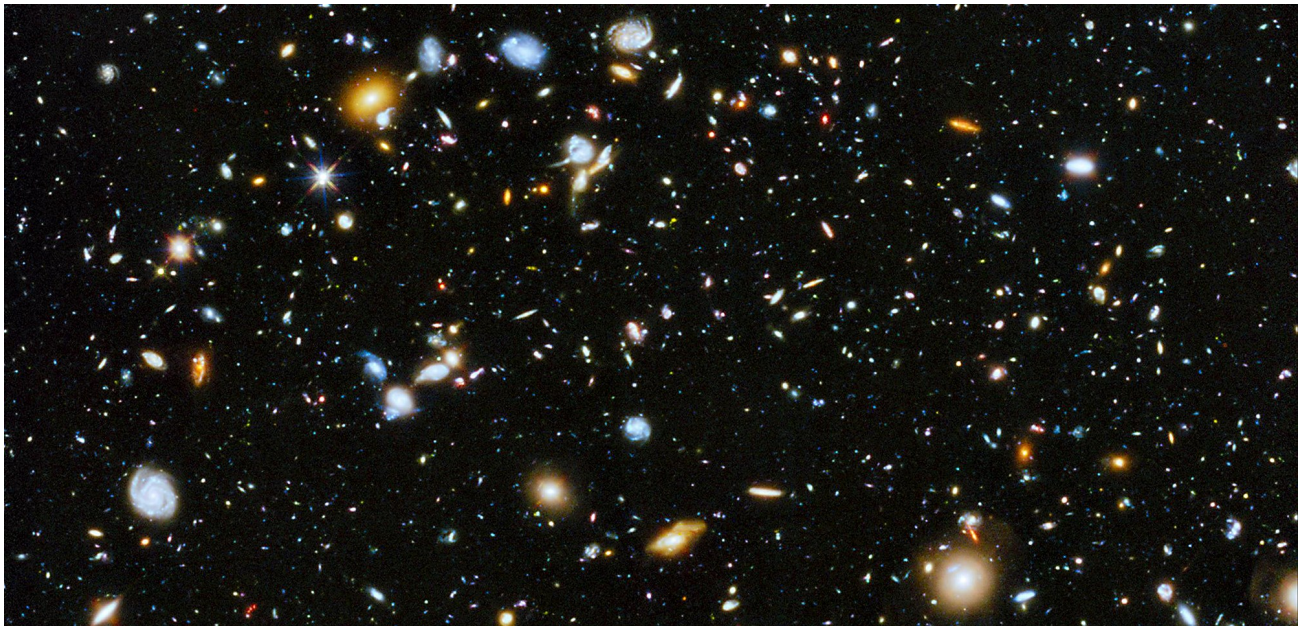
SCIENCE

What is dark energy?

The mysterious force is pushing galaxies apart and causing the universe to expand at an accelerating rate.



A view of the distant universe produced by the Hubble Space Telescope, combining observations of the field from 2002 to 2012. NASA / ESA / IPAC / CALTECH / STSCI /Arizona State University

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By Dan Falk

We've known for decades that the universe is expanding. The idea lies at the heart of the Big Bang model of the cosmos, which dates to the 1920s.

But in 1998, scientists made an astounding discovery: The universe isn't simply expanding but is expanding at an accelerating rate. No one knows exactly what's pushing galaxies apart, but that hasn't stopped physicists from naming this mysterious force.

They call it "dark energy."

We can't see dark energy. We can't feel it or detect it in any way even with sophisticated scientific instruments. But most astronomers are convinced it exists because we can see its effects in the movement of galaxies.

The Big Bang created all of the matter in the universe – from which galaxies eventually formed – and sent it spreading through space at great speed. In the absence of any additional force propelling galaxies apart, their mutual gravitational attraction would cause them to gradually slow down and

perhaps reverse course – think of how a baseball thrown straight up into the air slows down and then falls back to Earth.

But astronomical observations show that the galaxies are moving apart from one another at ever-increasing speed. If this continues for trillions of years, the universe could wind up as a cold, dark void utterly devoid of life and even light itself. It's a fate physicists call the heat death of the universe.

Do we have any idea of what dark energy might be?

One possibility is that it's a fundamental aspect of space itself, which despite the way it's ordinarily thought of really isn't empty at all. Instead, physicists think that it's pulsing with subatomic particles that constantly pop into and out of existence – and it's thought that this "quantum foam" gives rise to dark energy.

Not all physicists are on board with this concept. A few doubt the very existence of dark energy, arguing that the movements of the galaxies can be explained by a tweaked version of Einstein's theory of gravity, which is known as general relativity.

But to most, that's a long shot.

"Einstein has been right for 100 years – so to claim that his theory needs a correction is extraordinary," says University of Michigan cosmologist Dragan Huterer. "And extraordinary claims require extraordinary new findings" to be taken seriously.

How much of the universe is dark energy?

A lot. Dark energy is thought to account for most of the stuff (matter and energy) in the universe. "If you think of the universe as a pie, 75 percent of the pie is dark energy, and just 5 percent is the stuff that we understand – the planets and the stars and the gas and the dust and the people," says Alina Kiessling, a cosmologist at NASA's Jet Propulsion Laboratory in Pasadena, California.

The remaining 20 percent of the stuff in the cosmos is made up of an equally mysterious substance known as dark matter. Like dark energy, dark matter is invisible to us even with the most powerful telescopes. But rather than acting as a repulsive force, dark matter responds to gravity, just like ordinary matter.

Why can't we detect dark energy here on Earth?

Physicists think dark energy is everywhere, permeating all of space. But within our solar system, the effects of dark energy pale in comparison to the effects of gravity, so we don't notice it. It's only on scales of billions of light-years that the effects of dark energy become significant.

Will we ever figure out the truth about dark energy?

Scientists believe our best bet for understanding dark energy will come from more precise observations of distant galaxies and a better understanding of the large-scale structure of the universe. Several new telescopes are designed to do just that.

Later this year, the Dark Energy Spectroscopic Instrument (DESI) at Kitt Peak in Arizona will begin collecting data from tens of millions of galaxies, up to 11 billion-light years away, and mapping them in three dimensions. Beginning in 2023, the Large Synoptic Survey Telescope (LSST) in northern Chile will begin a decadelong sky survey that astronomers hope will shed new light on the structure and evolution of the universe.

Then there's NASA's Wide Field Infrared Survey Telescope, or WFIRST, a space telescope set for launch in the mid-2030s. While DESI and LSST will operate with visible light, WFIRST will record infrared light; invisible to the eye, infrared light can pass through dust and gas that blocks visible light.

"The WFIRST mission ... will lead to a very robust and rich interpretation of the effects of dark energy and will allow us to make a definite statement about the nature of dark energy," NASA cosmologist Olivier Doré said in a statement.

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