The Revolutionary General

John R. Bosworth

Oklahoma State University

A recent article in Philosophy of Science by Andrew Lugg (1985), revives interest once again in Johannes Kepler's so-called "discovery" of the laws of planetary motion. Typically, as if by some recurring philosophical instinct, it focuses on Kepler's finally settling on the ellipse for planetary orbits--the first of his three laws. There is a fascination with the limiting shape of what is still taken to be the scope of the Sun's sovereign domain, rather than with the second, or, even more rarely, the third law. Ever since the famous debate between John Stuart Mill and William Whewell, philosophers and historians have been drawn to this notable advance in early modern science--in what Kepler himself calls his "war on Mars" (the planet itself named after the "god" of war).

Professor Lugg argues that there is a "logic" and a "rationality" at work in Kepler's research that neither requires nor benefits from what he calls "philosophical articulation". His point of departure is a familiar chapter of Russ Hanson's Patterns of Discovery (1958a, Chap. 4). It is claimed that the philosopher, like Hanson, bases his arguments on a flawed picture--of his own making--of scientific research. Hanson is said to reconstruct Kepler's discovery, "when he turns from describing scientific research to exhibiting its rationale" (1958a, p. 210). In Hanson's defense, it will be suggested here, by example, that the philosopher's instincts are set off precisely at that crucial point in the historical record where evidence of Kepler's thought is almost entirely lacking.

This is the one which cites a fixed, or constant, ratio between the squares of planetary orbital times (their "periods") and the cubes of their mean distances from the sun.

For the philosopher, there is the familiar dilemma drawing him back, even today, to Kepler's field of battle. On the one hand, he cannot help but be associated with the putative enemy--the established tradition in thought running back to Aristotle. As the true "science of the polis", philosophy "determines which sciences are necessary in states, and what kinds of sciences should be learnt, and how far they should be learnt by particular people." (p. 80 (1094^b 1-3)). This "most

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authoritative and architectonic science or faculty" requires that a legitimate science be not only "good" in itself, but also a contributor to the "higher good"--bringing knowledge to bear in the contemplation of concerted human action by the community. If well-informed, this action is argued out in terms of all of four reasons or "causes" for proceeding--just as these same "causes" are marshalled, after the fact, in the law court. If well argued, logically and persuasively, every bit of scientific knowledge thereby translates into "good" action, without remainder--all because it makes good, common sense. The philosopher needs what the scientist can provide, but he sets the standard of what is expected from a science. By a division of intellectual labor, he sets up the conditions for his own work. Yet the new science appears, more and more, to have gone its own way. It pursues its own goals with little apparent regard for any authority other than that shared--back and forth--by its practitioners.

On the other hand, the philosopher is still deeply impressed by the potential intellectual power in the hands of the modern scientist. His new domain of knowledge appears to be established by a deliberate suspension of all "cause" questions of at least one sort--that of "final" cause, purpose, or intent. In the law, this is the last and most important question to be answered by anyone required to explain and defend his own actions. But the conclusions of the modern scientist are often the basis for devastating critiques of knowledge claims stemming from baseless fears and superstitions. These claims include, most particularly, the intellectual excesses of philosopher-metaphysicians themselves. It is this example of science's potential power for the good, for instance, which prompts David Hume to "perceive the necessity of carrying the war into the most secret recesses of the enemy . . . to subvert that abstruse philosophy and metaphysical jargon which, being mixed up with popular superstition, renders it in a manner impenetrable to careless reasoners and gives it the air of science and wisdom." (1748, p. 21).

In modern terms, the dilemma comes in the form of attempts to "justify" Kepler's work, or to find its results to be self-justifying. Such a justification, by definition, involves two parts. One, there must be some sort of indication, on Kepler's part, that he is doing something intellectually wrong, at the start. Two, there must be a clear and cogent claim of some right that effectively over-rides and denies that apparent wrong. Where no such awareness of the initial wrong is clearly forthcoming, in his writings, the typical response--unlike, perhaps, that of Hanson--is that there is no distinguishable "logic of discovery", to use F. C. S. Schiller's phrase (cited in Hanson 1985b, p. 150). Since Kepler gives no reason at all for his third law, the philosopher is likely to conclude for himself that the "logic of proof"--standing for the second step in a justification--must wait for the established authority of Isaac Newton. With him, full-fledged philosophical attempts at the whole "logic of explanation" begin. But difficulties in finding complete satisfaction of this legalistic demand, starting, perhaps, with Bishop Berkeley, remain to this day. The most familiar, last conclusion is that the steps taken by them all in turn--Galileo, Kepler, Newton, and, especially, the Newtonian succession--can be seen as moments in an on-going but never-ending "process" of justification. From there, it

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is but a short step, for the philosopher and the historian, to go back and see some kind of "rationality" at work all the time. Thus, Professor Lugg's article--fittingly called, "The Process of Discovery"--concludes that "there is no reason to think that 'conceptual inquiries' add anything to 'factual' ones. The 'circumstantial inquiries' of historians provide us with all that we need to understand scientific research and all that we can reasonably hope to obtain." (1985, p. 219-220). To Lugg, it's all to be seen, if at all, in the historical "context of justification"--in "why particular choices are good ones not with the character of the choices themselves." (1985, p. 219, footnote 20).

