THE DARK UNIVERSE

4 BIG QUESTIONS

Scientists have theories about dark matter and dark energy — and some observations — but both are poorly understood. Here are four of their biggest questions.

BY NEIL SAVAGE

QUESTION	WHY IT MATTERS	WHAT WE KNOW	NEXT STEPS
1 ***Is there a dark-matter particle?***	Subatomic dark-matter particles, analogous to the particles that make up the visible Universe, would fit nicely into current physics models. But discovering that dark matter is something else would expand scientists' understanding of the Universe.	Weakly interacting massive particles (WIMPs) are the leading candidates. Other possibilities include a potentially very light particle called the axion and a more recent proposal — the very heavy Planckian interacting massive particle.	The search for the particles is ongoing. Physicists at CERN's Large Hadron Collider are looking for WIMPs, the Axion Dark Matter Experiment is running at the University of Washington, Seattle, and China has launched the Dark Matter Particle Explorer.
2 ***Does dark matter interact with anything?***	To understand dark matter, researchers need to uncover how it affects the Universe around it. But so far the only known effect is gravitational pull. This paucity of information makes it hard to know whether dark matter is a particle, a field or a misunderstanding of how gravity works.	In 2015, scientists, observing large clumps of dark matter surrounding four colliding galaxies, found that one clump lagged behind its galaxy. This suggested that friction from other dark matter had slowed it down — thus dark matter seems to interact with other dark matter.	Astronomical observations are continuing. Meanwhile, in mines under Ontario in Canada, the PICO experiment is aiming high-speed cameras at detectors filled with super-heated fluids to look for signs of dark matter interacting with ordinary matter.
3 ***Does the cosmological constant explain dark energy?***	The simplest explanation for dark energy is that there is a small force that acts in opposition to gravity, known as the cosmological constant. The problem lies in explaining theoretically how the force could be small enough to fit observations.	By observing how fast the Universe is expanding, scientists know what the cosmological constant should be. But theory says that it is 10^{120} greater than that, a Universe-sized discrepancy. Quintessence is another theory — a field that pervades the Universe and causes the acceleration.	The Dark Energy Survey in Chile is three years into a five-year mission to discover whether the expansion of the Universe has changed over time. A change would support quintessence, whereas a steady rate of expansion would be evidence for the cosmological constant.
4 ***What will eventually happen to the Universe?***	Explaining dark energy may give us a clue to the ultimate fate of the cosmos.	If there's a cosmological constant, galaxies will eventually be spread so far apart that most will be invisible to the others. If there's a quintessence field, that expansion might speed up until it tears apart stars and atoms in a 'big rip'.	The European Space Agency's Euclid mission and NASA's Wide Field Infrared Survey Telescope will launch in the 2020s. They'll examine cosmological structures to learn how the Universe has evolved and could uncover the nature of dark energy.

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