An Overdose of Copernicus? Our Universe Might Yet Be Special - Facts So Romantic - Nautilus

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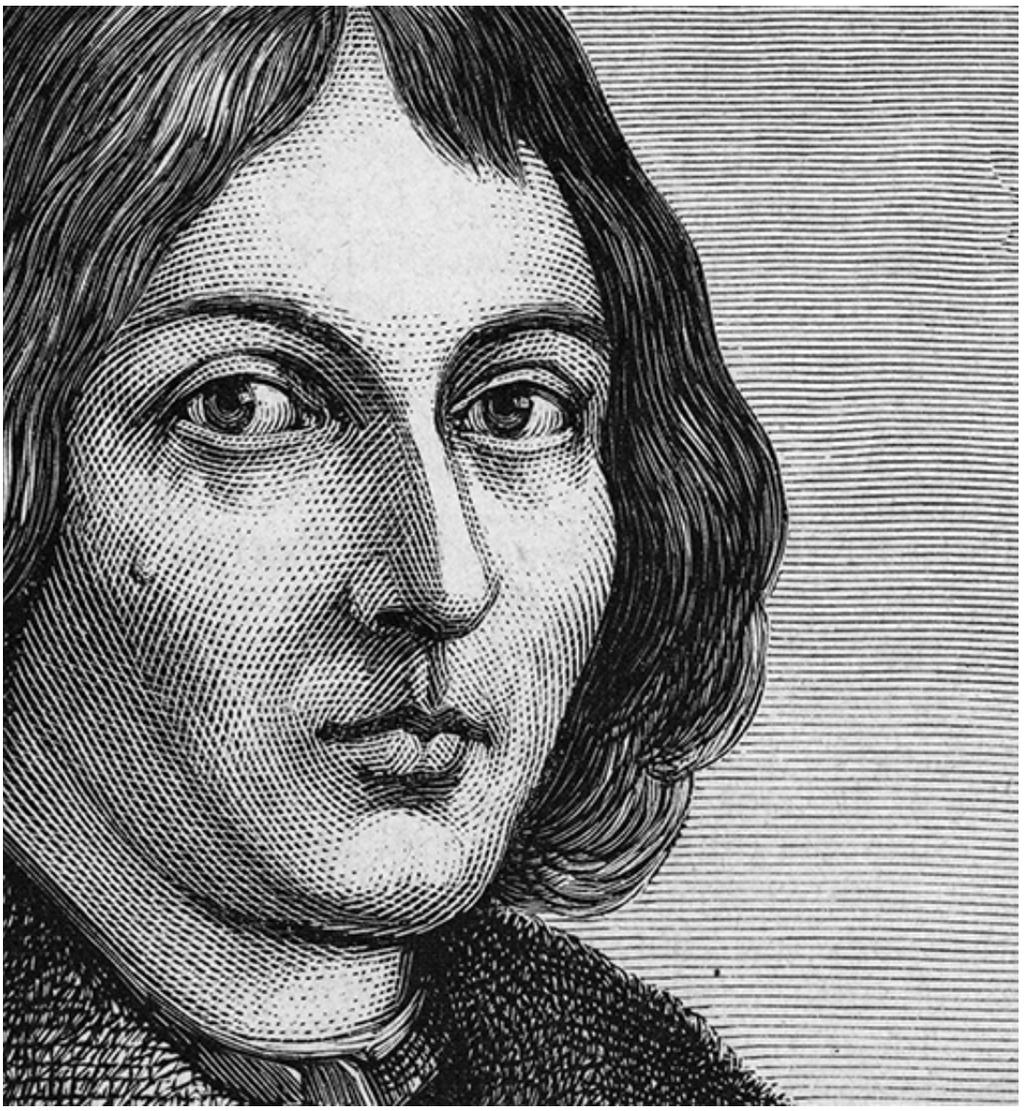

The mediocre universe… Depending on how you look at it, that is either a term of derision or an interesting, mind-warping concept. Cosmologists who are enamored of the theory that there are many, or perhaps infinite, universes like to look at our cosmic home and call it average, boring, run of the mill, vanilla. They don't do this because—like kids growing up in the suburbs—they long for the city lights of a more exciting cosmos. They do it because they think they have too. They do it because there is a problem that needs to be solved and, for some, Copernicus and his principle seems the right path to solve it.