It is not my purpose to enter this debate on either of its sides, if they both depend upon the perpetuation of the dilemma. Both the philosopher and the historian still confine themselves to relativistic views, so that what's right, or wrong, about a scientist's particular "choices"--today--may not be tomorrow, or, what's still not quite right, throughout, may not necessarily prove wrong, in the long run. Rather, I propose that there is a very familiar and unexceptionable "logic" at work in Kepler, that it follows a recurrent, vital, pattern in science, and that it's very importance is best seen in its philosophical "rationale". I propose, that is, that Kepler's decisive step in subduing Mars reveals his chief aim all along--to secure a binding arrangement not merely among the planets, but with his fellow astronomers. I will conclude with several remarks about the philosopher's true "business" with all this--where he and Kepler are seen at one with each other. I propose that the typical distinction by Reichenbach, between the "context of discovery" and the "context of justification" (cited in Lugg 1985, p. 218-219), contains the seed of an important idea, but an idea better revealed by distinguishing "justification" from "development". Not incidental to this distinction are considerations involved in the very "determination" of a new sovereign domain.

What is this new territory that Kepler would conquer? It is the very range of the Sun's apparent power to move the planets--its anima motrix. How can Kepler think to be its conqueror? By his very acts of measurement. He unashamedly feels a "manifest destiny" to stand at the very center of the "action". He takes himself, that is, as the fully empowered agent of the Sun--acting to take all measures of its domain from the one place designated for that purpose.

It is from this place that he mounts his earlier, main assault on Mars--to bring it, along with all the other planets, under the sway of the Sun's power. But that power he takes to be in his own hands. Thus, all of his--and Tycho's--acts of measurement can and must be taken as actually determining Mars' orbit, but only if they are taken as binding on any other orbital measures--just as the acts of others are to be binding on his own. All measurers must be bound to each other by all their acts. If those acts can be "justified", accordingly, he enjoys with all other astronomers the perfect right to "develop" that power, that is, taken literally, to unfold it as a flag or banner. To do this, he must show two things: One, that the orbital speed of a planet, as measured, varies according to some fundamental principle or law, under which it operates, and, two, he must show how this orbit, as measured, is a "variable" under this law

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along with the "determination" of any one of the other orbits. This requires, at the crucial point in his work, the introduction of a protocol statement--a "coordinating definition"--linking any act of measure on his part with this same principle as binding on them all. In short, he is interested in nothing less than taking a full initiative in the Sun's name, which he expects to share fully with any and all other such revolutionary initiatives.

The fundamental law he proposes is in three parts--all adding up, in their effect, to one integrated army of revolutionaries. First, planetary orbits are all to be taken as elliptical. Second, each planet is to be taken as sweeping equal areas in equal times, thus accounting for individual variations of speed in terms of a kind of "balancing out", or "libration". And, third, the ratio of the cubes of the mean distances to the squares of the periodic orbital times for any two planets is to be taken as constant--the same. As I. B. Cohen puts it:

> The significance of this third law is that it is a law of necessity; that is, it states that it is impossible in any satellite system for satellites to move at just any speed or at any distance. Once the distance is chosen [by an act of measurement], the speed is determined. In our solar system this law implies that the Sun provides the governing force that keeps the planets moving as they do. In no other way can we [as measurers] account for the fact that the speed is so precisely related to distance from the Sun. (1960, p. 144).

The remarkable historical fact, as mentioned at the beginning, is that this final step--in laying down the third law--is taken without any elaboration or explanation of any kind. There's nothing more for him to say, presumably, because in effect it has already been "said", over and over, all those years, in the pairing of his labors with those of his silver-nosed mentor. He takes each and every single act of measurement as performed by the two of them--together. They balance off.

The "logic" and the "rationale" of his culminating third law is all there in his and Tycho's practice. To him, it can be nothing less than a perfectly "good" thing to make certain that every single measure by Tycho should count, as must his own extensive calculations on Tycho's data--the taking of unit areas by unit times. He is at the point of invoking his "protocol" statement. The "original" of his protocol is likely to remain unstated, that is, to be kept diplomatically discreet, in order to preserve any two publically issued forms of their agreement. If one were to try, nevertheless, to say what he and his departed partner--and fellow agent of the Sun--have come to, it would have to be--in modern terms--by way of a linguistic rule or understanding. It would likely take the "neutral" form of a logical equivalence (taken as "saying the same thing") of two gerundive infinitives. What he and Tycho have been doing all along must be identified with what the Sun does, through their joint agency:

> To say, "To take the measure of mean distance of a planet to the Sun and to record periodic time." is the same as
> to say, "To determine the speed of each planet."

