How to cite this document:

Naṣīr al-Dīn al-Ṭūsī. *al-Risāla al-Muʿīniyya*, book 4, chapter 6. 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), 146–147.

size is 84+$\frac{1}{4}$+$\frac{1}{8}$ times [the size of] the Earth.

[9] Saturn: The [proportional] difference between its diameter at the farthest and nearest distances is as 1 to 1+$\frac{2}{5}$. When Jupiter's farthest distance is multiplied by this amount, it becomes 19,835, which is Saturn's farthest distance. According to this standard, the mean distance is 17,001. Thus, the mean distance is 44,909,818[1] miles and the farthest distance is 75,730,030 miles. [The ratio of Saturn's apparent size] to the Sun, when both are at mean distance, was found to be as $\frac{1}{2}$ of $\frac{1}{9}$. Saturn's mean distance was divided by 18, resulting in 944+$\frac{1}{2}$. [This] was divided by 218—the [standard measure in] parts of the Earth—resulting in 4+$\frac{1}{3}$. Therefore, the Earth's diameter to Saturn's diameter is 1 to 4+$\frac{1}{3}$. When both amounts are cubed, it will be found that [the ratio of] the Earth's size to Saturn's size is as 1 to 81+$\frac{1}{5}$+$\frac{1}{6}$.

CHAPTER SIX
On Determining the Distance and Sizes of the Fixed Stars

[1] Since all the fixed [stars] had been placed on one orb, their distance was taken to be the same distance, which is equal, according to the aforementioned standard, to Saturn's farthest distance. This [distance] has already been given in terms of the Earth's radius and in miles; in parasangs it is 25,243,343 parasangs. This is the limit of the distance of bodies for which humans have a way to know. When they considered the sizes of the [fixed stars], they classified them into six magnitudes, as has been stated, such that a star of the first magnitude is taken to be, for example, [the size of] a *dirham*, and that of the sixth magnitude to be [the size of] a *dāng* [i.e., one sixth of a *dirham*], according to this standard. This is only an extremely approximate estimation.

1. The correct number should be 64,909,818.

[2] The [apparent diameters of] stars of first magnitude were compared to [that of] the Sun at mean distance. The [ratio] of the most average [first magnitude] star in size to the [Sun's apparent diameter] has been found to be 1 to 20. They [then] divided Saturn's farthest distance by 20, the result being 991+$\frac{3}{4}$. [When] this was divided by 218, 4 parts and 33 minutes was obtained. Therefore, the Earth's diameter to the diameter of the largest stars is as 1 to this amount. When both amounts are cubed, [it is found that] the Earth's size to the size of any of these stars is as 1 to 94+$\frac{1}{5}$. Therefore, the largest of the fixed [stars] is 94+$\frac{1}{5}$ times the Earth. Dividing this amount by 6 gives the difference between each magnitude and another [i.e., the next]; thus, stars of the sixth magnitude are approximately 16 times the Earth, and stars of the fifth magnitude are twice this amount, and so on.

[3] This distance and size that has been calculated for any of the fixed stars is according to [the assumption of] being at the farthest distance of Saturn; if, however, they are farther, both their sizes and distances are greater, and under any assumption they cannot be less than that. From these chapters, it has become known that the smallest of the bodies is Mercury; larger than [Mercury] is the Moon, then Venus, then the Earth, then Mars, then [fixed] stars of the sixth magnitude, [then] the fifth [magnitude], then Saturn, then Jupiter, then stars of the first magnitude, and then the Sun. In conclusion, among the celestial bodies, the greatest is the Sun. These aforementioned distances were based on Ptolemy's reckonings. If desired, they can also be determined based on the reckoning of the moderns according to the preceding [method]—God is all-knowing.