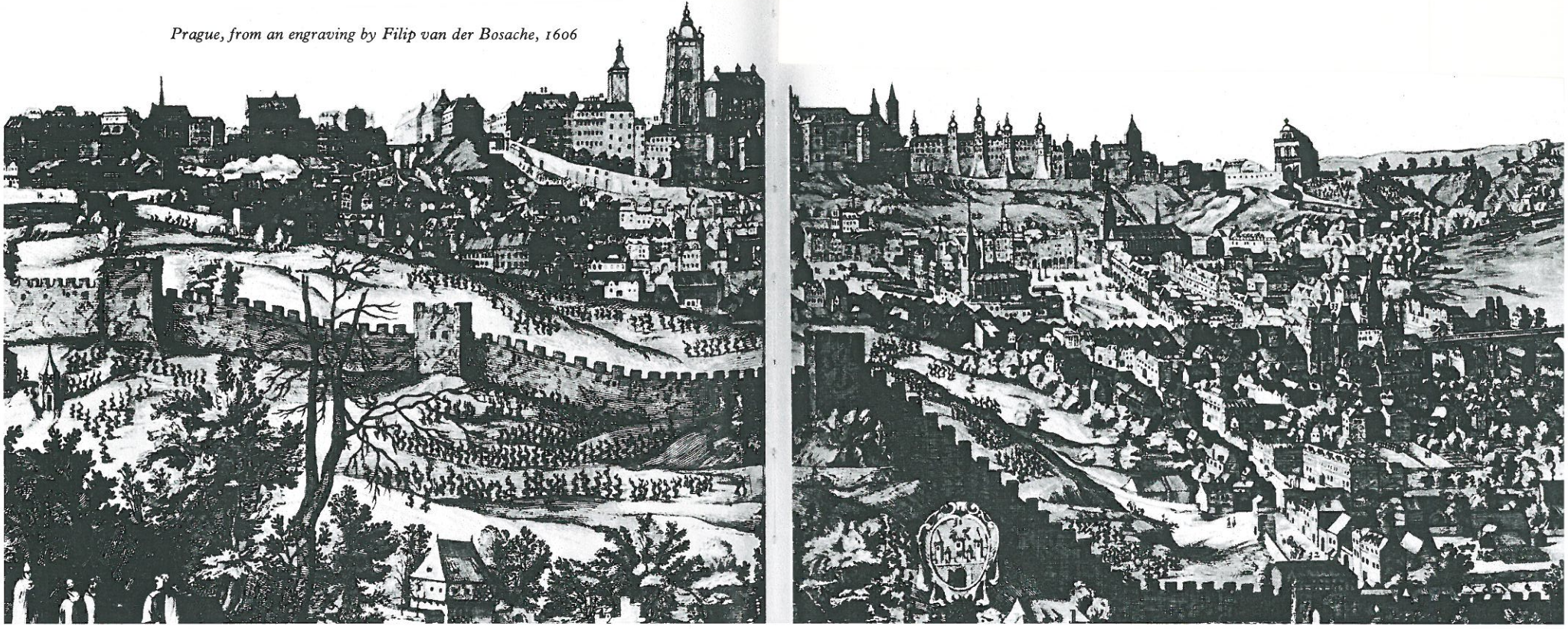
Prague, from an engraving by Filip van der Bosache, 1606



THE STATE OF MATHEMATICAL ASTRONOMY CA. 1600

Fact: The retrograde loops exhibited by the planets -- the so-called "second inequality" -- are attributed to entirely different sources in the Ptolemaic, Copernican, and Tychonic systems, yet all three systems can be made to yield the same predictions of longitude.

Can any empirical considerations establish any one of these three approaches to the second inequality, or still some further approach, over the others?

Fact: The longitudes calculated within the systems that have been worked out in detail -- the Ptolemaic as specified in the Alphonsine tables and the Copernican as specified in the Prutenic tables -- often differ from observation by more than a degree (two Moon diameters) and sometimes by much more.

What should be made of these discrepancies, and (for that matter) what level of agreement with observation is it appropriate to demand from any such calculation system?

Fact: The equant employed by Ptolemy and the minor epicycle employed by Copernicus to account for part of the apparent changes in speed of the planets -- the so-called "first inequality" -- make entirely different claims about the trajectory associated with the apparent changes in speed.

Can any empirical considerations establish what the trajectories are and how they contribute to the apparent changes in speed?

