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WHEN PHYSICS MEETS PHILOSOPHY: REFLECTIONS ON THE ROLE OF WORLD-VIEWS IN SCIENCE AND RELIGION

1. INTRODUCTION: BELIEF AND THE TECHNICAL MIND

Belief in and of itself is no stranger to the technically-minded individual. Engineers believe in the authority of the CRC Handbook when they look up physical constants or standard formulae. More subtly, a scientist starts every new project with a belief that a solution does exist. And likewise, the scientist or engineer usually starts working out problem solving with a non-rational intuition about where look to find that solution, and what the solution will look like once it has been found.

Notice how technical people handle these beliefs, however. First of all, they always recognize that these beliefs are fallible; tables have been known to have misprints, hunches sometimes turn out to be wrong. And secondly, they allow these beliefs to be tested by results. If we ultimately get an answer that works, it confirms our trust in the data, and it strengthens our preconceptions the next time we're looking for a hunch. In both cases, beliefs are thought to be confirmed by experience.

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This procedure works very well for every-day technical work. So why can't one apply it to a philosophical or religious belief? It sounds reasonable; every advance in knowledge proceeds from the known to the unknown, and the scientific/technical method is a proven method for finding reliable results. But in practice, what look like perfectly reasonable extrapolations from the known to the unknown, in the way that science progresses, can turn out to be absolutely disastrous in philosophy. The philosophical underpinnings of this procedure are not borne out by experience.

This paper seeks to examine a few examples from the history of science in which people have attempted to draw philosophical conclusions from good scientific observations. This is hardly to be considered an exhaustive historical study. But it is my aim to point out some general trends in the epistemology of science that have important implications on the use of science to learn about non-scientific truths. From these, one can hope better appreciate how science and philosophy can interact, and where such interactions are to be held highly suspect.

2. WHEN GOOD SCIENCE LEADS TO BAD PHILOSOPHY

About the year AD 500 in India a great mathematician and astronomer, Aryabhata, published a book on geometry and astronomy.[1] It was based o both his own work, and the accumulated wisdom he'd inherited from the Greeks and, through them, data on planetary positions going back to the Babylonians. A thousand years before Copernicus, in this book he suggests that the Earth is spinning; he says that the daily motion of the stars, rising and setting, is the evidence of this spin. Unlike Copernicus he still had the Ptolemaic system of planets moving about the Earth; but the spinning Earth was a major departure

[1] Aryabhata, *The Aryabhatiya of Aryabhata — An ancient Indian work on mathematics and astronomy,* translated with notes by W.E. Clark, The University of Chicago Press, Chicago 1930.

from Aristotelian physics, one that led to enormous controversy in India for the next several hundred years.

Whether it was this idea of a fixed set of background stars, or some other unspoken motivation, the observational data available to him and his advanced understanding of geometry led him to calculate the length of time it takes for the Moon, Mercury, Venus, Mars, Jupiter, and Saturn to make once complete circuit of the heavens, relative to those fixed stars. And he gives these numbers in his book to a remarkably high accuracy, even compared to known present-day values... better than one part in a hundred thousand, in some cases. This is important science, and science of a quality that would not be equaled for more than a millennium.

Yet there is a problem with his data. It's the way he presents these numbers. The trouble is, he wants to express the period of, say, Mars in terms of an Earth year; but the period of Mars is not some exact number of Earth years long. It's 1.8807 years, according to our best data to date. We express the fraction of a year by the numbers past the decimal point, and it's understood that whatever uncertainty remains in that data lies in the last significant figure. (The uncertainty is not in our precision of measurement, but in the motion of Mars itself; due to various perturbations, its period can vary by 0.0002 years over the course of an Earth year.)

But Aryabhata didn't have the decimal point to use, because mathematicians hadn't invented it yet. So how could he express the period of Mars? He was very clever. He could do it as a ratio. For instance, he could say that in 205 Earth years you'll find Mars making 109 circuits of the Sun. Do the arithmetic and you find that this ratio matches the modern figure to within the variation noted above.

