: it would have been considered undecidable by observation. The universe required Kepler's active, experimental seeking, rather than passive observations to reveal its secret! Without observing Mars, the perceived motion of the Sun in the heavens could not have been known. In engaging in a dialogue with Mars, we come to know the Earth.

A *Universal* Physical Principle

Now what held him back need no longer hinder him. Rather than *adding* an axiom of equant-motion, Kepler has *removed* an exception to the existence of a universal physical principle of motion; he has removed the exceptional status granted to the annual orb.

With his irrefutable demonstrations that the center of the annual orb is not its center of angular motion, and that, in fact, it too possesses an equant with bisected eccentricity, Kepler can look for a *universal* cause of motion:

> Now in my ***Mysterium Cosmographicum***… I postponed arguing this case of the cause of the Ptolemaic equant for the sole reason that it could not be said on the basis of ordinary astronomy whether the sun or earth uses an equalizing point and has its eccentricity bisected. However, now that we have the confirmation of a sounder astronomy, it should be transparently clear that there is indeed an equant in the theory of the sun or earth… Now that this is demonstrated, it is proper to accept as true and legitimate the cause to which I assigned the Ptolemaic equant in the ***Mysterium Cosmographicum***, since it is universal and common to all the planets. So in this part of the work I shall make a further declaration of that cause.[16]

It is in "making a further declaration of that *cause* [emphasis mine]" that Kepler leaps across the pit into which a statistician would stumble. (See box)

Kepler moves to declare this cause, with his demonstration in chapter 32, that an equant with bisected eccentricity closely imitates his physical hypothesis of the sun serving as the seat of a *power* moving the planets: the time for a planet to traverse equal amounts of arc is measured by its distance from the sun: "the elapsed times of a planet… on equal distances in the ethereal air are in the same ratio as the distances of those spaces from the… center of the world." This could also be stated that the planet's speed is in inverse relationship to its distance from the sun. But, this holds *only* when the equant and the sun are at equal distances from the center along the line of apsides. When they are at unequal distances along the line of

Box: Perfectly More

Since the equant works so well in the vicarious hypothesis, perhaps a slight alteration of it would work even better. This is the temptation to make a small addition to the model, to make it "more perfect." But, this is not Kepler's approach. Rather, he develops our reason to be "perfectly more." When Cusa was confronted with the paradox of the squaring of the circle, he developed a new *principle*, rather than seeking to fill a sieve by adding more and more sides to a polygon. Thus does Kepler, instead of making a slight change to the equant-model to better match observations, hypothesize the true, *physical* principle of which the *equant* acts as an imitation.

[16] Kepler, ***Astronomia Nova***, p. 372

apsides (as, for example, in the vicarious hypothesis) the motion created does *not* closely approximate speed depending on distance from the sun. Now, a solution to the mystery of the repeated appearance of bisected eccentricities can be proposed: the universal principle causing motion is imitated only by a *bisected* eccentricity.

Developing the Hypothesis

In a state of hurried excitement, the reader sweeps through Chapters 33, 34, 35, 36, 37, and 38. We discover more about this "immaterial *species*… the primary agent of every motion in the universe." But how could a physical species, which inheres in no matter, and "between the source and the movable thing is in a state of becoming, rather than of being," be subjected to geometrical laws?

> The reply is this: although the motive power is not anything material, nevertheless, since it is destined to carry matter (namely, the body of a planet), it is not free from geometrical laws, at least on account of this material action of carrying things about. Nor is there need for more, for we see that those motions are carried out in space and time, and that this power arises and is poured out from the source through the space of the world, all of which are geometrical entities. So this power should indeed be subject to other geometrical necessities.[17]

We discover that the sun is a magnetic body, like the Earth, and that it rotates, all before anyone had ever seen a sunspot move! The cause of motion explains why the planets all lie near a certain plane of power close to the ecliptic (hinting at a truly revolutionary insight in Part V). His new hypothesis allows him to make sense of the "variation" of the Moon's motion: the intension of the Moon's speed when it is along the line from the Sun to the Earth is because of the intensity of the force along this "diameter of power." Kepler writes: "It would be preferable to attribute to the Earth a force that retains the moon, like a sort of chain, which would be there even if the moon did not circle the earth at all."[18]

The cause of the planet's ascent from and descent towards the sun are understood by a *vis insita*, an inherent force in the planet which expresses itself only in its relation to the *species* of the sun. No direct cause pushes the planet along this direction, but only an *accidental* one, like the shape of a riverbed causing water, which seeks to move downwards, to move out to sea in a river. What a panoply of breakthroughs his pregnant hypothesis has engendered!

A Historic Recapitulation

Now, Kepler tests his hypothesis by posing his physical principle as the cause of motion. To offer a compelling conclusion, he must demonstrate that his hypothesis accurately describes the motion of the annual orb. In chapter 40, he finds between the equant model – which, by its close equivalence to the eccentric model, works – and his proposed physical model, a greatest difference of 33", well within observational precision. Thus, in the case of the annual orb, no objection can be raised to the implementation of the physical principle of gravitation to understand its motion.

Circular Motion?

A dynamic universe has a different potential than does a mechanical one. Near the close of Part III, with the dynamic universe in mind, Kepler re-approaches the assumption of circular orbits. Although circles are very easy to draw with a compass or a piece of string, they are literally *impossibly* difficult to generate with physically driven motion.[19]

Analysis Situs![20] What shape does this motion give itself? Instead of imposing geometric concepts from outside the self-governance of the orbit, ask instead: according to the principles causing motion, which shapes are possible?[21]

Completing His Mission

The operation of the *species* of the sun is very close to the use of an equant with bisected eccentricity, and such an equant was found to be within 8' accuracy for the motion of Mars. Has Kepler yet proven that gravitation is a *required* principle, and not only an interesting additional surmise? Armed with his hypothesized *physical* principle, and calling into question any use of geometry as a possible *cause*,[22] will Kepler find the perfection that the geometric mimic – the equant – missed? That is the task of Part IV.

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[17] Kepler, ***Astronomia Nova***, p. 383
[18] Kepler, ***Astronomia Nova***, p. 402
[19] See http://wlym.com/~animations/part3/39/index.html.
[20] G.W. Leibniz, "Analysis Situs," in ***Leibniz: Philosophical Papers and Letters***, trans. Leroy E. Loemker, Kluwer Academic Publishers.
[21] "This quality of experimentally premised conceptual evidence, which is associated, like the Pythagorean *comma*, with the notion of universals, implicitly defines the physical universe as composed *not of, but by* universal principles of this quality. These do not represent a perfected set of such principles, but a set undergoing implicitly *anti-entropic* developments. Any event in that universe is acting upon, and is acted upon by that universe, as Leibniz makes this point in, as referenced above, his sundry, anti-Cartesian writings on the subject of dynamics. This anti-entropic quality of the universe so defined, is echoed as the implications of Kepler's empirical demonstration of the problematic character of the implicitly anti-entropic notion of the paradox of the *equant*."

"Principles are not something amid, and as if connecting Cartesian-like objects in a pair-wise fashion. They are the essential, existing matter of which the universe is composed as a universe. It is a self-developing universe, in which essential action is expressed as, or in resistance to efficient action supplied by, for example, the human individual's will. This is, essentially, *dynamics* as its experience is traced in known history to the method of the Pythagoreans and Plato's circles."
From LaRouche: "What Congress Needs to Learn: The Lost Art of the Capital Budget," **EIR**, Jan 12, 2007
[22] Including the use of circular orbits