Kepler’s Physics of Non-Constant Change

Kepler’s revolution was, to derive the principles of planetary motion from physical principles, not mathematical ones. He conceived that the sun moved all the planets by a virtue (power) emanating from it, whose intensity diminished with distance. Thus, if the planet were moving in an orbit in which its distance from the sun varied, it would physically speed up and slow down as it moved around the sun.

(a) The planet at P\textsubscript{1} is closer to the sun A, than at P\textsubscript{2}. Thus, as the planet moves from P\textsubscript{1} to P\textsubscript{2}, it is always slowing down. This means that equal portions of the planet’s period do not correspond to equal distances along its orbital path. Kepler showed that these equal portions corresponded to equal areas swept out by a line connecting the planet to the sun.

(b) Kepler measured these areas. The area swept out as the planet moves from P\textsubscript{1} to P\textsubscript{2} is the white area (P\textsubscript{1}P\textsubscript{2}A). That area is measured by the portion of the circle, P\textsubscript{1}B-P\textsubscript{2} minus the triangle P\textsubscript{2}B-A. The area of that triangle is the distance BA times the height P\textsubscript{2}N. But, the line P\textsubscript{2}N, as Nicolaus of Cusa showed, is incommensurable with the arc P\textsubscript{1}P\textsubscript{2}. Thus, the principle of non-uniform planetary motion is dependent on magnitudes which are not susceptible of precise calculation. This gave rise to the famous “Kepler problem”: If Kepler knew where the planet had been, he could calculate what portion of the orbit (time) had elapsed. But, owing to the transcendental relationship between

TYCHO: I don’t understand. To better our children’s well-being?

KEPLER: It is well known, today, that those awe-inspiring pyramids standing on the shore of the Nile, built by peoples so long ago, however beautiful, are meaningless to a civilization out of harmony. And by “out of harmony,” I signify the reckless disregard of human reason in seeking to further mankind. Man goes about the world seeking knowledge, and using that knowledge to better his surroundings, in order to live better and happier. If only we had a nation based on that today—a nation whose sole purpose was to perpetuate the happiness of men’s souls, by allowing them to participate in a process of making discoveries and implementing them to the benefit of themselves and their posterity. Today, war
and disease are all that nations seem to perpetuate.

TYCHO: Oh, Johannes! The young are easily deceived, because they are quick to hope. We make war, so that we may live in peace.

KEPLER: Where’s the peace? Religious warfare has been raging since before my birth. In war, truth is the first casualty, our fathers the second.

TYCHO: Truth? We will never know truth.

KEPLER: So, even you don’t think that man can know the truth, and that the truth sets men free?

TYCHO: Man can never and will never know the truth. All man can do is sharpen his eyes, so that he may better perceive that which is happening; but sadly, he will never know why it is happening. Do not look too much into the underlying causes of things; simply try to find a nice model that everyone can accept, which fits the description of what you see. And if at some time it no longer works, don’t worry, just make whatever adjustments are needed to your system . . .

KEPLER: But . . .

TYCHO: . . . as long as it fits your observations, it will do just fine. Besides, you can never really know what is going on, especially up there in the heavens.

KEPLER: Take, for example, the observed motion of the planet Mars, god of war. See how he marches steadily across the sky, relative to the fixed stars behind him, in the same eastward direction as the rest of the planets and our moon. Yet, every two years he turns back westward, pausing for a brief moment before looping back eastward to resume his annual track. He certainly is a troublesome god, for not being able to proceed regularly along his perfectly circular orbit like this. [pause] The paradox leads me to wonder . . .

TYCHO: You and I can’t solve that. All we can do is provide a model that best represents what is happening.

KEPLER: In other words, an opinion about what is happening?

TYCHO: Yes, an opinion.

KEPLER: Your beloved Hippocrates said, “There are, in fact, two things, science and opinion; the former begets knowledge, the latter ignorance.” So, then, the question becomes, are we—but more specifically, you—a scientist at all?