Is the puzzle not why it took so long for Aristotelian natural philosophy to be overthrown, but why it was ever overthrown at all?

This seems to be a question about what is worthy of study and what is not. It seems to contend that what should be studied about the shift from Aristotelian to Copernican/Newtonian natural philosophy is not why Aristotelian natural philosophy lasted so long, but that the changeover ever occurred at all. So, then, the issue to be discussed consists of two parts: Why is the first of these problems not worthy of being studied and why is the second more worthy than the first?

There would seem to be three possible reasons for proposing a thesis like the first part of this quote. Either the writer feels that it is trivial to explain why Aristotelian natural philosophy lasted so long, they feel that there is something 'wrong' with studying this, or they feel that explaining the second problem also explains the first. The second point of view seems very odd. I feel that it is odd enough to exclude it from consideration, assuming a reasonably rational speaker who has been educated in a reasonably standard manner about history and its study. However, the idea an explanation of the second problem also explaining the first is very interesting.

For the moment, though, I will consider the assumption that the writer of this quote felt that it was trivial to explain why Aristotelianism persisted so long, and correspondingly, it is less easy, and therefore more interesting, to explain why Aristotle was ever dethroned. To examine this, it is necessary to briefly review some characteristics of Aristotelianism and of its successor, the combined natural philosophy of Copernicus, Galileo and Newton.

Aristotelianism began, naturally enough, with Aristotle in antiquity. He designed a consistent physics based on a system of natural philosophy that was itself based on a number of ideas. Firstly, he repudiated Plato's notion of forms as existing in a separate realm, but still retained some notion of forms with his notion of enmattered formulable essences. These were the forms of matter, which could not exist without the matter. Change was represented 'in terms of a progression from the privation of the form or *vice versa*'[1] Thus all change was based on the idea of 'natural' and 'forced' changes.[2] Natural changes were those that moved toward the objects natural place, or towards its form, whereas movement away from the form was seen

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[1] Lloyd, G.E.R., *Aristotle: The Growth and Structure of his thought*, Cambridge University Press, Cambridge, 1968, ch 7. This quote from page 289

[2] Toulmin, S & Goodfield, J. *The Fabric of the Heavens*, Hutchinson & Co., London, 1961. See page 95 for the source of this material.

as privation and unnatural. These changes could operate on almost all the properties of bodies, such as colour, heat etc. Because of all of this, to explain natural changes it was only necessary to demonstrate that such a change 'was characteristic of the species'[3]. To explain forced changes it was necessary to examine the outside agents responsible.

In this way the Aristotelian system of motion followed. Motion was considered to be either natural or forced. 'Things either move of their own accord, or they are forced to move by an outside agent.'[4] Aristotle felt that the form of natural motion for all matter was vertical and limited in duration.[5] Any motion other than this was unnatural, and so bodies could only move sideways if acted on by an external force. Therefore impermanence and change were the mark of all matter on Earth. However, in the Heavens, we see objects moving unchanging with no apparent cause for their movement. That is, there appeared to be no change in the celestial realm, and all of the celestial objects moved in a circular fashion with no apparent mover. Thus, Aristotle argued, circular motion is the natural motion of celestial objects.[6]

Thus the universe is divided in to the sub-lunary and super-lunary regions, the lower part of the crystal sphere that the moon rides on being the dividing line between the transient and the eternal, between the four elements of the Earth (earth, air, fire and water), and the celestial element aether. The heavenly bodies are each carried on a crystal sphere made out of aether, and their motion is transmitted by contact to the sub-lunary region, keeping the basic elements in motion. The cause for the motion of the heavenly spheres is the outermost sphere, the Unmoved Mover, the Final Cause.[7]

Aristotle also felt, in sharp contrast to Plato, that mathematics was of limited scope. The only measurements of the real world that were valid were measurements relative to something else.[8] Mathematics was therefore firmly in the 'secondary' category, meaning created by humans, not existing independently.

Given these two sets of ideas, about natural motions and mathematics, it follows that experimentation in the modern sense is useless, and worse than useless, because this is only observing forced motion, and thus making conclusions about this sort of motion are really only conclusions about your own properties. Similarly, looking for regularities in results obtained by forcing motions is invalid because mathematics is a human construction, not inherent in the

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[3] ibid. p 95

[4] ibid. p 95

[5] ibid. p 95

[6] This is all summarised from ibid. p 95-97

[7] Condensed from, Lloyd, G.E.R., *Aristotle: The Growth and Structure of his thought*, Cambridge University Press, Cambridge, 1968, ch 7, p 133-158

[8] from op. cit. 1, p 94

nature of the world.

