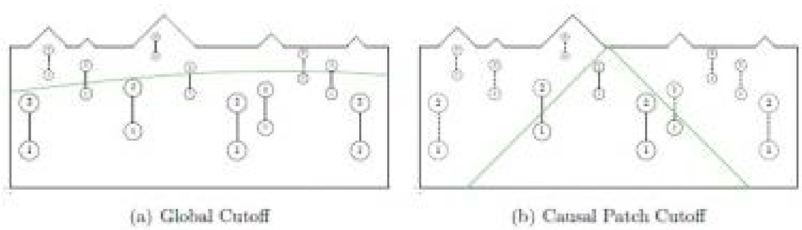
Time likely to end within 5 billion years, physicists calculate

October 1 2010, by Lisa Zyga



This figure shows two different cutoff scenarios showing how time could end. Image credit: Raphael Bousso, et al.

(PhysOrg.com) -- As far as astrophysicists can tell, the universe is expanding at an accelerating rate, and will likely continue to do so indefinitely. But now some physicists are saying that this theory, called eternal inflation, and its implication that time is endless pose a problem for scientists calculating the probability of any event occurring. In a recent paper, they calculate that time is likely to end within the next 5 billion years due to some type of catastrophe that no one alive at the time will witness.

The physicists, Raphael Bousso from the University of California, Berkeley, and coauthors have posted a paper detailing their theory on arXiv.org. In their paper, they explain that in an eternal universe, even the most unlikely events will eventually occur -- and not only occur, but occur an infinite number of times. Since probabilities are defined in terms of the relative abundance of events, there would be no point in determining any probabilities because every event would be equally likely to happen.

"If it does occur in Nature, eternal inflation has profound implications," write Bousso and coauthors in their paper. "Any type of event that has nonzero probability will happen infinitely many times, usually in widely separated regions that remain forever outside of causal contact. This undermines the basis for probabilistic predictions of local experiments. If infinitely many observers throughout the universe win the lottery, on what grounds can one still claim that winning the lottery is unlikely? To be sure, there are also infinitely many observers who do not win, but in what sense are there more of them? In local experiments such as playing the lottery, we have clear rules for making predictions and testing theories. But if the universe is eternally inflating, we no longer know *why* these rules work.

"To see that this is not merely a philosophical point, it helps to consider cosmological experiments, where the rules are less clear. For example, one would like to predict or explain features of the CMB [cosmic microwave background]; or, in a theory with more than one vacuum, one might wish to predict the expected properties of the vacuum we find ourselves in, such as the Higgs mass. This requires computing the relative number of observations of different values for the Higgs mass, or of the CMB sky. There will be infinitely many instances of every possible observation, so what are the probabilities? This is known as the 'measure problem' of eternal inflation."

One solution to this problem, the physicists explain, is to conclude that time will eventually end. Then there would be a finite number of events that occur, with the improbable events occurring less often than the probable events.

The timing of this "cutoff" would define the set of allowed events. Thus, the physicists have attempted to calculate the probability of when time will end given five different cutoff measures. In two of these scenarios, time has a 50% chance of ending within 3.7 billion years. In two other scenarios, time has a 50% chance of ending within 3.3 billion years.

In the fifth and final scenario, the timescale is very short (on the order of the Planck time). In this scenario, the scientists calculated that "time would be overwhelmingly likely to end in the next second." Fortunately, this calculation predicts that most observers are "Boltzmann babies" who arise from quantum fluctuations in the early universe. Since most of us are not, the physicists could rule this scenario out "at a high level of confidence."

What would the end of time be like for observers around at the time? As the physicists explain, the observers would never see it coming. "The observer will necessarily run into the cutoff before observing the demise of any other system," the scientists write. They compare the boundary of the time cutoff to the horizon of a black hole.

"The boundary ... can be treated as an object with physical attributes, including temperature," the authors write in their paper. "Matter systems that encounter the end of time are thermalized at this horizon. This is similar to an outside observer's description of a matter system falling into a black hole. What is radically new, however, is the statement that we might experience thermalization upon crossing the black hole horizon." Yet the thermalizing "matter system" would still not notice anything unusual when crossing this horizon.

For those who feel uncomfortable about time ending, the physicists note that there are other solutions to the measure problem. They don't claim that their conclusion that time will end is correct, only that it follows logically from a set of assumptions. So perhaps one of the three assumptions underlying the conclusion is incorrect instead.

The first assumption is that the universe is eternally inflating, which is a consequence of general relativity and well supported by the experimental evidence so far observed. The second assumption is that the definition of probability is based on the relative frequency of an event, or what the scientists call the assumption of typicality. The third assumption is that, if spacetime is indeed infinite, then the only way to determine the probability of an event is to restrict one's attention to a finite subset of the infinite multiverse. Some other physicists have already looked into alternatives to this third assumption.

Whatever happens in the next 3.7 billion years, Bousso and his coauthors' paper will likely be spurring a variety of reactions in the near future.

More information: Raphael Bousso, et al. "Eternal inflation predicts that time will end." arXiv:1009.4698v1
via: The Physics ArXiv Blog

Citation: Time likely to end within 5 billion years, physicists calculate (2010, October 1) retrieved 23 April 2024 from https://phys.org/news/2010-10-billion-years-physicists.html