The Pedagogy for Teaching Kepler's 'Astronomia Nova'

by Jason Ross

The author is a member of the LaRouche Youth Movement Basement Team of scientific researchers, and has done extensive work on Johannes Kepler; he participated in an international conference in Prague, Czech Republic, Aug. 24-27, 2009, which commemorated the release, 400 years ago, of Johannes Kepler's Astronomia Nova *(The New Astronomy). The theme of the conference was "Kepler's Heritage in the Space Era," and 60 people from some 12 nations took part. There were about two dozen presentations, including one by Ross. The participants were also asked to submit written reports for publication in the* Proceedings *of the conference. The author's submission for publication, "Teaching the Astronomia Nova: Computer Animations and Pedagogical Techniques," is reprinted here.*

The present paper serves three purposes: to discuss pedagogical techniques, including computer animations, for the mass-instruction of Kepler's *Astronomia Nova*; to explain why the staff of an American political action committee was assigned to work on this project, making breakthroughs in a field seemingly far removed from political economics; and how manned space exploration to Mars and beyond will develop human economy, culture, and science, as one single process.

The assignment of teaching the essential aspects of the *Astronomia Nova* to a group of over 100 young people [in the LaRouche Youth Movement], the vast majority of whom had not previously studied much astronomy, raised special challenges and presented unique opportunities for experimentation with pedagogical methods. The ability to use "natural selection" to focus only on a narrow audience was not available, and the book had to be rendered understandable (without sacrificing rigor or truth) to a general audience. While many classroom pedagogical techniques were developed, such as "acting out" the operation of a uniformly-rotating equant using four student-participants, the main focus of this paper will be on the development and content of the website (www.wlym.com), created for this purpose.[1]

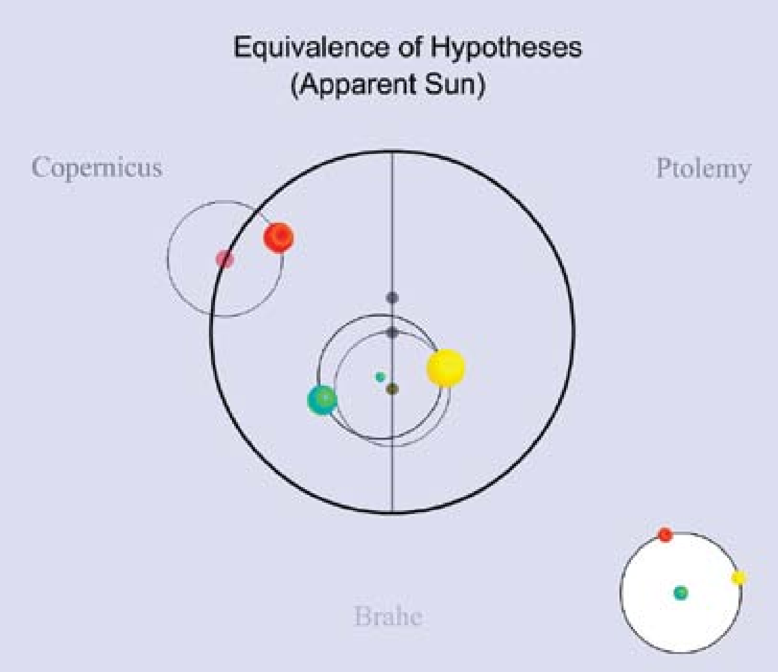
Particular attention will here be given to the most important concepts of Kepler's book: the equivalence of hypotheses, which demonstrates the impossibility of deciding between relative and absolute motion from a geometric standpoint; the failure of the vicarious hypothesis, which reveals, in the style of Plato's Socrates, the impossibility of applying a geometric approach to understanding Mars; the birth of the distance-law and then, the area-law, as a mathematical way of measuring the physical (solar) cause of motion; and the birth of the ellipse through a series of hypothetical "eggs."

Examples of Computer Animations

The equivalence of hypotheses can be demonstrated in a static mathematical fashion, but a gripping conviction of its verity comes from motion, whether in the form of a mechanical model, or a visual representation.