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This rule allows for the <u>deduction</u> of a planet's speed from the fundamental law and from the instantial statement of initial conditions met by Tycho's acts of measurement. By this deduction, moreover, what is taken as logically binding on Tycho is taken as holding for himself, as for any other individual who would also take on the determination of a planet's orbit. The rule is biconditional. It works both ways. The result is a binding contractual agreement <u>between astronomers</u> in a single scientific enterprise. Each act of one partner must be <u>met</u> and "balanced out" by a matching act of the other.

Thus Kepler realizes, in coming to this point, that the "ellipse [which he had earlier rejected as making no sense] and the librations stand or fall together" (quoted in Lugg 1985, p. 213). To him, the orbit of a planet must be measured as with a "balance". Both Lugg and Hanson rightly emphasize Kepler's own conclusion that "there is no other middle term between a circle and an ellipse save another ellipse" (quoted in Lugg 1985, p. 213)--to those "operating" a balance between them. No planet can be taken as merely going its own complicated (and circular) way, but only because no astronomer, in taking its measure, can go it alone. When one astronomer puts his measure on the balance, another must do the same on <u>his</u> "side". In the traditional logic familiar to Kepler, the agreement would take a form like this:

> All measures on an ellipse (E) are measures of distance over time (D), by equal areas.
> Some measure on an ellipse (E) is a measure of planet speed (S). Therefore, some measure of planet speed (S) is a measure of distance over time (D), by equal areas.

The full force and effect of the above linguistic "rule" of understanding, in the tradition, is seen in the "reduction" of this categorical syllogism to its "perfect" form. Under the principle that all must conclude (be saying) the same thing, or none--<u>dictum de omni et nullo</u>--the argument takes this form:

> All E is D.
> All S is E. (The universal form of the second premise, as converted.)
> __________
> All S is D.

All credit goes to Kepler for this fundamental law in operation, <u>because</u> of his insistence that <u>all acts</u> be "coordinated" with each other--<u>not</u> because he would impose a way of thinking needing "justification". To him, this is the way to <u>settle</u> all such questions, once and for all.

This is clearly a decisive advance over his predecessors, because it sets up a way for all astronomers to proceed together. Never again is anyone left to his own devices, while everyone is set <u>free</u>, by the ellipse, to form open alliances without restriction. The sole and exclusive recommendation of the ellipse is that there is nothing in it to <u>stop</u> them from joining each other. Each is then free to proceed with <u>his</u> measures as instantly backed up and guaranteed by the measures of the astronomer next door. In geometrical terms, this is expressed by saying that the "circle" is a "degenerate" form of the ellipse. It means, in practice, no more "circles" of astronomers in rivalry with each other. The ellipse always allows for two "points of projection" by any two "pencils of lines" which, under projection, will always stand in what is called a "biunique correspondence" with each other. In practice, this means that any astronomer can go "one on one" with any other astronomer. In fact, the open, but binding, arrangement Kepler sets up literally defines the ellipse in the first place. They are what the mathematician calls "duals". Finally, any "fifth point" from which two pairs of measures are made is not "free to move in the plane of projection", which means that two astronomers together can "pin down" the orbit of any planet to "their" ellipse. Ellipsis, of course, is the perfect rhetorical device for this purpose. By it, their arrangement is left unstated, but "understood" by all.

As for the ratio of the two "powers", d^3 and t^2, to each other as constant, any two astronomers can perform a simple calculation on their measures--a mathematical "paper and pencil operation"--to match the paired operations carried out with sighting and timing devices. Kepler comes before the modern notation of superscripts for marking these "powers", but the very "power" of agents (still) of the Sun to contract with each other--to carry out their single charge--is exercised every time they use K, his constant. When Kepler takes a measure of orbital, periodic time, he is acting for the Sun, but his right to do so is confirmed and guaranteed only by another doing the same. It is the combined pairing of two measures--marked off by each other--that produces the effect of the Sun's assumed power. Thus, t x t, or t^2, but only because t^2 stands for "dividing up" the exercise of that power. The single measure is shared by them. The same arrangement holds for measures of equal areas, as obtained by each one of them squaring his unit measures of mean distance--d^2. The measure of a planet's entire orbital area is taken, once again, as an act which is "divided up" and balanced off by any two astronomers. d^3 stands for this effect of the Sun at work through its measurers, and could, incidentally, be "pictured" by taking any two paired measures of area as its "components".