In his thoughtful article "Goodbye Copernicus, Hello Universe," astrobiologist Caleb Scharf lays out the foundations of so-called *Copernican principle*. The idea is central not only to astronomy but to science as a whole. The Copernican principle says that you, as an observer, are not special. You don't live in a special time. You don't see things from a special position. The power behind the Copernican principle is that scientists try to never, ever, ever forget its admonition as

they attempt to explain the world. Relativity—with its emphasis on the lack of any privileged frame of reference—was a triumph of the Copernican worldview. Thus, from Copernicus' perspective, you, and everything about you, is mediocre.

Sorry.

Now there was a time when the universe as a whole could be thought of as special; it was, after all, the only one there was, by definition. The problem, however, was the universe turned out to be a little too special.

As cosmologists poked around Big Bang theory on ever-finer levels of detail, it soon became clear that getting this universe, the one we happily inhabit, seemed to be more and more unlikely. In his article, Scharf gives us the famous example carbon-12 and its special resonances. If this minor detail of nuclear physics were just a wee bit different, our existence would never be possible. It's as if nuclear physics were fine-tuned to allow life. But this issue of fine-tuning goes way beyond carbon nuclei; it infects many aspects of cosmological physics.

Change almost anything associated with the fundamental laws of physics by one part in a zillion and you end up with a sterile universe where life could never have formed. Not only that, but make tiny changes in even the initial conditions of the Big Bang and you end up with a sterile universe. Cosmologically speaking, it's like we won every lottery every imaginable. From that vantage point we are special—crazy special.

Fine-tuning sticks in the craw of most physicists, and rightfully so. It's that old Copernican principle again. What set the laws and the initial conditions for the universe to be "just so," just so we could be here? It smells too much like intelligent design. The whole point of science has been to find natural, rational reasons for why the world looks like it does. "Because a miracle happened," just doesn't cut it.

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In response to the dilemma of fine-tuning, some cosmologists turned to the multiverse. Actually the history works a bit the other way round. Various theories cosmologists and physicists were already pursuing—ideas like inflation and string theory—seemed to point to multiple universes. Given the sticky wicket that fine-tuning already represented, these scientists were happy to take the beloved 10-dimensional strings and jump on board.

The great thing about multiverses is they provide a natural and Copernicus-friendly answer to the problem of fine-tuning. Sure, our universe looks fine-tuned, but since there are so many other universes out there, we can use that information to actually tell us something about their properties. Given the Copernican principle, it must be that the seemingly fine-tuned conditions in our universe are actually average properties across the multiverse. We must be mediocre, right? That means that if you could look around the multiverse, you might find a universe with

very different values than ours for the fundamental constants of physics, but on average the values you will find will be the ones we have here. End of story.

There is a compelling momentum to the argument when you hear it run that way. There is, however, a small problem. Well, maybe it's not a small problem, because the problem is really a very big bet these cosmologists are taking. The multiverse is a wildly extreme extrapolation of what constitutes reality. Adding an almost infinite number of possible universes to your theory of reality is no small move.

Even more important, as of yet there is not one single, itty-bitty smackeral of evidence that even one other universe exists. Worse still, there are some who would say it's been precisely the shortcomings of ideas like string theory that led them to become multiverse-friendly. Not so long ago it became clear that string theory was not leading to a single prediction for this single universe we inhabit. Instead it predicted 10^{500} possible universes. For some folks, this was not a good thing. It seemed string theory went from a "theory of everything" into a theory of nothing. Advocates stayed true however and proclaimed that string theory had in a sense, discovered the multiverse. (Inflationary cosmology was also discovering the multiverse in its own way.)

Finding evidence of a multiverse would, of course, represent one of the greatest triumphs of science in history. It is a very cool idea and is worth pursuing. In the meantime, however, we need to be mindful of the metaphysics it brings with it. For that reason, the heavy investment in the multiverse may be over-enthusiastic. The multiverse meme seems to be everywhere these days, and one question to ask is how long can the idea be supported without data. Recall that relativity was confirmed after just a few years. The first evidence for the expanding universe, as predicted by general relativity, also came just a few years after theorists proposed it. String theory, in contrast, has been around for 30 years now, and has no physical evidence to support it.

There are likely other ways to solve the fine-tuning quandary that don't require creating an infinite number of potentially unobservable universes. Some of these may require changing the way we look at time, as Lee Smolin has suggested. Or perhaps these solutions will include a deeper understanding of the limits of the Copernican principle. Perhaps there is a natural, rational reason why we, or at least our universe, really is unique in its one-time history.

Now that wouldn't that be special.

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