

Book Review

Maurice A. Finocchiaro. 2010. *Defending Copernicus and Galileo: Critical Reasoning in the Two Affairs*. Boston Studies in the Philosophy of Science Vol. 280. New York: Springer. (Pp. xlii, 1–350. Hardcover. ISBN: 978-90-481-3200-3. US \$139)

In *Defending Copernicus and Galileo*, Maurice A. Finocchiaro offers a defense of Galileo against both the charges of his official trial and the charges of subsequent philosophers, historians, and theologians that extend until the present day. In doing so, Finocchiaro displays the richness of the two Galileo affairs. The first affair consists of Galileo's defense of Copernicanism from his early work in mechanics through his trial, and the second consists of the analysis and evaluation of the first affair in the four centuries since. The aims of the book are three. First, Finocchiaro aims to display the importance of critical reasoning—of offering arguments, developing objections, and responding to criticisms—in both affairs. Second, he aims to defend Galileo by showing that Galileo's defense of Copernicanism is, though mistaken in some areas, more right than wrong and thus ultimately successful. Third, Finocchiaro aims to adopt Galileo's approach to critical reasoning to defend Galileo from anti-Galilean criticisms that have emerged since the trial. This Galilean approach to argumentation is characterized as reasoned, critical, fair-minded, and open-minded. The ensuing defense of Galileo generates discussions of scientific reasoning, epistemology, metaphysics, and theology. This great breadth of coverage along with the clarity that Finocchiaro brings to all of these issues makes *Defending Copernicus and Galileo* not only a significant contribution to Galileo scholarship but also an ideal point of entry to the field for the non-specialist.

After a careful preface and introduction that outline the author's aims in some detail, the book follows in two parts. Part I presents Galileo's defense of Copernicus against a host of objections to the geokinetic thesis that were known to Galileo. These objections include empirical concerns, worries from Aristotelian physics, and theological criticisms. Finocchiaro presents a careful analysis of these objections and Galileo's own responses to them. Finocchiaro does not attempt to show that Galileo is flawless in his defense. Instead, he demonstrates that Copernicanism can be defended on the same general lines advanced by Galileo even if Galileo was mistaken on some of the specifics. Aside from treating historical and evaluative issues that arise from Galileo's defense of

Copernicanism, Part I includes: a concise introduction to the geostatic cosmology that is second to none (Ch. 2), the use of Galileo's early assessment of Copernicanism to evaluate the claims of contemporary philosophers of science about theory selection (Ch. 3), a discussion of the distinction between mathematical, physical, and physical-mathematical reasoning (Ch. 5), and a nuanced treatment of the complementary roles of reasoning, criticism, and instrumentation (Ch. 6).

The lengthy discussion of the objection to the geokinetic theory from "the extruding power of whirling" (p. 97) is perhaps the best example of Finocchiaro's balanced approach to defending Copernicus and Galileo. The objection from the extruding power of whirling is based on what we now call centrifugal force. Objectors to the geokinetic theory claimed that if the earth were indeed rotating, then there would be an extruding power tending to expel objects from the surface of the earth. Since this extruding power was known to be proportional to linear velocity and since the linear velocity at the earth's surface is very large, it was claimed that every object on earth would be flung into space. Since objects are stable on the earth's surface, the earth must not be in motion.

Finocchiaro displays both the merits and mistakes of Galileo's response to this objection. In short, Galileo acknowledges the truth of the conditional claim that if the earth were rotating, there would be an extruding power tending to expel objects from the surface to the earth. He even notes a weakness in the standard formulation of the objection and subsequently reformulates the objection to make it stronger than any that had previously been stated. In so doing Galileo exemplifies his fair and open-mindedness. To this clarification, Galileo adds three criticisms of the objection. First, he notes that this extruding power is opposed by the force which draws objects on the surface of the earth towards the earth's center. Rather than carefully calculating the relative magnitudes of these forces, Galileo estimates that the extruding power is 1000 times weaker than its opposing force: a calculation later completed by Christian Huygens and Isaac Newton both of whom demonstrated that the gravitational force is 289 times that of the centrifugal force (p. 103). So though his estimation was off by nearly an order of magnitude, Galileo's criticism was essentially correct.

Galileo's second criticism comes in the form of a geometric proof to show that no rotating sphere could rotate fast enough to expel objects from its surface. While critics regularly point to this proof as invalid, Finocchiaro notes a crucial ambiguity in the conclusion of the proof which critics of Galileo have ignored. On one reading of the conclusion, the argument is invalid. On another, the argument is valid but not sufficient to refute the criticism from the extruding power of whirling. The geometric proof is flawed in ei-

ther case. But this reasoned, critical, open-minded approach bears fruit by opening new lines of inquiry into Galileo's defense of Copernicanism.

