Lecture 28: May 4, 2021

PHYSICS 419 - Spring 2021

1 Anthropic Coincidences

Weyl in 1919 noticed that the ratio of the electromagnetic force to the gravitational force between two electrons is $N_1 \approx 10^{39}$. He wondered why this number rather than some number which was system independent such as π. What picks this out was the question? Eddington in 1923 attempted to connect this number to another a fundamental number, namely the number of protons in the universe. He estimated this to be $N \approx 10^{79}$ which is roughly N_1^2. So perhaps N_1 is not unreasonable. Dirac noticed that N_1 is the same order of magnitude as the ratio of a typical stellar lifetime to the time for light to traverse the radius of a proton. Is this just a coincidence? Dicke pointed out that the latter number is necessarily large to allow the formation of heavy elements. Hence, life might be related to N_1. This is the beginning of what are called anthropic coincidences. Here are a few more:

1.) A fairly large number of physical constants, not currently constrained by any established theory, probably have to have values close to those that we observe in order for any life to evolve.

2.) $\Omega \approx 1$: a dense universe would collapse before anything could evolve. A sparse universe wouldn't form galaxies, 2^{nd} generation stars, elements with interesting chemistry.

3.) The strength of the attractive nuclear force has to fall within a fairly narrow range (a factor of about 1.5) to make deuterium stable, but not diprotons. Outside that range, there's no apparent way to form heavy elements.

4.) There's a particular excited state of the carbon nucleus whose energy just matches up with the rest mass of three helium nuclei. This allows carbon to form, and hence the heavier elements. These energy levels have to be very fine-tuned. Maybe there are other possible tunings that would work, but it seems that in a random draw of the strengths of these interactions (near the current values) most results wouldn't allow heavy elements to form.

5.) Various special properties of C, O, H, N, etc are needed for the formation of our form of life.

It is conceivable that something other than complex chemistry (for which 1-3 are prerequisites) could provide the combination of stability and complexity needed for a substrate for evolution of conscious creatures, but there are no remotely plausible reasons to presume that. (contrary to science fiction)

Let's discount (4)- the question isn't why us but why anybody, and we have no reason to doubt that a variety of detailed chemistries could give rise to life.

Many quite different ideas are grouped under the vague heading of "anthropic principle". Generally, those who find the match between us and our universe unsurprising are called the weak anthropic principle. Those who try to draw some further inferences about the universe from its suitability for us are claiming what is called the strong anthropic principle. Here is the weak anthropic principle (Barrow and Tipler):

"The observed values of all physical and cosmological quantities are not equally probable but take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the Universe be old enough for it to have already done so."

This is an example of the weak anthropic principle (WAP).

Here is an example of the strong anthropic principle (SAP):

"The Universe must have those properties which allow life to develop within it at some state in its history."

This statement is due also to Barrow and Tipler. They also have a final anthropic principle:

"Intelligent, information processing must come into evidence in the Universe, and, once it comes into existence, it will never die out."

All of this is pointing to some sort of design.

2 Probabilty and Deductive Syllogisms

Much of this lecture will focus on whether or not design arguments are valid. Here I will be rephrasing the arguments of Elliott Sober. It turns that what is wrong with design arguments actually stems from a pitfall of probabilistic interpretations of standard deductive arguments.

Modus Ponens:

If X then Y

X

Therefore Y.

Here is a probabilistic analog of Modus Ponens:

Pr(Y/X) is high

X

———

Pr(Y) is high

Here Pr(Y/X) is the conditional probability of Y given X. To refine this argument we need to specify the time that each of these propositions obtains.

$Pr_{t1}(Y/X)$ is high

X

———

$Pr_{t_2}(Y)$ is high.

So all of this works. MP can be generalised probabilistically.

What about Modus Tollens? Here is Modus Tollens:

If X then Y

not-Y

———

not-X

As we will see, design arguments turn on there being a probabilistic generalization of Modus Tollens. But nothing along these lines is to be had. Lets see why.

$Pr_{t_1}(Y/X)$ is high

not-Y

———

$Pr_{t2}(not - X)$ is high

Let's say that a theory X says that Y is highly probable. Let's say that Y does not obtain (hence not-Y in the above syllogism). Hence, we conclude that the theory X that says Y is highly probable is probably false. There are many counterexamples to this. The probability of rolling double 6 with two dice is 1/36. Lets say that you roll double six. Does this mean that the dice are loaded? According to probabilistic Modus Tollens, you would have to conclude so. Here's the form of the argument:

1.) If the dice are evenly weighted, then the probability of rolling other than a double six is 35/36. That is, the probability is high.

2.) a double six is rolled (that is, not anything other than 6/6)

3.) Therefore the probability that the dice are equally weighted is low.

This is clearly a false conclusion. Hence, the probabilistic interpretation of Modus Tollens is false.

Richard Dawkins has proposed that the probability of life occurring is 1/number of planets in the universe. This number is $1/10^{20}$. Life evolved on this planet. Hence, our initial theory is wrong. All design arguments hinge on arguments of the form: A is highly unlikely. Therefore it is impossible without a designer. If there is no probabilistic version of Modus Tollens, then all arguments along such lines are false.