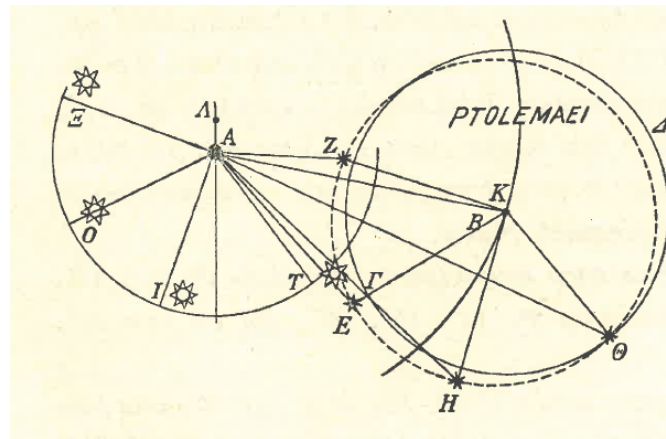


Bisected Eccentricity of the Ptolemaic Epicycle



That these characteristics belong to the Ptolemaic epicycle is properly demonstrated. But that they are carried over from the epicycle to the theory of the sun is shown by a probable argument only, pieced together from Ptolemaic opinions....

So by this reasoning even Ptolemy will be persuaded that $a\tau$, the eccentricity of the sun's motion found by Tycho, should be bisected at ξ , and the center of uniformity of motion at τ .

Now this argument in the Ptolemaic form (as I just now began to say) is no firmer than the Ptolemaic world system itself. For anyone who believes Ptolemy, thinking that for the three superior planets there are three theories of epicycles, exactly equal to the theory of the sun, in quantity and quality, in lines as well as motions, in absolutely all respects – this same person will not admit this one inconsistency, but will gladly derive the bisection, too, from the epicycle, transferring it to the solar theory as if from an image in a mirror to the face itself.

And, finally, when a comparison of hypotheses has been made, and it has appeared that four theories of the sun (or rather, six, as will be said elsewhere) can be generated from a single theory of the earth, like many images from one substantial face, the sun itself, the clearest of truth, will melt all this Ptolemaic apparatus like butter, and will disperse the followers of Ptolemy, some to Copernicus's camp, and some to Brahe's....

Let it be enough for now to present this form of demonstration in the three hypotheses. In what follows, whenever there is need of the same demonstration, I shall use Copernicus's form alone, it being the simplest, so as not to be long winded. Here, in contrast, the industrious reader has seen how any of these diagrams can be transformed into either the Ptolemaic or the Copernican form using parallel lines.

James R. Voelkel and Owen Gingerich

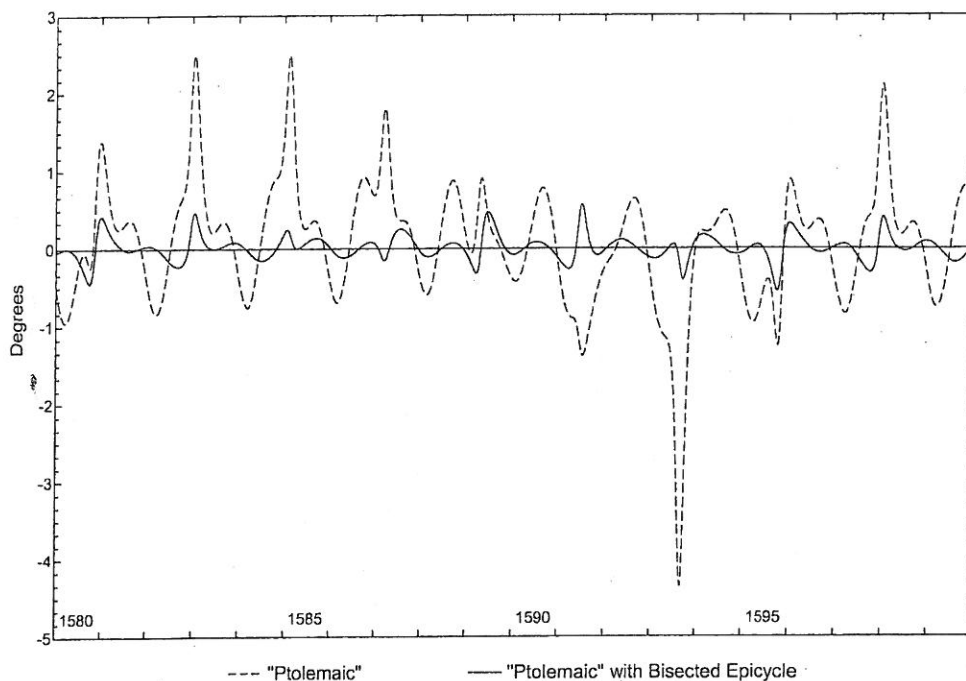


FIG. 4. Errors in geocentric longitudes of Mars, comparison of models with a Ptolemaic epicycle and with an epicycle with bisected eccentricity and non-uniform motion.

Let us now examine more closely the error in the Ptolemaic theory we introduced earlier. The Ptolemaic error pattern results from the multiplying effect of two independent error cycles, one arising from the representation of the orbit of Mars and the other from the representation of the orbit of the Earth. The former corresponds to the position of the epicycle centre on the deferent, and the error repeats with Mars's tropical period of 686.93 days. The latter corresponds to the position of Mars on its epicycle, and the error repeats with Mars's synodic period of 779.97 days. In 15 years, 8 integral tropical and 7 integral synodic periods will have passed, so the error pattern will repeat approximately. Indeed, this can be seen in our "Ptolemaic" error graph (Figure 4) where the first three peaks in 1580–81, 1582–83 and 1585 are repeated in 1595–96, 1597–98, and 1600. A more exact repetition occurs after 32 years, when 17 integral tropical and 15 integral synodic periods will have passed. Indeed, the catastrophic error shown in the graph at the time of the 1593 opposition, where Mars's predicted position is over 4° behind its true position, recurred 32 years later, in 1625. Kepler noted this striking error in the preface to the *Rudolphine tables*, ~~where he~~

Chapter 33: The Power that Moves the Planets Resides in the Body of the Sun

It was demonstrated in the previous chapter that the elapsed times of a planet on equal parts of the eccentric circle (or on equal distances in the aetherial air) are in the same ratio as the distances of those spaces from the point whence the eccentricity is reckoned; or, more simply, to the extent that a planet is farther from the point which is taken as the center of the world, it is less strongly urged to move about that point. It is therefore necessary that the cause of this weakening is either in the very body of the planet, in a motive force placed therein, or right at the supposed center of the world.

Now it is an axiom in natural philosophy of the most common and general application that of those things which can occur at the same time and in the same manner, and which are always subject to like measurements, either one is the cause of the other or both are effects of the same cause. Just so, in this instance, the intension and remission of motion is always in the same ratio as the approach and recession from the center of the world. Thus, either that weakening will be the cause of the star's motion away from the center of the world, or the motion away will be the cause of the weakening, or both will have some cause in common. But it would be impossible for anyone to think up some third concurrent thing which would be the cause of these two, and in the following chapters it will become clear that we have no need of feigning any such cause, since the two are sufficient in themselves.

Further, it is not in accord with nature that strength or weakness in longitudinal motion should be the cause of distance from the center. For distance from the center is prior both in thought and in nature to motion over an interval.... Therefore, distance will be the cause of intensity of motion, and a greater or lesser distance will result in a greater or lesser amount of time.