

## Theory of Comets, 1618-1627

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Questions about the nature and location of comets had not been definitively decided by 1618, a year marked by a succession of three comets visible to the naked eye, culminating in the great comet of 1618. These events resulted in the publication of multiple treatises about comets by numerous observers, not the least being those of Libertus Fromondus, the Jesuit Horatio Grassi, and Galileo, responding to Grassi, in defense of his own position, as elucidated by his disciple, Mario Guiducci. I discuss Fromondus' critique of the Aristotelian account of comets, which causes him subsequently to reject Galileo's explanation as well; I comment as well on the treatment of comets by historians and philosophers of science.

In his treatise, Fromondus argues that the comet of 1618 is not a fiery exhalation: because of (i) the height of such exhalations, (ii) the nature of fire, (iii) its lack of scintillation, (iv) its motion, and (v) its tail. The interesting thing is that the five arguments are alike in that they are all basically Aristotelian arguments employed to attack an Aristotelian conclusion; Fromondus uses some entrenched Aristotelian principles against the Aristotelian conclusion that comets are terrestrial exhalations. Having, from his own perspective, demolished Aristotle's account of comets based on the Aristotelian theory of elements and their motions, Fromondus proceeds to construct a new account of comets. For Fromondus, as it was for Tycho, superlunary comets count against the solid spheres and for fluid planetary heavens. Fromondus rehearses a possible "Copernican" plurality of worlds explanation of comets as planetary exhalations arising from planets viewed as systems of elements, on analogy with the elements around our earth, but rejects the hypothesis for a simpler one, in which comets originate out of ethereal matter. Comets, then, are formed through condensation or rarefaction of celestial ether, coagulated for various lengths of time; they are like planets wandering above the sphere of the moon, describing a circular motion.

Not everyone took the route followed by Fromondus. For example, the Paris mathematician Jacques du Chevreur maintained a more traditional Aristotelianism, and even though he accepted the new astronomical observations, he rejected both the Copernican system and Tycho's solution. One might even count Galileo and his disciple Guiducci among the traditionalists, or at least among Tycho's opponents, about comets. Horatio Grassi, a Jesuit astronomer, wanted to argue against Aristotle based on the lack of observable parallax for the comet of 1618. Galileo and Guiducci disputed his findings, contending that one cannot use the parallax of a comet to calculate its location: "Whoever wishes the argument from parallax to bear upon comets must first prove that comets are real things." For Galileo and his disciple, parallax is a valid method only when one has a real and permanent object; for example, one cannot use the parallax of a rainbow to calculate its location. Thus, the parallax of a comet (or its lack of parallax) cannot give us its supra-lunary location and is not evidence for concluding that the Aristotelians are wrong (or for concluding further that there is an imperfect terrestrial object in the heavens) unless, of course, we had previously accepted comets as objects whose nature is terrestrial, and not meteorological phenomena or mere appearances. Galileo in 1623 proposed that comets are luminous reflections of atmospheric exhalations, an account similar to the one he had proposed in 1606 and similar to the Aristotelian account: "The substance of the comet ... may be believed to dissolve in a few days, and its shape, which is not circularly bounded but confused and indistinct, gives us an indication that its material is more tenuous than fog or smoke."

In his *Meteorology* (1627), Book III, *De Cometis*, Fromondus rejected Galileo's account and argued for the Anti-Aristotelian view that some comets are supra-lunar. There Fromondus repeated the arguments from his shorter 1618 tract, with a few interesting changes. Fromondus argues that some comets are celestial but also allows that some are sublunary. Thus there are two kinds of comets: those generated in the heavens, that share the motion and matter of the stars, and others that are sublunary and drawn from terrestrial elements. Fromondus is clear that many comets have a smaller degree of parallax than that of the moon; thus comets move among the stars. He describes in detail the argument by Galileo and Guiducci against the use of parallax for measuring the distance of comets. As he explains it, positional visual phenomena such as parhelia, halos, and rainbows are to be located below the heavens next to us but evince no measurable degree of parallax. Comets, then, could have no measurable parallax and still be some kind of terrestrial exhalations in the sublunary region. Fromondus understands that this is the conclusion of Guiducci and Galileo, but he rejects it. He notes that comets are not visual phenomena but lucid bodies like stars, and that they frequently move from place to place, from South to North and vice versa—that which a mere positional appearance could not do. Fromondus revisits the opinion of Guiducci and Galileo that comets are terrestrial exhalations in his chapter on the matter of comets. Against their view, he repeats his analysis from 1618 that such exhalations climbing so high would become so rarified that they would become invisible. Moreover, in his chapter on the motion of comets, Fromondus argues that terrestrial exhalations do not have the lengthy motions exhibited by comets; if Galileo and Guiducci were right, the proper motion of comets above the moon would measure only one or two degrees of arc for the whole of their duration.

Fromondus made significant modifications to his Aristotelianism to accommodate astronomical novelties such as supra-lunar comets. While he could be thought as a normal scientist, he made changes that went well beyond what could be described as the articulation of the Aristotelian paradigm (or exemplar) or as part of the sequence of theories in the Aristotelian "research programme."