1. Jason Ross, editor, "Johannes Kepler's New Astronomy," wlym.com/~animations/newastronomy.html (2006).

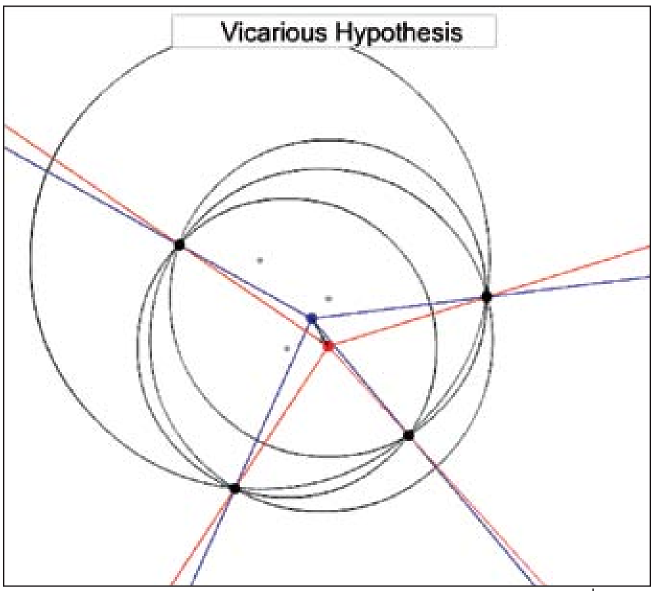
FIGURE 1



wlym.com

The three points on the line of apsides are, from the top: equant, center, and the observer. This image from the animation combines the theories of Ptolemy (90-168 A.D.); Copernicus (1473-1543); and Brahe (1546-1601). See animation at http://tinyurl.com/ygjrbyt.

FIGURE 2



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Kepler's predecessors assumed that the center of Mars' orbit lay equidistant between the equant and the center of the universe (the Sun for Copernicus; the Earth for Ptolemy), while Kepler used four observations and adopted an iterative (rather than determined) procedure to develop the astronomical parameters for the model. See animation at http://tinyurl.com/yh8zxq2.

The interactive animation found on the website (**Figure 1**) [http://tinyurl.com/ygjrbyt] allows the student to move freely among the systems of Ptolemy, Copernicus, and Brahe, even creating systems that are a mixture of all three. Because of the complete geometrical equivalence among them, it is possible to move continuously between these three systems that may at first seem to be separated discretely. Many of the students found this animation to be particularly helpful, by making it possible to explain almost the entirety of Part I to others, using this and other animations on the site.[2]

Kepler's successful demonstration of the failure of his Vicarious Hypothesis is of absolutely crucial importance to scientific thought. Calculating the parameters took Kepler an entire year, and over 40 trials, and the calculations he presents in Chapters 16 through 19 may intimidate readers without much mathematical background. A comprehensive guide was developed, covering not only the calculation of the vicarious hypothesis, but also the observational corrections that Kepler had to make, including, significantly, Chapter 9, where Kepler develops the proper way of referring a zodiacal position to the ecliptic of Mars. Kepler's difficulty in a calculation that his predecessors found easy, came from his not assuming that the center of Mars' orbit lay equidistant between the equant and the center of the universe (the Sun for Copernicus; the Earth for Ptolemy). The interactive animation for the Vicarious Hypothesis (**Figure 2**) [http://tinyurl.com/yh8zxq2] allows the student to see why only three observations are required if this assumption is made, and why Kepler must use four observations and adopt an iterative (rather than determined) procedure to develop the astronomical parameters for the model.

2. The first non-interactive animations were produced in 2006 using Mathematica to produce a series of images which were combined into an animated GIF file. The use of ActionScript programming as part of the Adobe Flash software allowed for the authoring of interactive (and more visually appealing) animations: while Mathematica produces a series of fixed images, the files created by Flash can respond to the user and dynamically change their appearance. The interactive demonstration of the equivalence of hypotheses was created in Flash using the ActionScript language (transferred from text).

The failure of the Vicarious Hypothesis to properly give both distances (as measured by latitudes) and longitudes meant not that Kepler's parameters were wrong, but that the attempt to find an orbit as a circular path governed by an equant was doomed to failure. A method of thought was demonstrated to be wrong, and a new method was required. This allowed Kepler to dispense with the equant altogether in Chapter 32, where he shows that the operation of an equant with bisected eccentricity gives the effect, that the speeds of the planet at various places in its orbit, are inversely proportional to the distance from the Sun.

Kepler, since the publication of his *Mysterium Cosmographicum*, had believed that the Sun moved the planets, and that the equant served merely as a geometric mimic of a physical motion.[3] Now, he has shown that the specific motion that the equant mimics is the relation of speed to the distance from the Sun. In the following chapters, Kepler offers his physical rationale for how the Sun could cause such a changing speed, and uses the changing speed of the Moon as further support for his theory.

