

How to cite this document:

Naṣīr al-Dīn al-Ṭūsī. *al-Risāla al-Muʿīniyya*, book 2, chapter 10. In F. Jamil Ragep, Fateme Savadi, Sajjad Nikfahm-Khubravan. *al-Risāla al-Muʿīniyya (al-Risāla al-Mughniya) and its Supplement*. Vol. II, *English Translation* (Tehran: Mirath Maktoob), 86–88.

CHAPTER TEN

An Exposition of Retrogradation and Direct Motion, and
Orientality and Occidentality

[1] Ptolemy stated in the *Almagest* that retrogradation of planets can be [explained] either by epicycle orbs or by eccentric orbs. Neither one makes any difference in the positions of these two orbs, on the condition that the ratio of the radius of the paretic orb to the radius of the epicycle be the same as [the ratio of the radius of the paretic orb to] the distance between the two centers on the assumption of the eccentric [orb]. And this [assumption] can be represented when the motion of the eccentric is assumed to be in the opposite direction to the motion of the paretic. Inasmuch as practitioners of this discipline have established the eccentric for another purpose, they have set the epicycle for [explaining] retrograde and direct motion.

[2] Now, if the motion of the epicycle center on the circumference of the deferent is more than the motion of the planet on the epicycle, the planet does not retrograde, but rather is faster in the half whose two motions are in the same direction, with a motion that is a combination of the two motions. In the other half, whose motion of the epicycle is counter to the motion of the center, it is slower by the amount of the excess of the motion of the center over the proper motion. This conception is what has been related for the Moon. If the proper motion with respect to the center of the World is additive to the motion of the center, as it is for the five planets, it follows that retrogradation occurs with respect to the center of the World in the half where the motion of the epicycle is counter to the motion of the center.

[3] In the *Almagest*, it has been proven that when a line goes from the center of the World to the epicycle orb and [then] passes through it, if half of the part [of the line] falling inside the epicycle to that falling

outside between [the epicycle] and the center of the World has the same ratio as that of the motion of the center to the planet's proper motion, then when it reaches that line in the opposite half, [the planet] will become stationary. In an area where the ratio of half the inside part to the outside part is less than the ratio of the motion of the center to the proper motion, the planet moves directly, whereas in the other area, where it is more, it retrogrades. So, there will be no retrogradation in any epicycle that has a ratio of its radius to the line between it and the center of the World less than the ratio of the motion of the center to the proper motion. In any epicycle where these two ratios are equal there will be a station but no retrogradation.

[4] Now that these preliminaries are understood, let us say that when these five planets move in the sequence of the [zodiacal] signs in the upper half of their epicycles, their speed at that time with respect to the center of the World is faster than the mean. When they pass that [half] reaching the mean distance of the epicycle orb, the [planets] descend on a straight line with respect to the center of the World; hence the motion of the epicycle is not perceptible, and the planet's motion is its mean motion. Thereafter, they move in the counter-sequence [of the zodiacal signs]; as long as their motion in the epicycle is less with respect to the center of the World than the motion of the center of the epicycle, their speed is slower but is still direct. When the two speeds are equal, the planet is stationary. When the speed of the planet on the epicycle overtakes the speed of the center, [the planet] retrogrades. When it reaches perigee, it will be at the midpoint of retrogradation. On the other side, as before, it will become stationary, then slow down, then be at mean speed, then speed up, and then at apex it will be in the middle of direct motion. Were it not for the motion of the center, the planet would retrograde for approximately a half, such that it would move in the counter-sequence [of the zodiacal signs] with respect to the center of the World. This is the situation of

retrogradation and direct motion.

[5] Since all the planets combust at the apex, the Sun overtakes the upper planets after combust; therefore, they rise before the Sun does. They are then called oriental [to the Sun] until there are 60 degrees between them and the Sun. When they reach near the Sun's trine, they become stationary. Then they retrograde, and, at the midpoint of retrogradation, which occurs at perigee, they will be in opposition to the Sun. After that, near the second trine, they become stationary, and then they move directly. When there is less than 60 degrees between them and the Sun, they set after the Sun and are occidental [to the Sun] until they reach the Sun at apex.

[6] When Venus and Mercury pass the apex, they precede the Sun and therefore set after it does. They are then called occidental [to the Sun] until they reach *ribāt-i aʿzam*, which is the maximum distance, and there their speed is slower. Thereafter they retrograde, and at the midpoint of retrogradation they reach the Sun. This is the second combust, which occurs at perigee. When they pass beyond, they will rise before the Sun and become oriental [to the Sun] and again move directly. When they reach the maximum distance, their speed increases until the initial state of affairs is reached. In one half of their cycle they are occidental [to the Sun], and in the other half they are oriental [to the Sun], [the halves being] opposite to those of the upper planets—God is all-knowing of the Truth.

CHAPTER ELEVEN

An Exposition of Parallax of the Lower Planets

[1] Since the positions of the planets on the zodiacal orb are determined by the line that passes from the center of the World through the center of the body of the planet and reaches the surface of the sphere of the zodiacal orb, the line that reaches the planet and the