# Three Distinct "Working Hypotheses" at the Core of Ptolemaic Theory

---

1) **The Earth is motionless -- in particular, its location does not vary with respect to the stars along the zodiac over the course of the year.**

2) **All zodiacal motion -- that is, motion from one day to the next along the zodiac -- is centered around the Earth.**

3) **All real celestial motion is compounded out of uniform -- or at least equiangular -- circular motions.**

Evans –
pp. 355, 362, 368

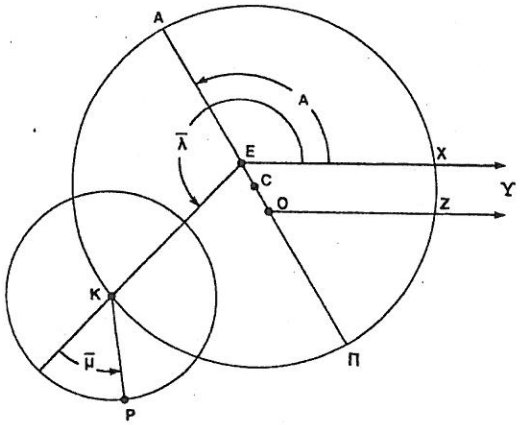


FIGURE 7.32. Ptolemy's final theory of longitudes for Venus and the three superior planets. The Earth is at *O*. *C* is the center of the deferent circle. But the epicycle's center moves at uniform angular speed as viewed from the equant point *E*.

How can we know how large a planet's epicycle is? How can we know how large to make the eccentricity? In this section we demonstrate how the parameters for a superior planet can be determined from observations. We use Mars as an example, but the same procedures could be applied to Jupiter or Saturn. Although the methods demonstrated here do not exactly follow those of the *Almagest*, they show, clearly and simply, the connection of each parameter with the observed motion of the planet. And who knows? It is more than likely that some such rougher method preceded the elegant perfection of Ptolemy.[71]

There are seven parameters to be determined:

1. The mean angular speed of the epicycle's center around the deferent circle—in other words, the rate of change of the mean longitude $\bar{\lambda}$ (see fig. 7.32). This angular speed we denote $f_\lambda$.
2. The angular speed of the planet on the epicycle. This speed, denoted $f_\mu$, is the rate at which the mean epicyclic anomaly $\bar{\mu}$ changes.
3. The longitude of the apogee of the deferent, denoted *A*.
4. The eccentricity of the deferent, denoted *e*. This is the ratio *OC*/*R*, or *CE*/*R*, where *R* is the radius of the deferent.
5. The initial value of $\bar{\lambda}$ for some specific date. This initial value will be denoted $\bar{\lambda}_0$.
6. The initial value of $\bar{\mu}$, which we will denote $\bar{\mu}_0$.
7. The radius of the epicycle, denoted *r*. All that matters in Greek astronomy is the size of the epicycle in relation to the deferent, that is, the ratio *r*/*R*.

TABLE 7.4. Modern Ptolemaic Parameters for Venus, Mars, Jupiter, and Saturn

| Planet | Mean Motion in Longitude $f_\lambda$ (°/day) | Mean Motion in Epicyclic Anomaly $f_\mu$ (°/day) | Radius of Epicycle *r* | Eccentricity *e* | At epoch January 0.5 GMT 1990 = J.D. 241 5020.0 | | |
|---|---|---|---|---|---|---|---|
| | | | | | Longitude of Apogee $A_0$ | Mean Longitude $\bar{\lambda}_0$ | Mean Epicyclic Anomaly $\bar{\mu}_0$ |
| Venus ♀ | 0.985 647 34 | 0.616 521 36 | 0.72294 | 0.01450 | 98°10′ | 279°42′ | 63°23′ |
| Mars ♂ | 0.524 071 16 | 0.461 576 18 | 0.65630 | 0.10284 | 148°37′ | 293°33′ | 346°09′ |
| Jupiter ♃ | 0.083 129 44 | 0.902 517 90 | 0.19220 | 0.04817 | 188°58′ | 238°10′ | 41°32′ |
| Saturn ♄ | 0.033 497 95 | 0.952 149 39 | 0.10483 | 0.05318 | 270°46′ | 266°15′ | 13°27′ |

General precession $f_p$ = 0.000 038 22°/day = 1°23′45″ per Julian Century = 0.838′ per year.

# Evidence for Ptolemaic Astronomy

- **Success in predicting salient phenomena: timing of stationary points, timing and extent of maximum elongations (Venus and Mercury), timing and shape of retrograde loops (Mars, Jupiter, Saturn), eclipses of Moon and Sun, and previously unrecognized inequalities in longitude of the Moon in quadrants and octants**

- **This success achieved by "theories" of the seven bodies, employing only five basic parameters (with a model in common for Venus, Mars, Jupiter, and Saturn), thus reducing multiple apparent degrees of freedom in the motions to just a few degrees of freedom in the "theories"**

- **The values of these parameters were determined by means of model-mediated measurements from observations that, when repeated at different times, kept yielding the same values to reasonably high precision, thereby providing evidence that the parameters are constants of nature**

***The combination of these, especially the stability over time of the model-mediated measurements of the parameters, gave evidence that there was something fundamentally correct in Ptolemaic theory, notwithstanding the existence of alternative models, by virtue of Apollonius's theorem, that achieve the same as above***