Since the time required for the planet to traverse a certain small portion of arc is measured by its distance from the Sun, the way to measure the time for the planet to traverse a given amount of its orbit is to: break down the total path into small pieces, determine the distance of each piece from the Sun, and sum these distances to get the total time required, calibrating by measuring the sum of distances all around the orbit. Since this leaves some difficulty, Kepler considers using the area subtended by the moving planet as a preliminary measure of time. These concepts are covered somewhat roughly on the website, since they did not lend themselves to animations (except for Chapters 39 and 40). It was difficult to develop pedagogical novelty in these chapters—doing the calculations was really the best way to get an understanding.

With the cause of revolution preliminarily solved, Kepler takes up the path of the planet in Part IV. Computer animations became very useful here, in order to compare equants with area time, and, in particular, to explore the variety of eggs that Kepler creates. His first egg (or "blind puppy," as he reflects upon it) is produced in Chapter 45, by allowing uniform circular motion on an epicycle to create the distances from the Sun. This hypothesis leads to four different eggs in Chapters 46 through 49 (**Figure 3**) [http://wlym.com./~animations/eggs.html]. This project created the first animation of the operation of these four different eggs, with the ability to change the eccentricities interactively.[4]

In addition to images of the individual eggs themselves, the website includes guides to the calculations for the more difficult ovoid paths.[5] The reader is encouraged to inspect the website, which contains a page for nearly every chapter in Part IV. It is to be noted that by examining the different eggs in detail, the eventual development of the ellipse is not presented, as it unfortunately often is, as Kepler trying out a particular shape. By presenting the constructions that Kepler uses along the way, the site presents the geometric construction, based upon his hypothesized physical principles, that gives rise to the ellipse, but presents it as a construction, not as a shape. The ellipse does not cause the motion; the motion creates an ellipse.

It is hoped that the overall presentation on the website helps readers discover how Kepler's approach to astronomy differed fundamentally from that of his predecessors. While they produced models, Kepler produced physical hypotheses.

Kepler and Political Economy

The present author and his team were given the assignment of developing an educational program for the *Astronomia Nova* as a bit of a surprise. The author works with a U.S. political group, the LaRouche Political Action Committee, chaired by Lyndon H. LaRouche, Jr., a past candidate for U.S. President. LaRouche's primary field of expertise is economic science, and his long-range forecasts are the most accurate of any presently known practicing economist. The author and his team assembled to work on an economic research project, expecting to continue their earlier study of the development of transportation infrastructure and technology within the United States. Instead, they were given a different mission by LaRouche: to offer "a correct demonstration of Johannes Kepler's often misunderstood discovery of universal gravitation."[6]