Fact: The contrasting approaches taken to calculating the latitudes of the planets by the Ptolemaic and Copernican systems are both very complicated, yet each yields discrepancies with observation that often exceed 1 degree even though the greatest latitude any planet reaches is but a few degrees.

Given the lack of patterns in the observed latitudes -- i.e. the absence of anything so well behaved as the first and second inequalities -- how can empirical considerations be marshalled to improve the calculation of latitudes?

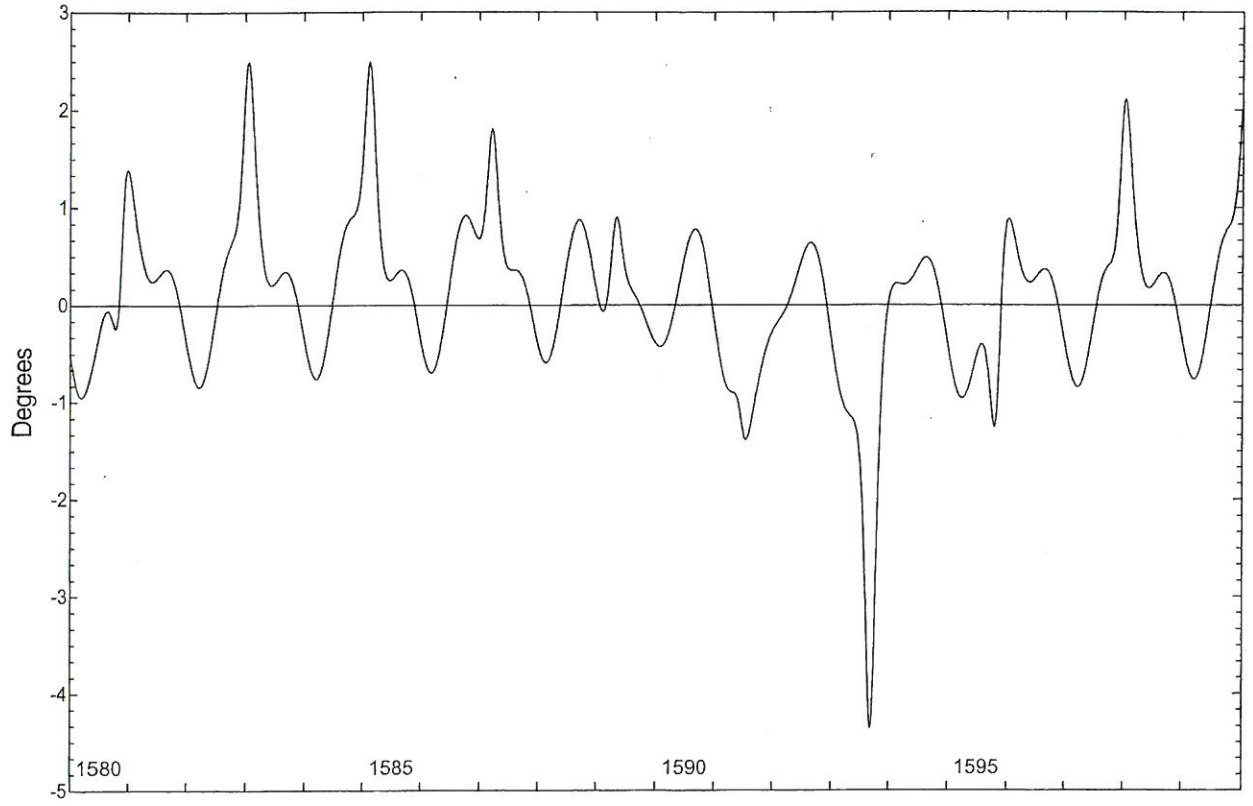


FIG. 1. Errors in geocentric longitudes of Mars from a Ptolemaic model with best parameters.

A Commitment Made by Some

In the case of questions about the empirical world, the empirical world itself should be the ultimate arbiter

***But how are questions to be resolved in a principled way on the basis of empirical information given the omnipresent problems of separating appearance from reality, especially as highlighted by Copernicus*?**

Aspects of the challenge in orbital astronomy:

1. **Observations can be made only from the Earth, yet the primary questions concern motions relative to the fixed stars.**

2. **Insofar as the observed changes in motion can be represented geometrically in multiple ways, need some other way to identify which are real.**

3. **Unable to conduct experiments – i.e. to intervene – unclear how to gain empirical access to the physics of the celestial realm.**