Finally, Galileo claims that the extruding power does not vary only with linear velocity as the initial objection assumes. He claims instead that the extruding power is also inversely proportional to the radius of the motion. Since the earth's radius is so large, the extruding power is small even though the linear speed at the earth's surface is significant. Here Galileo's insights and oversights are clear. He is correct that linear speed is not the sole determinate of centrifugal force and thus his criticism of the objection from the extruding power of whirling is essentially correct. But Galileo incorrectly claims that the extruding power is proportional to the linear speed divided by the radius. In fact, the centrifugal force is proportional to the linear speed squared and inversely proportional to the radius of motion.

Such a fair, critical, reasoned treatment of Galileo is a prime case of Finocchiaro employing the Galilean approach to critical reasoning. By laying all of the mistakes in Galileo's arguments alongside his successes, we see that Galileo offers all the pieces necessary to successfully respond to the criticism from the extruding power of whirling. Finocchiaro is thus successful not only in defending Galileo but also in demonstrating the fecundity of the Galilean approach to critical reasoning.

In Part II of the book, Finocchiaro turns from Galileo's defense of Copernicus to the defense of Galileo. This includes both the criticisms leveled at Galileo during his trial and the subsequent criticisms of historians, philosophers, scientists, and theologians that have emerged since Galileo's conviction on vehement suspicion of heresy. Here Finocchiaro continues his efforts to show that Galileo can be defended from these criticisms and does so by employing Galileo's own reasoned, critical, open-minded, and fair-minded approach. Part II commences with a concise overview of the events of Galileo's trial (Ch. 7) which is a prelude to the lengthy historical survey of arguments and counter-arguments about Galileo's trial which constitute the second Galileo affair (Ch. 8). The historical material here is vast and Finocchiaro does well to focus only on issues relevant for assessing four prominent criticisms of Galileo.

The first of the four criticisms considered by Finocchiaro (Ch. 9) is that, though Galileo was correct in concluding that the geokinetic hypothesis was true, he made substantial logical and methodological errors in defending this thesis and these errors were sufficient to warrant his condemnation by the Inquisition. Here Finocchiaro's historical acumen yields its greatest rewards as he disambiguates the formal charges brought against Galileo at trial and

convincingly shows how proper understandings of the *Dialogue Concerning the Two Chief World Systems* and the *Letter to Grand Duchess Christina* reveal that, though Galileo did make several minor errors, his primary reasons for defending the geokinetic hypothesis were cogent and his scientific and theological methodologies were justified.

The second criticism considered is that Galileo was convicted because he used scripture to support the truth of an astronomical claim (Ch. 10). Finocchiaro labels this a “myth” and traces its origin, spread, and development. This leads through a complex historical episode including forged letters and outright fabrications that were instrumental in convincing a sizable group of scholars that Galileo believed scripture authoritative on astronomical matters when he maintained exactly the opposite.

Pierre Duhem’s influential claim that the trial of Galileo was a tragic clash brought on by a faulty realist epistemology is the third criticism considered (Ch. 11). Duhem claimed that had Galileo been an instrumentalist—someone who believes that scientific theories are not attempts at true descriptions of reality but are instead useful formalisms for organizing phenomena—then he would never have asserted the truth of Copernicanism and would never have come under the scrutiny of the Inquisition. Here again Finocchiaro combines historical and philosophical prowess. He first shows how Duhem has conflated several important philosophical distinctions under his realism/instrumentalism distinction. Once the proper distinctions are made, Finocchiaro presents the relevant historical evidence to make clear that Galileo was not committed to an epistemology that both demanded and promised demonstrative certainty to establish the truth of Copernicanism as is often claimed.

The final criticism considered deals with the place of Galileo’s trial in the debates over the relationship between science and religion (Ch. 12). The commitment to Galilean critical reasoning is as clear here as anywhere. The central targets include both Pope John Paul II and the philosopher of science Paul Feyerabend. The former claimed that the trial of Galileo is a case-study in the harmony between science and religion and Galileo a hero for this cause while the latter offers a distinctive account of how science and religion came into conflict at Galileo’s trial. Finocchiaro is critical, fair, and open-minded in his approach to these competing claims. In John Paul II’s harmony thesis, Finocchiaro finds an accurate description of Galileo’s views but a dismissal of the hostility of many church leaders toward those views. In Feyerabend’s conflict thesis, Finocchiaro finds an historically untenable description of the trial but an example of the innovative turn in Galileo scholarship of the past century where less plausible views of earlier scholars are modified in ways which further illuminate both Galileo affairs.

In summary, Maurice A. Finocchiaro's *Defending Copernicus and Galileo* is a significant scholarly achievement. It is a model for historians of philosophy in that it combines historical erudition with penetrating philosophical analysis. Finocchiaro's arguments are compelling, his writing lucid, and his coverage well-focused. This is material that philosophers of any specialization can find stimulating and it is handled in a manner that is, as intended, a fine example of reasoned, critical, fair-minded, and open-minded scholarship.

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