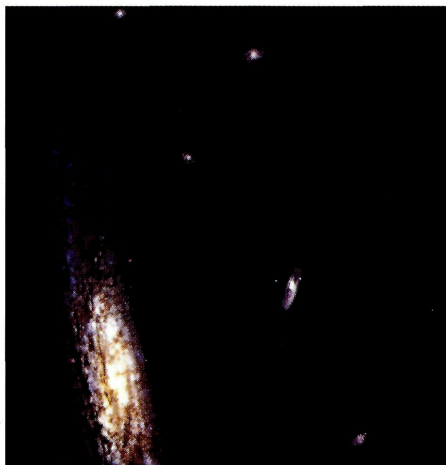


The end of the universe may be frozen in time

The long-term future of extragalactic astronomy could be dark and dreary, according to new theoretical research. Such a prediction might have not have been taken so seriously, had it not originated from Abraham Loeb of the prestigious Harvard-Smithsonian Center for Astrophysics. Professor Loeb's assertion is based on a serious study of the evolution of how we will see the universe in the future.

According to the current cosmological model, some 70% of the universe could be composed of "dark energy" acting as a repulsive force opposing gravitation. If this were true, then rather than slowing down its expansion, the universe would actually be entering a phase of accelerated expansion similar to the inflation that lasted for a split second soon after the Big Bang. Consequently, over the next few billion years, the remotest galaxies would pass beyond our cosmic horizon. They would not suddenly disappear over the horizon, but their image would become frozen while gradually fading away. "This process is analogous to what you see if you watch a light source fall into a black hole," explains Loeb. "As an object crosses the black hole's event horizon, its



A photomontage of the only galaxies still visible in the distant future, seen from the edge of the Milky Way (bottom left). (Harvard-Smithsonian Center for Astrophysics.)

image seems to freeze and fade away because you can't see the light it emits after that point."

In some distant future, this will have ominous consequences for our study of the universe. Not only will the number of observable galaxies decrease, but we will also be

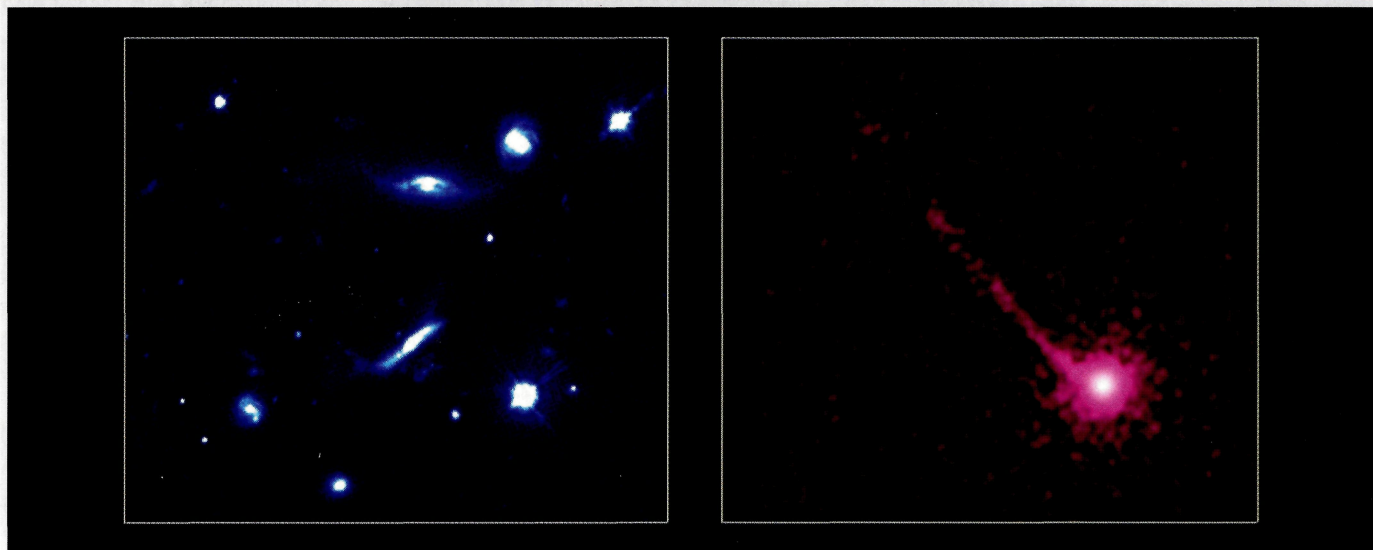
unable to observe their evolution beyond a certain time. Take the example of the most distant quasar observed to date. The light we receive from it left the quasar when the universe was only about a billion years old. If we observe this quasar over the next few billion years, we will see it solidifying and disappearing slowly at an age of only 6 billion years, which is less than half the universe's current estimated age of 14 billion years. So, even by observing distant sources over extremely long time scales, we will always have to rely on indirect arguments to connect the properties of such objects to those of nearby galaxies. Similarly, a light signal sent today from Earth will never be able to reach a galaxy currently observed with a spectral shift higher than $z = 2$.

In less than about 100 billion years, the only galaxies still visible will be those gravitationally linked to the local group of galaxies, including the Virgo cluster and perhaps part of the local supercluster. All other light sources will have frozen in time and faded to invisibility.

Reference

A Loeb 2002 *Phys. Rev. D* **65** 047301.

Picture of the month



An enormous jet of matter expelled from quasar PKS 1127-145 has been observed in the X-ray region by the Chandra satellite (right). This quasar is about 10 000 million light-years distant from the Earth ($z = 1.187$) and its jet extends over a distance of at least 1 million light-years, or about 10 times the diameter of our galaxy. The strong X-ray emission of the jet arises from interactions between relativistic electrons in the jet and photons of the cosmological microwave background. The image on the left, obtained using the Hubble Space Telescope in the visible region, shows the same field of view (40×32 arcsec). Distant galaxies appear, but the quasar is invisible. (X-ray: NASA/CXC/A Siemiginowska (CfA) and J Bechtold (U Arizona). Optical: NASA/HST/CfA/A Siemiginowska et al.)

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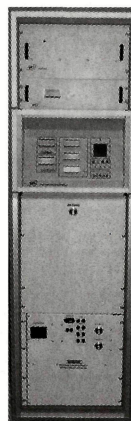
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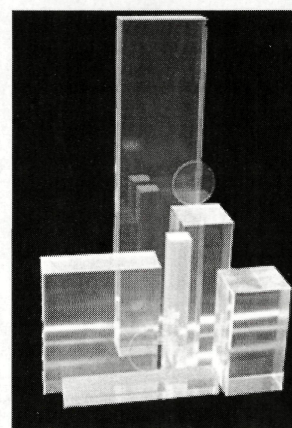
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