8.1: Introduction to Planetary Motions

The word "planet" means "wanderer" (πλάνητες αστέρες − wandering stars); in contrast to the "fixed stars", the planets wander around on the celestial sphere, sometimes moving from east to west and sometimes from west to east – and of course there are "stationary points" at the instants when their motions change from one direction to the other.

In this chapter, I do not attempt to calculate planetary ephemerides, which will come in a later chapter. Rather, I discuss in an idealistic and qualitative manner how it is that a planet sometimes moves in one direction and sometimes in another. That the treatment in this chapter is both idealistic and qualitative by no means implies that it will be devoid of Equations or of quantitative results, or that the matter discussed in this chapter will have no real practical or observational value.

I shall assume in this chapter that planets move around the Sun in coplanar circular orbits. Pluto apart, the inclinations of the orbits of the planets are small (Mercury is 7 degrees , Venus 3 degrees and the remainder are smaller), and if you were to draw the most eccentric orbit (Mercury's) to scale, without marking in the position of the Sun, your eye could probably not distinguish the orbit from a circle. Thus these ideal orbits, while not suitable for computing precise ephemerides, are not unrealistic for a general description of the apparent motions of the planets.

I shall assume that the angular speed of Earth in its motion around the Sun, relative to the stars, is $0.017\,202\,098\,95$radians per mean solar day, or $147.841\,150$arcseconds per mean solar hour. In this chapter I shall use the symbol ω_0 for this angular speed, though in many contexts it is also given the symbol k, and is called the gaussian constant.

It may be noted that the *definition of the astronomical unit* (AU) *of distance* is the radius of the orbit of a particle of negligible mass that moves around the Sun in a circular orbit at angular speed $0.017\,202\,098\,95$radians per mean solar day. In other words, the formal definition of the astronomical unit makes no mention of planet Earth. However, to a good approximation, Earth does move around the Sun in a near-circular orbit of about that radius and about that speed, and that is the assumption that will be made in this chapter. [In 2012, the International Astronomical Union redefined the astronomical unit as 149 597 870 700 m exactly, and they recommended the symbol au rather than AU. This makes no substantial difference to the content of this chapter.]

I shall also make the assumption that other planets move around the Sun in coplanar circular orbits at angular speeds that are proportional to $a^{-3/2}$ and hence at linear speeds that are proportional to $a^{-1/2}$, where a is the radius of their orbits. This is, as we shall describe in Chapter 9, Kepler's third law of planetary motion.