Islamic Reactions to Ptolemy's Imprecisions

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Consider the following quotation from the author of the treatise *Fī sanat al-shams* ("On the Solar Year"), most likely written in Baghdad in the first part of the ninth century:

> Ptolemy, in persuading himself that the period of the solar year should be taken according to points on the ecliptic, also persuaded himself as to the observations themselves and did not in reality perform them; coming from his imagination, this was of the greatest harm for what was described for the calculations (Morelon 1987, p. 61; my translation).

Or the following from Ibn al-Haytham in the eleventh century:

> When we investigated the books of the man famous for his attainment, the polymath in things mathematical, he who is [constantly] referred to in the true sciences, i.e. Ptolemy the Qlūdhī, we found in them much knowledge, and many things of great benefit and utility. However when we contested them and judged them critically (but seeking to treat him and his truths justly), we found that there were dubious places, rather distasteful words, and contradictory meanings; but these were small in comparison with the correct meanings he was on target with (Ibn al-Haytham 1971, p. 4).

As the quotation from Ibn al-Haytham indicates, there was a real ambivalence towards Ptolemy among Islamic scientists. Widely respected, he was held by many of them to be a paragon of the mathematician whose truths transcended cultural and religious difference. And yet it was also clear that there were many flaws in his various works, many of which were puzzling and led to a variety of doubts (*shukūk* [ἀπορίαι]). There has been a great deal written in recent years about the doubts regarding his models. (For a summary, see Sabra 1998). In this paper, I would like to turn to another aspect of the Islamic doubts toward Ptolemy and other Greek astronomers, namely observations.

For quite some time, I have had the impression that there is a significant difference between the types of observations one finds in antiquity and those one finds in the Islamic world, beginning sometime in the early ninth century during the ʿAbbāsid period. In what follows, I shall first try to give a sense of the differences by providing some examples. I will then try to characterize these differences. And lastly I will provide some reasons, admittedly speculative, that might account for these differences.

Before continuing, let me explain a few terms that I will be using. By *exact methods*, I mean those mathematical and observational procedures that could potentially lead to accurate results. By *accurate results*, I mean those that are in accord with modern values. Now exact methods may or may not lead to accurate results, depending on the underlying mathematical and observational tools that are used. Results may be *precise*, i.e. to several digits, without being accurate, since many of these digits could be spurious, i.e. the result of carrying out calculations to a greater precision than supported by the original data or measurements. In order to determine accuracy, one needs to engage in *testing*, i.e. checking received values by some means to determine their accord with newer observations or theories. I distinguish between *confirmation* of earlier parameters or results that leads to the acceptance of a received value, and the testing of parameters or results that may or may not lead to the revision of those values. (I'll have more to say about this later.)

Let us take as our first example the measurement of the size of the Earth.

The Measurement of the Earth

There is a heroic story that is well-known in the secondary literature about the early measurements of the Earth. Eratosthenes (3rd c. BCE), head of the library of Alexandria, is said by Cleomedes (1st c. BCE) to have measured the size of the Earth using a simple but effective means (see Fig. 1). This consisted of taking a known distance along a meridian in linear distance, finding its equivalent angular distance, and then setting up a proportion that would yield the meridional circumference. Eratosthenes is said to have taken the linear distance between Alexandria and Syene (modern day Aswan) to be 5,000 stades, and he found the angular distance to be 1/50 of a complete circle. In addition, Eratosthenes evidently made the following assumptions:

(a) Syene is on the tropic of Cancer, so there would be no shadow cast by the Sun at noon on the day of the summer solstice.
(b) The Sun is at an infinite distance, so all its rays are parallel.
(c) Alexandria and Syene are on the same meridian.