What are Aristotelian natural motions? How did post-Copernicans come to reject this concept? What is gained and what is lost in this rejection of natural motions?

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1 Thesis

I will argue that from the emancipation of Aristotelian natural motions, there is a loss of metaphysical hierarchy and bias in the conception of space (and thus cosmology), and at the same time took part in the eventual overthrowing of the Peripatetic methodology and doctrine in philosophical thinking and reasoning at the time. This leads to a freer mode of thinking for the concept of space, which helped (re)-introduce mathematical and mechanistic elements as part of a revival of the Platonic and Atomist methodology.

(**L**) (P1) There is a loss of metaphysical emphasis on *telos*.
(P2) A gain in new methodology in attempts to reject/replace natural motions.

(C) My thesis.

2 Introduction

3 Aristotelian natural motions

In Aristotle's *Physics*, natural motions were those which bodies exhibit naturally, without any "constant action of an external agent".[1] To determine natural motions, according to Aristotle, one considers the composition and proportion of the four terrestrial basic elements (earth, air, fire, and water). Each element had its own natural place to which they move with their natural motions. The heavier an element is, the closer it is to the centre of the universe, while the lighter an element is, the natural place is found closer to the edge of the universe (Aristotle's universe was finite). Earth's natural place is at the centre, as it is the heaviest element, so its natural motion is downwards; while for fire, it is upwards. Therefore, all terrestrial elements move in vertical, straight lines. The heavenly

[1] Cushing 1998, p. 18.

element, aether, had its natural motion associated with uniform circular motion, because the heavens must be eternal and perfect.

Aristotelian philosophy was endowed with ontological explanation (in comparison to Atomists' physical character or Platonists' mathematics)[2] and full of dual concepts, notably potentiality-actuality, matter-form. This is central to understand why bodies move towards their natural place. Once reached, bodies are in full actuality and remain there— while moving towards their natural place, they still have potentiality and must continue to move. In Aristotle's *De Caelo*, the universe is an organism, not in the literal modern sense, but as a way to explain that because all bodies have a goal (the final cause, or *telos*, one of the Aristotle's four causes, the rest being material, formal and efficient) and all bodies tend towards their natural goal, there must be inherent "directional tendencies" for all matter in the universe.

4 Post-Copernican rejection of natural motions

Aristotle's metaphysics and physics posed many problems and both pre- and post-Copernican figures have extensively dissected and attempted to solve these problems. With this in mind, I can only discuss one notable argument that lead to arguably the most compelling rejection of natural motion, an argument put forth by Galileo. That is to say, what Galileo rejected was more subtle than the entire Aristotelian concept of natural motions. He wanted to challenge the dogma that a body will fall with a rate proportional to how heavy it is,[3] i.e. much earth it comprises (I use the term *weight* henceforth to denote heaviness). The argument is laid out as follows:

A lighter body m falls with velocity v, while a heavier body M falls with velocity V. The connected body $(m + M)$ falls with velocity v'. Now, here are the inequalities entailed by Aristotle's physics: $m < M$ (with respect to their weights), so $v < V$. Consider the joint body—since m contains less earth, it should retard M, thus $v < v' < V$ (conclusion A). At the same time, $(m + M) > M$, so it follows that $v < V < v'$ (conclusion B). But A and B contradict *a priori*, except in the case where $v = V = v'$ (conclusion C). However, Aristotle's physics maintained as fact that $v < V$, and as a result, Galileo's argument, a *reductio ad absurdum*, shows that one must refute Aristotle's statement stated above via sound mathematical deduction.[4]

Consequently, if a body's heaviness (W) does not affect the degree of tendency (s) it has to reach its *telos*, then this is a result of faulty metaphysics on Aristotle's part. The variant between W and s does not exist, so a body does not fall (faster) because it has (more) earth, i.e. the addition of earth m does not result in increased rate of fall. The metaphysical implication of this refutation meant that Aristotelian natural motions and places would have to be given up.

While this argument is compelling on its own, Galileo, influenced by "impetus theory" of Philoponus, also developed a system to describe the kinematics of projectile motion that also stripped away the *organismic* element in which natural motions found its roots,

[2]Jammer 1954, p. 69.
[3]Cushing 1998, p. 81.
[4]Ibid., p. 82.

and furthered the necessity to move away from this Aristotelian doctrine. I cannot go into depth, but consulting the critique from Philoponus alone; the cause of natural motion is found not within space, but by the agent to the body, and thus inherent in the moving body (which "shows a remarkable resemblance to the gravity suggested by Copernicus"[5]). EXPAND THIS?

5 Losses

By accepting this rejection, the entire body of Aristotelian metaphysical doctrine could be brought under scrutiny. Those who held onto the shaky foundations of his theories did so not out of philosophical justification but was a matter of theological power struggle. Nevertheless, what was challenged was not only the philosophical soundness the powerful Aristotelian authority could employ to push their dogmatic scripture and religious orthodox, but also the metaphysical emphasis on *telos*. I shall argue now how this is loss with the rejection of natural motions.