In considering the question of whether the explanation of Aristotelianism's long reign as primary natural philosophy is trivial, it would seem that what needs to be shown is why the theory is easy to accept and difficult to argue against. Obviously this is the case on some level, as the theory did survive for quite a long time.

However, as Dijksterhuis[9] notes, it is sometimes difficult to disentangle Aristotle's original theories from the 'expositions and accretion due to his ancient commentators and Scholasticism.'[10] In other words, we should not neglect to consider the changes wrought in the theory to bring it in line with Christianity. Trivial as such things as the equation of the Unmoved Mover to God may seem to us, this would have to provide Christianized Aristotelianism with much argumentative force, given the importance of the Church and religion in general in the Scholastic period, and indeed during the period now known as the Scientific Revolution.

The important point to note here is that the fitting of Christianity into the framework of Aristotelianism gave it an additional basis for being accepted and created additional difficulties for anyone wishing to argue against Aristotelianism.

These difficulties all seem to stem from the interdependent nature of the system. If you wish to get rid of any one part of basic Aristotelianism, you really have to provide a good way to explain why you do not advocate dumping the whole system. This was an especially cogent problem after the system had Christian elements introduced, because if you were arguing against some part of Aristotelianism and you were incautious, it could look like you were an atheist or some other non-christian crazy person.

One final point to make, following Kuhn[11] is that Aristotle had said that the world was a certain way, and his word 'was taken with immense seriousness'[12]. This is similar to the influence of Christianity in making arguing with Aristotle difficult, because these two are more social and cultural factors that were all but ignored in earlier histories of the Scientific Revolution.

It would seem that all of this *would* explain, in large part, why Aristotelian natural philosophy lasted so long. The doctrine of natural motions created a philosophy that indicated what was valid and what was invalid to study. That is, the only valid topics for study were those that involved observing natural phenomena, not creating artificial circumstances. Also, the

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[9] Dijksterhuis E.J. *The Mechanization of the World Picture*, Oxford University Press, Oxford, 1961

[10] ibid. p I:17

[11] Kuhn T.S. *The Copernican Revolution*, Harvard University Press, Cambridge Massachusetts, 1979.

introduction of Christianity created another set of rules about what could be speculated about, by introducing God into the harmonious Aristotelian whole, and thus creating a situation where it was difficult to question Aristotle without questioning the existence of God.

The question is, however, whether this explanation is trivial to construct. Obviously I have not outlined in full, but even in the short space I have spent here outlining it, I feel that it is a relatively good explanation. So it seems that the first question is relatively easy to answer. That is, it does seem somewhat trivial to explain why it took so long to overthrow Aristotelianism. Of course, there are other, more subtle issues, but on the whole, I think that these are the major factors in the keeping of it.

To return to another possible reason for posing the question of what is worthy of study; it may yet be that the explanation of why Aristotelianism was overthrown at all will explain why it took so long. We have seen that it is relatively easy to explain why the overthrow took so long, but is it more difficult to explain why it was overthrown, and does this explanation also explain why the overthrow took so long?

To answer this properly it is necessary to briefly review some of the changes in natural philosophy that occurred during the changeover period from Aristotle to the new system.

The first major development were the ideas of Copernicus. Copernicus, for whatever reason, seems to have disliked the equant, to such an extent that he was willing to forsake a very important axiom of Aristotelianism, namely the axiom of a geocentric universe. Unfortunately for him, although his system did remove all of the equants, the change to a heliocentric universe rendered a large portion of Aristotelian physics and natural philosophy useless.

Another problem that Copernicus had was that one of his major reasons for accepting the heliocentric hypothesis was that it created greater mathematical harmonies than the Aristotelian geocentric hypothesis. Based on the brief description of Aristotelianism given in this paper, it can be seen that he was always going to have a hard time convincing a dyed-in-the-wool Aristotelian that mathematical harmonies in Nature were a good thing to look for.[13]

At the same time, about fifty to sixty years after Copernicus published his book *De Revolutionibus Orbium Celestium*, Galileo and Kepler were both working on making Copernicus' model more appealing, each in their different ways.

Johannes Kepler was a natural philosopher as much as an astronomer. Kepler's natural

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[12] ibid. p 85

[13] This paragraph and the preceding paragraph have most of their ideas coming from Schuster, J. *The Scientific Revolution*, Schuster, Sydney, 1995, chs 7 & 8

philosophy was Neo-Platonic in a very important way, in that he believed there was a mathematical blue-print for the structure of nature. He also believed that, by looking for regularities in data obtained by systematic experimentation, you could gain access to portions of this blueprint in the from of mathematical relations between events.