Of course, it's not correct in the sixth decimal place. It couldn't be, no planet's orbit would be, because no planet orbits the Sun with a period that is a perfect ratio of a round number of Earth years (nor is any period constant to that precision, for that matter). The period of each planet, expressed in terms of an Earth year, is always a slightly varying number whose values beyond the decimal point never occur in a repeating pattern. It is a number that cannot be expressed as a ratio — an *irrational* number.

That's not surprising, to us. Irrational numbers, like pi and the square root of two, occur all the time. When it turns out that two orbits actually do make a simple ratio then we immediately look for some reason of mutual perturbations to force planets into such a state, because a simple ratio of planetary periods is not, in general, what we expect. (The ratio of the periods of Pluto to Neptune, for example, actually is 2/3... on average, given the fluctuations in their orbits. Understanding how orbiting bodies get „captured" into resonances like these is one of the main goals of modern planetary orbital theory.)

But Aryabhata didn't know that. He just knew that these ratios — hardly simple numbers in themselves — did match a thousand years' worth of data. And given ratios like this for each planet, like astronomers before him going back to the Babylonians, he took the next obvious step of comparing all the ratios against a common period. In essence, he multiplied all these ratios together to find the common denominator of the ratios for all the planets together, which had been worked out by the Babylonians to be 4.32 billion Earth years.

What does this common denominator mean? It means that, if the planets all did really orbit with periods in perfect ratios to the Earth's period, then this 4.32 billion years would represent the amount of time it would take for the whole system of planetary positions to repeat itself.

Now, put yourself into the ancient Hindu cosmology, one that accepted the astrological idea of human and Earthly events being controlled by the positions of the planets. If the planets repeat their positions every 4.32 billion years, like the best astronomy of those days implied, then this calculation provided „solid scientific proof" that life on Earth was indeed trapped in an endless cycle, relentlessly and inevitably repeating itself. And science even gave us the length of time between cycles of the universe: 4.32 billion years! Later Hindu astronomers speculated about when exactly the time was, when all the planets started out perfectly lined up; and how long it would be (given current planetary positions) before this perfect line-up would occur again, and what this would mean for the future of humanity...

Knowing what we know today, that planetary periods are not perfect ratios, we immediately see the fallacy of this argument. Planetary positions never repeat. There was no moment when all the planets were perfectly aligned, nor will there be in the future. There is no scientific basis for the concept of a repeating universe.

Yet this Hindu philosophy seemed to be backed up by a science that was not only good for its day, but impressive by anyone's standard. The numbers it was based on were good to four or five significant figures! What more could you ask for?

The trouble is, every scientific „fact", every data point, has — spoken or unspoken — error bars. No scientific number is perfect. No measurement is perfect. And every scientific theory, no matter how good or useful, is at best only an approximation of the truth. It can be a phenomenally good approximation; but phenomenally good is not the same as perfect. Because of this, basing a philosophy on science is fraught with danger.

3. WHEN BAD PHILOSOPHY LEADS TO GOOD SCIENCE

Another story about science and philosophy has a different kind of ending. It involves Johannes Kepler, whose laws of planetary motions made the heliocentric system actually work.

Copernicus had proposed a system where the Sun was the center of the solar system and the Earth moved around it, but the Copernican system still was a system of circular orbits. Just like Ptolemy before him, in order to match the actual observed positions of the planets Copernicus had to assume „epicycles" — the planets moved in little circles around their „average" circular, orbits. And he had to assume „eccentric" circles, namely circular orbits that were centered not exactly on the center of the solar system, but on some point offset from that center. Even the Sun itself did not sit at the center, but rather did a small circular dance about its average position.

None of this was satisfactory to Kepler. The problem to him wasn't only one of inelegance; indeed, it was a theological problem. Kepler had a very peculiar notion of God's place in the universe.

He considered himself a Protestant, but none of the Protestant churches of his day satisfied him. (Nor did they want any part of his theology. Kepler wound up living and working in Catholic Prague, with a special exemption from the law that said all government officials had to be Catholics.) Unlike the standard theologies of his day, Catholic or Protestant, Kepler's mysticism told him that everything in the physical world exactly mirrored, or paralleled, the spiritual realm. Thus to him the light of the Sun represented in some real way, more than just symbolically, the Holy Spirit itself pouring itself upon the Earth. And the source of this light, the Sun, was to his thinking the physical manifestation of God the Father himself!