First, how can the role of *telos* be emphasised if matter, being composed by smaller earth elements which all individually express the urge to seek its natural place, no longer varies with the rate taken to reach its goal? If mechanistic and mathematical relations can describe the motion of a projectile, in the case of Galileo, or the world-system, in the case of heliocentric overturn of natural places, better than Aristotle's theories, then where is the causal role of *telos* in nature? Although theistic and mystic elements have yet to leave natural philosophy (even Newton's conception of space was religiously motivated, as he was influenced by the work of H. More CITE) until the logical positivist revolution took over the domains of natural philosophy (the view that statements can only have meaning if they can be demonstrated through direct observation or lgoical proof), *telos* as a final cause did not find itself revived in the post-Copernican theories. Take Galilean invariance—physical laws are unchanged in two systems with relative motion between each other—which Descartes fully fleshed out in his mechanistic natural philosophy as the first law of motion (QUOTE and CITE), this would seem to imply that the degree of *telos* is changed under a simple Galilean transformation between frames of reference. Consider a barrel next to me, both on a moving ship, would appear stationary in my frame (it has reached its natural place), but indeed is moving at the ship's speed with respect to the waves (which might have some vertical motion), and the waves at some relative speed with respect to the earth (which moves in a complex manner, a combination of both vertical and horizontal), so on and so forth. So with each subsequent transformation, the rate at which the barrel travels to the centre of the universe is different, implying either that its matter has to be changing (which is not), or that its *telos* is. As the final cause, however, *telos* ultimately emenates from the Prime Mover, which is the teleological divine entity responsible for world order. The Prime Mover is absolutely actual and never potential, thus cannot change.

What's more, even though Leibniz came the closest to the Aristotelian concept of hylomorphism (duality of matter and form) by imbuing material bodies with *vis viva*—the

[5]Jammer 1954, p. 57.

quantity mv^2 known otherwise as living force—even such a quantity is to be determined from another mechanistic quantity: velocity squared (mass m here is left open for interpretation; Leibniz's monadic philosophy will not be discussed here, but it was likened to Atomism (CITE JAMMER) rather than Aristotelianism or Scholasticism). The causal nature of *telos* was nowhere to be found. For many of these theories, there is a shift in nature, from being organismic to being mechanistic,[6] and the four causes collapsed to just one efficient cause. While it is possible to provide more accounts of new, non-Aristotelian metaphysical foundations, I hope this is ample evidence to show that the concept of *telos* was buried alongside natural motions.

6 A shift in methodology

I shall argue now that the departure of natural motions meant space is now open to new physical and metaphysical foundations, leaving room for a gain in better physical methodology, and indeed such a gain was observed.

However, I wish to exercise my attempt carefully as to avoid sweeping generalisations. First, this gain in new methodology is not the same as but definitely affected by the loss of long-standing metaphysical bias demonstrated in Section 4. The reason why these are not the same arises from the fact that not long before the modern physics we know of today, science and theology were intertwined (even Newton's conception of space was his only religiously-biased one), therefore any figure post-Copernican who proposed new physical theories in place of natural motions will replace its metaphysical groundings with something else. Now, whether this "something else" shows a different methodological practice (and a more effective one) usually comes unjustly with the unavoidable input of hindsight. Rather, it is a careful analysis of historical records at the time which can only decide whether signs of modern scientific methodology were shown (indeed, even this requires some form of hindsight). Let me explain using cosmological world systems as an example.

Aristotle viewed space and matter as inextricably linked, since natural places differ by virtue of the basic elements, so earth, being the heaviest, found its natural place at the centre of the universe, and the natural motions of the terrestrial elements took place within the first sphere, the sublunary region. Beyond this lied the celestial sphere, the planets and stars were considered heavenly bodies, their element being aether, and their orbits around earth uniform and circular. Mathematicians whose constructions stayed faithfully close to this Aristotelian two-sphere model had to employ many workarounds in order to fit observational data. These workarounds are called *ad hoc* devices, a pejorative term given to parts of a model introduced in order to fit observational data.[7]

On the other hand, a new methodology was recorded. The invention of the telescope lead Galileo to make observations which showed many problems with the Ptolemaic model. As well as not showing bias for a Copernican model,[8] he argued with evidence and clear reasoning why such a model should be preferred. Merits were to be given to

[6] Cushing 1998, p. 19.
[7] Ibid., p. 22.
[8] Ibid., p. 142.

Galileo, who argued for the "superiority of reason and observation"[9] and demonstrated a methodology different to those who came before him. Note that as part of the series of arguments against Aristotelian straight natural motion, experiments with objects rolling down inclined planes were performed and the method detailed. Kepler, equipped with Brahe's data, also arrived at his First Law, where bodies now travel on elliptical paths, and this signified the death of all Aristotelian natural motions. Therefore, with historical evidence, I put forth my claim that new theories of motion and space proposed in place of Aristotle's natural motions and places lead to a different and better methodology.

7 Conclusion

References

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[9]Cushing 1998, p. 141.