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Zillions of Universes? Or Did Ours Get Lucky?

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CLEVELAND — Cosmology used to be a heartless science, all about dark matter lost in mind-bending abysses and exploding stars. But whenever physicists and astronomers gather, the subject that roils lunch, coffee breaks or renegade cigarette breaks tends to be not dark matter or the fate of the universe. Rather it is about the role and meaning of life in the cosmos.

Cosmologists held an unusual debate on the question during a recent conference, "The Future of Cosmology," at Case Western Reserve University here.

According to a controversial notion known as the anthropic principle, certain otherwise baffling features of the universe can only be understood by including ourselves in the equation. The universe must be suitable for life, otherwise we would not be here to wonder about it.

The features in question are mysterious numbers in the equations of physics and cosmology, denoting, say, the amount of matter in the universe or the number of dimensions, which don't seem predictable by any known theory — yet. They are like the knobs on God's control console, and they seem almost miraculously tuned to allow life.

A slight tweak one way or another from the present settings could cause all stars to collapse into black holes or atoms to evaporate, negating the possibility of biology.

If there were only one universe, theorists would have their hands full trying to explain why it is such a lucky one.

But supporters of the anthropic principle argue that there could be zillions of possible universes, many different possible settings ruled by chance. Their view has been bolstered in recent years by a theory of the Big Bang, known as inflation, which implies that our universe is only one bubble in an endless chain of them, and by string theory — the so-called theory of everything — whose equations seem to have an almost uncountable number of solutions, each representing a different possible universe.

Only a few of these will be conducive to life, the anthropic argument goes, but it is no more surprise to find ourselves in one of them than it is to find ourselves on the moist warm Earth rather than on Pluto.

In short we live where we can live, but those can be fighting words.

Scientists agree that the name "anthropic principle," is pretentious, but that's all they agree on. Some of them regard the idea as more philosophy than science. Others regard it as a betrayal of the Einsteinian dream of predicting everything about the universe.

Dr. David Gross regards it as a virus. "Once you get the bug you can't get rid of it," he complained at the conference.

Dr. Gross, director of the Kavli Institute for Theoretical Physics in Santa Barbara, Calif., had agreed to lead a panel discussion on the notorious principle. Often found puffing on a cigar, he is not known to be shy about expressing his opinion.

"I was chosen because I hate the anthropic principle," he said.

But playing a central role in defending the need for what he called "anthropic reasoning" was Dr. Steven Weinberg, a Nobel laureate from the University of Texas. Like Dr. Gross, Dr. Weinberg is a particle physicist who is known for being a hard-core reductionist in his approach to science, but he evinces a gloomy streak in his writings and his talks. He is still famous for writing in his 1977 book, "The First Three Minutes," "The more the universe seems comprehensible, the more it also seems pointless."

Dr. Weinberg is among the most prominent of theorists who have reluctantly accepted, at least provisionally, the anthropic principle as a kind of tragic necessity in order to explain the gnarliest knob of all.

Called the cosmological constant, it is a number that measures the amount of cosmic repulsion caused by the energy in empty space. That empty space should be boiling with such energy is predicted by quantum theory, and astronomers in the last few years have discovered that some cosmic repulsion seems to be accelerating the expansion of the universe. But theoretical attempts to calculate this constant, also known as lambda, result in numbers 10^{60} times as high as those astronomers have measured.

So despairing are physicists of understanding the cosmological constant that Dr. Weinberg joked earlier at the meeting that he would no longer read papers about it.

Back in 1989, before any cosmological constant had been discovered, Dr. Weinberg used the anthropic principle to set limits on the value of the constant. Suppose instead of being fixed by theory, it was random from universe to universe. In that case the value of the cosmological constant in our universe may just be an "environmental effect," he explained, and we shouldn't expect to be able to predict it exactly any more than you can calculate how much rain will fall in Seattle this Christmas.

In his paper, Dr. Weinberg argued that lambda in our universe could not be too big or the repulsive force would have prevented the formation of galaxies, stars and us. Since we are here, the constant should be small.

The recently discovered "dark energy" causing the cosmic acceleration fits comfortably inside Dr. Weinberg's limits, vindicating in a way the anthropic approach.

In his talk, Dr. Weinberg described the anthropic principle as "the sort of historical realization scientists have been forced to make from time to time."

"Our hope was to explain everything," he said. "Part of progress is we learn what we can explain on fundamental grounds and what we cannot."

Other panelists, including Dr. Alex Vilenkin, a physicist from Tufts University, suggested that the anthropic reasoning was a logical attempt to apply probabilities to cosmology, using all the data, including the fact of our own existence. Dr. John Peacock, a cosmologist at the University of Edinburgh, argued that the anthropic principle was not a retreat from physics, but an advance. The existence of an ensemble of universes with different properties, he explained, implies a mechanism to produce variation, a kind of cosmic genetic code, the way that evolution implies the existence of genes.

"You gain new physics," Dr. Peacock said.

But when his own turn came, Dr. Gross questioned whether the rules of the anthropic game were precise enough. What were the parameters that could vary from universe to universe? How many could vary at once? What was the probability distribution of their values, and what was necessary for "life"?

Anthropic calculations are inherently vague and imprecise, he said. As a result, the principle could not be disproved. But he was only getting warmed up. His real objection, he said, was "totally emotional."

Ascribing the parameters of physics to mere chance or vagaries of cosmic weather is defeatist, discouraging people from undertaking the difficult calculations that would actually explain why things are they way they are. Moreover, it is also dangerous, he declared to ringing applause.

"It smells of religion and intelligent design," he said, referring to a variety of creationism that argues that the universe is too complex to have evolved by chance.

Dr. Lawrence Krauss, the astrophysicist from Case Western who had organized the conference and recruited the panel, characterized the anthropic principle as "a way of killing time" when physicists didn't have a better idea. Dr. Krauss, who has battled creationists over biology instruction in the public schools in Ohio, said he had encountered anthropic arguments as an argument for fine-tuning, the idea that God had fixed the universe just for us.

Dr. Weinberg replied that the anthropic principle was not really a part of science, but rather "a guess about the future shape of science."

"If we didn't have things in our universe that seem peculiar, like the value of the cosmological constant, we wouldn't worry about it," he said.

Dr. Weinberg compared the situation to a person who is dealt a royal flush in a poker tournament. It may be chance, he said, but there is another explanation: "Namely, is the organizer of the tournament our friend?"

"But that leads to the argument about religion," he said to much laughter.

In fact, Dr. Weinberg said, the anthropic principle was "a nice nontheistic explanation of why things are as nice as they are."

By then the audience was squirming to get in on the action. Hands were waving as Dr. Gross called the session to an end. "Clearly there is a diversity of opinion," he intoned. "Some people find the small value of cosmological constant so bizarre that only the anthropic principle will pick it out."

Nobody who adheres to the anthropic principle, he said, would hold on if there were "an honest old-fashioned calculation," that explained the cosmological constant.

Given the floor for the last word, Dr. Weinberg agreed that it was too soon to give up hope for such a breakthrough. "I'm prepared to go on hoping that one will be found," he said. "But after the passage of time one begins to entertain other possibilities, and the anthropic explanation is another possibility."

Applying that mode of reasoning, he said, could help make the cosmological constant less peculiar,

"But we don't know if that's the help that we really deserve to get," he concluded.

And it was time for lunch.

Dr. Gross reported later that younger physicists had thanked him for his stand.

Dr. Weinberg said the panel had generated more fuss than the subject deserved.

"Those who favor taking the anthropic principle seriously don't really like it," he said, "and those who argue against it recognize that it may be unavoidable."