As he explained in a letter to his friend Herwart von Hohenburg (quoted in Job Kozhamthadam's book[2] , *The discovery of Kepler's laws*, among the reasons for adopting his theory was the mystical significance of the structure of the Celestial Sphere: „The center is the origin and beginning of the sphere. Indeed, the origin has precedence everywhere and is by nature always the first. When we apply this consideration to the most Holy Trinity, the center refers to the image of God the Father. Hence the center of this material world-sphere should be adorned by the most ornate body, that is the Sun, on account of light and life..."

Kepler reasoned that it would hardly be fitting for God the Father to make this eccentric little dance around the center of the universe. God had to be the center, in a literal sense. So Kepler went searching for an astronomical system that allowed the Sun, God, to remain fixed. Eventually he hit upon replacing the circles and epicycles of Copernicus with elliptical orbits, and the rest is history.

Kepler the philosopher also had an interesting axiom of philosophy. He maintained that no true deduction can be made from false

[2]J. Kozhamthadam, *The discovery of Kepler's laws: The interaction of science, philosophy, and religion,* Notre Dame Press, Notre Dame 1994.

premises. We merely note in passing that his deductions of planetary motions in elliptical orbits have stood the test of time far better than his theological premises.

Indeed, science regularly comes up against variants of what's called the „inverse problem." In geophysics, for instance, you can measure the gravity field at the surface of the Earth, and then try to deduce what ore masses or rock structures below the ground produced that gravity field. The problem is that there is no one unique solution. Though most possible starting conditions can be ruled out, there remain any number of possible starting conditions that could give rise to the same gravity field. Only one of those starting conditions is true.

Kepler was exactly wrong. It is quite possible to start with false premises and still arrive at a true conclusion. Back in 1865, Maxwell derived his famous equations uniting electricity and magnetism (predicting the electromagnetic wave nature of light, and the possibility of radio, and the transmission of electric power, and just about everything else we use in electronics today) by assuming that the „ether" had a "finite compressibility." His equations led to Einstein's theory of relativity, which in turn showed that there was no such thing as an „ether." Yet our electrical appliances still work, regardless.

I think it is striking to see how differently philosophy and physics behave. Physics seems to be pretty robust; if your starting assumptions are not too far away from reality, you have a good chance of arriving somewhere close to the truth. Physics converges on the truth. Philosophy, by contrast, exhibits what could be called extreme sensitivity to starting conditions. Reminiscent of mathematical chaos, a slight change in your philosophical assumptions can result in a radically diverging outcomes.

(Of course, even in science, not every false assumption will inevitably lead to a true conclusion. Like with the inverse problem, there are lots of possibilities we can rule out, that will never work.)

Science is an approximation of the truth. The art of the scientist, and even more of the engineer, is knowing how close is close enough — when does the job we're trying to do demand higher precision, and when is such precision a waste of time? But inevitably, scientific results carry with them a small degree of uncertainty. That is precisely why they are so dangerous to use as the basis of one's philosophy, given this extreme sensitivity to starting conditions in philosophy.

A religion based on the best science of its day is inevitably a false religion. Indeed, Michael Buckley in his book *At the origins of modern atheism*[3] suggests that the atheism of the 18th and 19th centuries arose precisely because the religious thinkers of those times tried to base their religion on the new certainties of Newton and Leibnitz.

In some cases they tried to fit the traditional idea of a loving, active God into the places where the new physics was not yet successful (say, the motion of the planets through the ether, or the chemistry of life). But as physics and chemistry developed to the point where Laplace could say of God, „I have no need of that hypothesis," then God was squeezed out of the gaps, and out of their universe.

In other cases, they kept reducing the role of God in the universe until he was nothing more than the clock maker that started things going, and then watched them evolve from a distance. In both cases, the God of the philosophers had become delaminated from the God of revelation, and the God of one's personal religious experience.

It is equally false to conclude that, because your science starts from a certain philosophical viewpoint, the success of that science proves your viewpoint was correct. Remember the „inverse problem" — many different starting conditions can lead to the same result, and so success at arrival is no proof that your starting conditions were correct.