This is, of course, not the end of the story. It waits for Newton to pick up Kepler's proposal, without further question and without any express interest in saving the Sun as "principal" of their agency. He establishes the new regime under his three laws--of "motion" in general. He takes the notion of planets, each one and all of them balancing themselves out under the sway of the Sun, and proceeds to include the Sun in all such balances. But Kepler's constant is picked up with confidence. It makes perfectly good sense to proceed by it in effecting these balances--not only for Newton, but for others such as Hooke, Halley, and Wren, at their famous meeting. But it is Newton who pulls off the final move, by way of a second and decisive co-ordinating "protocol", taking logical precedence over Kepler's. It is, once again, in the form of a logical equivalence, a linguistic "understanding"--between "mass" and "distance" determinations, on the one hand, and determinations of the mutual "accelerations of bodies", on the other. There, a further, and final, "reduction" is made. The constant of measure is taken to be universal and non-differentiating as to the brute "bodies" involved, and is taken in the brute name of "gravity". The "balancing" act is no longer confined to the limiting agency of the Sun. Under this new "rule", each and every "body" is seen as entirely "on its own"--or "inert"--save for its binding relationship with any and all others. The same, of course, can be said for the astronomer turned physicist, or, as Newton prefers, "natural philosopher". Each is off on his own, when he passes through the laboratory or observatory door, but only because each is bound by his discipline--as by a hard-won, universal, social privilege. Like the bodies of the universe, each is "backed up" in whatever he does by the "equal and opposite" actions of all others--no matter how "distant" they might be from each other. Under these new "wide-open" terms, astronomers are quite willing to act in concert with each other, because, just like the bodies of the universe, there is nothing to stop them.

Let there be no doubt about the "rationale" of all this. Newton and his successors act still as sovereign agents--not of the Sun, but of the truth itself. By "truing" up the measuring acts of Tycho with those of any other astronomer, Kepler has won the truth, because there is no way they can ever be intruded upon or manipulated. Faithful to his charge as this truth's first guardian, he even considers the working legitimacy of his own constant--taken as martial law of the heavens:

> You said, at the beginning of this speculation on motion, that the periodic times of the planets are exactly in the sesquialteral proportion of their orbits or circles; I ask, what is the cause of this?--There are four causes which combine to determine the duration of the periodic time. (quoted in Koyré 1961, p. 355).

His answers, point by point, go to all the relevant parts at play in the peaceful "Harmony of the Universe". About them, Koyré says:

> It seems unnecessary to comment on these passages. They are classic in their blinding clarity...[Kepler] corrects the mistake he had made...in not having understood that the principle of variation...could not involve exceptions; and, therefore, that not only the distances and the motions, but also the material structure and the dimensions of the bodies in the Cosmos ought to adapt themselves to this requirement and embody the simple proportions which form the very basis of harmony (1961, pp. 357-358).

The manifest power of the truth at work here, sets a strict condition on us all. With its full development, it is we who must justify whatever we might choose to do with its backing. For the philosopher, this means but one thing. An army of scientific volunteers stands in service, if he would bring the truth to bear in all his determinations of that which is "good" for this new domain. As Aristotle assumes, this work is not merely "conventional" because it is based on the truth. Science knows no arbitrary and "conventional" state boundaries, but there is ample evidence here in Kepler's life work of his staunch, unquestionable loyalty, first to his teacher and friend, and then to the human community--to all those

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creatures destined to contemplate and to measure the universe together.

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References

Aristotle. Nicomachean Ethics. (As reprinted in Basic Problems of Philosophy. Edited by D.J. Bronstein, Y.H. Krikorian, and P.P. Wiener. (trans.) J.E.C. Welldon. Englewood Cliffs, NJ: Prentice-Hall, 1964. Pages 79-85.)

Cohen, I.B. (1960). The Birth of a New Physics. Garden City, NY: Doubleday.

Hanson, N.R. (1958a). Patterns of Discovery. Cambridge: Cambridge University Press.

-----------. (1958b). "The Logic of Discovery." Journal of Philosophy LV: 1073-1089. (As reprinted in Science: Men, Methods, Goals. Edited by Boruch Brody and Nicholas Capaldi. New York: W.A. Benjamin, Inc., 1968. Pages 150-162.)

Hume, David. (1748). Philosophical Essays Concerning Human Understanding. London: Printed for A. Millar. (As reprinted as An Inquiry Concerning Human Understanding. (ed.) Charles W. Hendel. Indianapolis, IN: Bobbs-Merrill, 1983.)

Koyré, A. (1961). La révolution astronomique. Paris: Hermann. (As reprinted as The Astronomical Revolution. (trans.) R.E.W. Maddison. Ithaca: Cornell University Press, 1973.)

Lugg, A. (1985). "The Process of Discovery." Philosophy of Science 52: 207-220.

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