Galileo, however, was creating arguments for the Earth being moving. In doing this, however, he used some very important changes in metaphysics from Aristotle. Firstly, he also believed that systematic experimentation was the way to arrive at true conclusions about the world. From his arguments about relative motion it follows that what you directly observe with your senses is not necessarily the case. There may be other explanations, and the only way to look at these explanations is to experiment in a systematic fashion.

Now that we have a basic understanding of where the new philosophers were contradicting Aristotle, we can consider just what was going on in the changeover, and how complex it was. One indicator of how complex the explanation of the changeover from Aristotelianism to Copernicanism/Newtownianism is is the number of attempts to create a methodology for science and scientific change that have foundered on it. Currently, as far as I am aware, all of the attempts to produce a methodological story that saved the privileged status of science have failed when trying to explain the Scientific Revolution (as it is now called).

By qualifying that statement, I am really excluding all of the post-Kuhnian work, for reasons I will explicate once I have looked at the three method stories I am thinking of; the inductivist story, the Popperian story, and the 'vanilla' Kuhnian story.

The whole idea of a scientific revolution, where what was accepted as true becomes false, would seem to be responsible for the death of the inductivist story of method. Following Schuster[14], in the inductivist view, an unbiased observer makes observations directly from their perceptions and then induces laws from regularities in the observations. Testing predictions tests the laws, and when the predictions are confirmed, the theory is good, otherwise the theory must be thrown out. Laws are thus generalisations of facts, second-order facts, if you will. Science thus progresses by discovering laws (second order facts) and laws of laws (third order facts) and so on, linking previously unlinked laws to create an enormous structure which will eventually explain everything.[15] Obviously, if you admit that there are revolutions in the history of science, this story breaks down, and it is necessary to devise some new explanation.

This was, of course, part of Popper's enterprise. Popper attempted to give science a

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[14] ibid. see esp. ch 9

[15] based on ibid. 13, ch 9

mechanism by which it could change its theories, and still preserve its privileged status as 'creator of truth' as it were. This was the idea of falsification, which provided a mechanism by which scientists could legitimately forsake a previous theory in favour of a new theory when the old theory was disproved or falsified. Unfortunately, although Popper acknowledged the theory-dependence of observation, he did not completely apply this to his position, especially with respect to the actual testing being conducted. The problem here is that, because of the theory dependence of observation, no test can be considered conclusive. There is always some sort of normative correction that can be applied to the data to make it fit, or the theories underlying the observation can be questioned. Without the falsification mechanism, the use of Popper's theory to explain scientific revolution falls down in a heap.[16]

The problems with Kuhn's basic theory of scientific revolutions are not as clear-cut as these however. Kuhn's theory of revolutions in science requires both revolutionary and normal periods of science. Obviously, before the scientific revolution, natural philosophy was working in a period of normal science, then at some stage, the field entered a revolutionary period. However, Kuhn's basic model, as expressed in *The Structure of Scientific Revolutions*,[17] provides no mechanism for this changeover. What exactly put the field in a state of revolution, and when did this state end?

This and other problems have led to the basic Kuhnian model being rejected and a 'post-Kuhnian' philosophy of science. One of the things that this new philosophy of science addresses is the is the operation of external forces on the field as well as the internal forces driving it. Thus post-Kuhnian philosophy of science is necessarily more complex than any of the options presented here.

To return to the main point of this essay, it does seem relatively trivial to explain why Aristotelianism took so long. All that needs to be done is to show how it is very difficult to argue against, once the perceptual grid has been inculcated in a prospective scientist. On the other hand, it would seem that any explanation of the overthrowing of the old model must necessarily include some account of the dynamics of the arguments for and against the new model, and so in order to understand the changeover from one model to another, it is necessary to specify what makes Aristotelianism hard to argue against, thus explaining why Aristotelianism lasted so long.

Also, if subjects are going to be classified as worthy of study by the amount of study possible in them, then the transition from Aristotelianism to Copernicanism (for lack of a better name) is very, *very* worthy of study. I think that this is the reason that many attempts to explain such

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[16] this paragraph uses a lot of ideas from ibid. chs 10 & 11

[17] Kuhn, T.S. *The Structure of Scientific Revolutions*, 2nd. Ed., University of Chicago Press, Chicago, 1970

transitions in terms of a simple framework have failed, because these changes are *not* simple at all, but as many-faceted and interesting as any other type of human interaction.

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