Modern science developed precisely because the medievals believed in a creator God, and thus had the confidence to assume that this chaotic universe ultimately made sense (and was worthy of study). The fact that science has turned out to be a fruitful endeavor does not, unfortunately, prove that their assumption of a Creator was necessarily correct.

[3] *Yale University Press, New Hawen 1987.*

On the other hand, a modern biologist starts with a purely mechanical view of the universe. (Unlike physics, which has been humbled by the oddities of the quantum state, biology still operates in a Newtonian universe.) The fact that the biologist can map the genome, and even invent pills that restore your sexual prowess and cure your baldness, does not necessarily mean that this mechanical viewpoint is necessarily correct, either.

Kepler's laws do not prove Kepler's theology. Science can't make that judgment, either way.

4. A FRUITFUL INTERACTION

So what good is science to philosophy, or philosophy to science? Do they ever interact at all? The answer is yes, but in a way that is more subtle than Kepler or the ancients realized.

Essentially, they interact because all scientists, and all philosophers, are first and foremost human beings. That means that as scientists, they must have human motivations and desires and intuitions before they can do their science. As human beings, they must live in the physical world whose truth must invariably set limits and inspire questions for their philosophies.

Philosophy does two things for the scientist. It sets the reasons why the scientist does the work in the first place: for example, love of Truth, or love of a creator God. And it provides a road map to suggest fruitful directions for future research. Being able to recognize elegance is a powerful weapon in a scientist's arsenal. Not only is a sunset beautiful; so are the equations that describe it.

(There is a famous story about Albert Einstein... in the 1920's, while lecturing in Germany, he was told of a new set of experiments done in Cambridge which seriously challenged his theory of General Relativity. His colleagues wanted to know his reaction. We all have been taught, of course, how science is supposed to work: the theorist proposes, the experimenter tests, and if the theory fails the test it must be rejected.

But Einstein's reaction when he heard that his theory had failed this test was quite different. „The experimenters made a mistake," he said.

How could he be so sure his theory was right, and the experiment wrong? His reply: „God is subtle; he is not malicious." He knew his theory was so beautiful, it had to be true.

And he was right. The experimenters had made a mistake.)

Just as philosophy, and a sense of esthetics, can guide science (though it is understood that even an esthetically beautiful theory must eventually be confirmed by experiment), so science provides corrective evidence for the philosopher. It may be fallacious to attempt to deduce a philosophy from a scientific theory, but certainly a philosophy that predicts a universe different from what is observed by the scientist has serious problems. As with the „inverse problem" some set of assumptions can be ruled out.

And science suggests new philosophical questions to be pursued: Is the Earth unique? If so, or if not, does that tell us anything about our place in the universe? Does the Anthropic Principle tell us fascinated by it?) In a universe defined by the laws of physics, where does God act? Where does physics end and human freedom begin? Why do prayers work?

But perhaps better than these reasons, these questions, science and philosophy enrich each other with new perspectives and a new language in which to attempt to engage traditional problems. A philosopher can bring to science a more subtle and deeper understanding of what its truth means. It was philosophy that first warned scientists that all data are theory-laden, all theories meaningful only within a structure or paradigm, all scientific work is done in a social setting that can both limit what questions are considered interesting and what answers are considered acceptable. Philosophy speaks to the human scientist of humility, patience, and wisdom.

Science can teach philosophy of the joys of testability; the usefulness of division of labor; a model of work based on a team of equals rather than a master/disciple relationship. And a scientist living intimately with the natural universe is one who comes to recognize by instinct how things are likely to be, rather than merely how they might possibly be.

Like Einstein, the scientist comes to know in his heart, in her soul, the personality of creation. Perhaps — as I believe — one thus comes to know the Personality of the Creator.

GDY FIZYKA SPOTYKA FILOZOFIĘ: REFLEKSJE O ROLI POGLĄDÓW NA ŚWIAT W NAUCE I RELIGII

Autor przedstawia kilka przykładów z historii nauki, ukazujących, jak dobra nauka może prowadzić do złej filozofii, a jak zła filozofia do dobrej nauki. Z przykładów tych wyciąga metodologiczne wnioski, wyjaśniające relacje pomiędzy nauką a religią.

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