3. Johannes Kepler, *Mysterium Cosmographicum* (1596); Chapter 15.

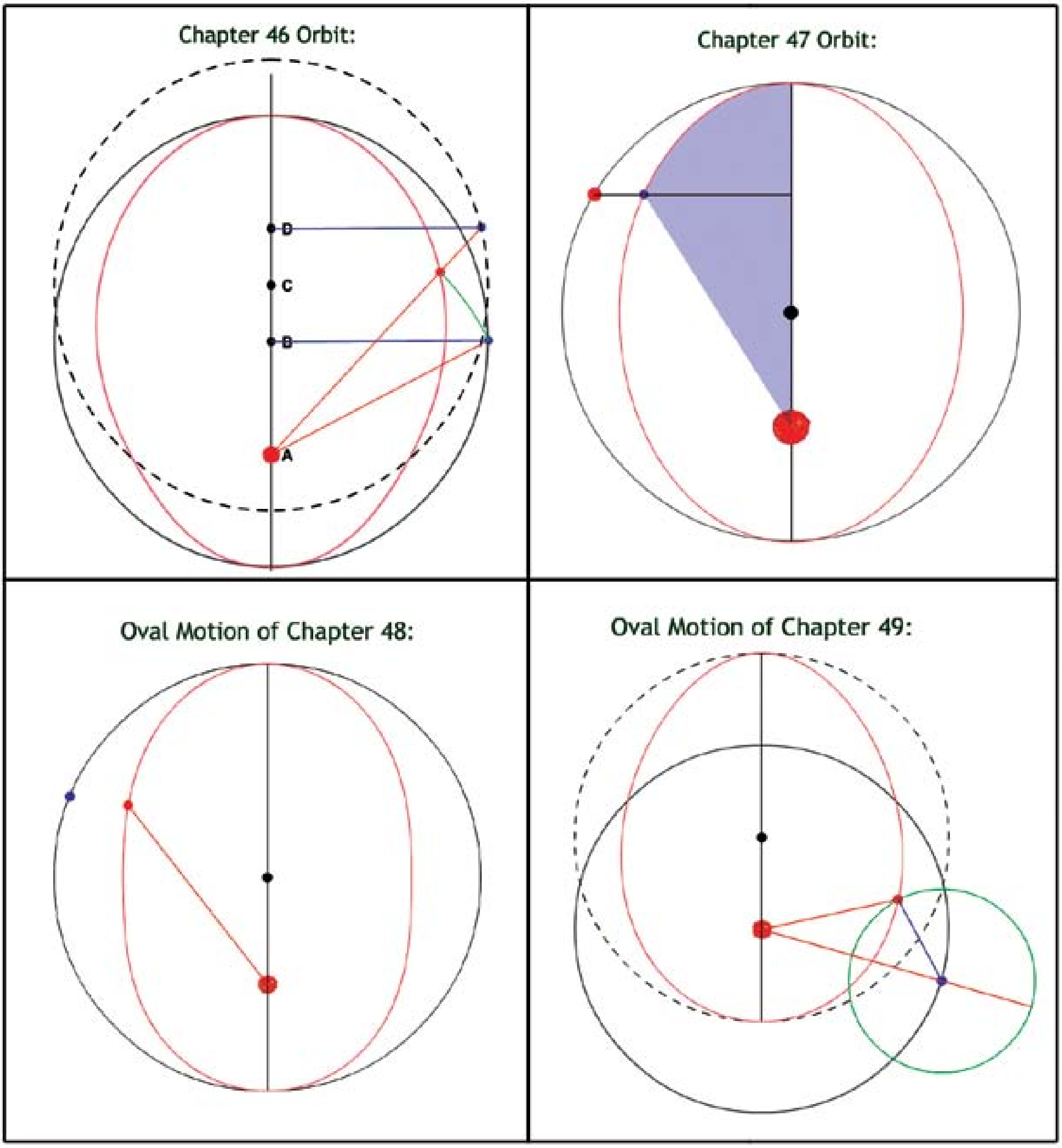
4. As in the other interactive animations on the site, this was done using the ActionScript programming language in Flash.

5. These include Microsoft Excel spreadsheets in which Kepler's degree-by-degree calculations are re-performed.

6. Lyndon LaRouche, "Why the Senate's Intelligence Has Failed: Reanimating an Actual Economy," *EIR*, Aug. 4, 2006; p. 7 (footnote 6).

FIGURE 3

Kepler's 'Blind Puppies' ('Eggs')



This project created the first animation of the operation of these four different eggs, with the ability to change the eccentricities interactively. See animation at http://wlym.com./~animations/eggs.html.

In the document given as an assignment to the research team, LaRouche wrote:

"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.

"So, for pedagogical purposes here, what are usually regarded as long-term business cycles, may be compared, broadly, with that scientific method for defining orbital cycles which was discovered by Kepler."[7]

In "Reanimating an Actual Economy," LaRouche discusses the mistakes in the approach of William D. Nordhaus, in his study "Geography and Macroeconomics: New Data and New Findings" [http://www.pnas.org/cgi/reprint/103/10/3510]. Briefly, Nordhaus performs a geographical-economic study, by dividing the planet into geographical units of resolution 1° latitude and 1° longitude, and then compiling an array of economic indicators for each geographical unit. He then concludes with correlations between geographic conditions and economic performance. The trouble with Nordhaus's report, is that it does not seek to uncover the causes for these differences, and gives a false impression about how geographic conditions per se produce economic outcomes.

LaRouche writes that the real task is to: "discover the principal factors which are determining, or might determine either net growth, decline, or stagnation in the rate of the performance of the economic phase-space considered. . . . The latter task, the uncovering of the principal determining factor, is the functional requirement essentially lacking in the approach to defining animations in the exemplary case represented by Nordhaus's report."[8]

In order to accomplish this task, LaRouche advises: "The most suitable pedagogical approach to this crucial feature of the study, is that modeled on the most essential distinctions of Kepler's referenced discovery: the discovery of the principle of the 'infinitesimal.' That is the distinction which is apparently beyond the comprehension of today's commonly encountered academic classroom and related productions respecting the principles of physical scientific and related investigations."

Filling in the 'Wholes'

It was with this mission in mind that this author's team approached Kepler's work. Since this present report is not intended for an audience of economists, a summary of LaRouche's physical economic science is in order. Nordhaus, like almost all contemporary economists, looks for trends in economic indicators to find correlations. The price theory of monetary economics holds as an axiom that the supply-and-demand method of associating value with the components of the physical economy is either useful for mankind, or an unavoidable practice in political economy. LaRouche, on the other hand, stresses that the value of anything in an economy must not be looked at in terms of how much people are willing to pay for it (think of all the silly and useless things that people waste money on or mis-invest their savings in), but rather in the value to the future which is yet to be.

The fundamental distinction between the human species and any other living species on the planet, is that while evolutionary developments of "technology" (such as the development of warm-blooded creatures, cephalization, and the supremacy of mammals over marsupials) take place in the living world, it is only with the human species that changes in our manner of living are the subject of conscious, intentional change. This is accomplished through our discovery of universal physical principles, which fundamentally change our species character, as measured by the number of people who can successfully live and thrive on a certain quantity of land-area. This potential population density (relative to geographic conditions) is the first-approximation measure of the success and economic development of a power.

Kepler's infinitesimal, as seen "between the cracks" of the equant, as a physical cause of motion, gives an entirely new conception of a planetary orbit. The orbit does not exist in an ontologically primary sense; rather it is the result of an intention which expresses itself constantly. The full elaboration of Kepler's principle of universal gravitation is found in his *Harmonice Mundi* (Harmonies of the Worlds), where the harmonic requirements of the Solar System, as a system, give rise to the local characteristics of the orbit.

It must be so in economic practice, where the future determines the present, and value must be measured not with respect to what is, but with respect to what is to be. Even the same object or action, such as the occupation of a plumber, takes on a different value when the trajectory of the total economy and culture changes: Installation of water piping has a different value for mankind, when the piping is for a scientific research facility, instead of a casino, even if the activity of the plumber himself is otherwise exactly the same in both cases.

7. *Ibid,* p. 8.

8. *Ibid,* p. 9.

EIRNS/Liz Mendel

Group work on the Astronomia Nova. *Several dozen young people work together following a presentation by the author on Part I, October 2006, at a LaRouche Youth Movement cadre school near San Bernardino, Calif.*

Mars, Kepler's Captive: 400 Years Later

The proper practice of economics, like the proper practice of medicine, requires that the practitioner not merely forecast the future condition of the object of his study, but propose how to create the best possible future state. One cannot be a true economist without crafting economic policy. At the present moment, the world economic system is hopelessly bankrupt, and only its replacement by a new system through bankruptcy reorganization, could allow the continued survival of the physical economy, and the majority of the human population. Key to this must be the scientific and cultural mission of manned space exploration.

Not only has Kepler's discovery of the physical infinitesimal enabled economic thinkers to conceive of intention as primary, but the possibility of actually going to Mars, to set up a scientific research facility and supporting infrastructure and personnel, would very much please our friend Kepler, the author of the *Somnium* (The Dream). Space exploration offers a large variety of benefits. Accomplishing a feat which is currently beyond human ability requires an upshift in manufacturing technique and basic scientific knowledge, such as the requirement for fusion power in order to accelerate and decelerate our human-bearing craft to Mars for a total trip time (starting in Moon orbit) of only a few days. Having an overarching mission-orientation allows for the proper valuation of economic production.

The potential for scientific advancement provided by a manned Mars research base is nothing short of breathtaking. How will living processes operate in an environment differently situated with respect to the Sun, with different gravitational and magnetic-field characteristics? How will the universe respond to the creation of an "artificial" 1-G environment in the constantly accelerating spacecraft? What wonders will we be able to observe and study in deep space, with the immense parallax offered by full observation stations in Mars orbit and Earth orbit?

The Poet

Rather than looking for a payback measured in monetary terms (although, as U.S. experience with the Apollo project demonstrates, the monetary payback will be enormous), let us briefly consider the cultural implications of adopting such a mission. What a source of optimism the journey to the heavens will provide, as mankind grows out of its adolescence into the truly human freedom of discovery! Scientific discovery is absolutely universal, and the ability to discover is common to all human beings. Working together towards a goal that uniquely encapsulates our humanity, in the midst of what otherwise is a societal economic collapse, provides a moment in history in which, to quote from Shelley's "A Defence of Poetry," "profound and impassioned conceptions regarding man and nature" can be exchanged.

This future for our species can be secured, but it will require changes that will seem almost impossibly fast. However, there are no limits on mankind besides those that he sets upon himself, and this change requires a commitment on the part of real scientists to see to it that society is organized in the best way. To truly be a scientist, one must also be a poet.