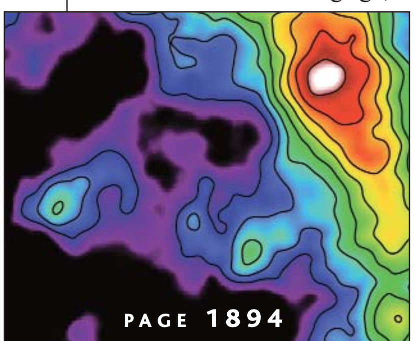
INTRODUCTION

Welcome to the Dark Side: Delighted to See You

Dark stars, the dark age, dark matter, and dark energy are the major components of the dark side of the universe: 96% of the universe consists of mass and energy we can't see and don't really understand. Fortunately, the badly outnumbered 4% of luminous matter feels the dark side through gravity and other forces. Stellar struggles with the dark side, which we can see through gravity and electromagnetic emissions, have much to tell us about the bulk of the universe. Here five intrepid astronomers and two News writers review what we know or think we know about these epic battles throughout cosmic time.

Perhaps the best-understood component of the dark side is the dark stars called black holes. Begelman (p. 1898) explains that black holes are common. By studying black holes in the center of the Milky Way and other galaxies, astronomers have discovered that their masses are correlated with certain types and masses of galaxies, suggesting that either the black hole knows about the structure of the stars in the galaxy or the stars know about the black hole through other indirect forces. The answer to this "who-saw-who-first" question may hold the key to explaining how black holes and galaxies form.

Long ago, the universe was dark and there were no stars. Miralda-Escudé (p. 1904) reviews what we know about this dark age. He concentrates on the hints of light at either end of the dark age: the cosmic microwave background radiation that dispersed right after the big bang, at a redshift of 1100, and the first stars that formed about 75 million years later, at a redshift of about 38. Although we have not seen the first population of stars, we can observe stars as far back as a redshift of about 6. During the dark age, dark matter clumped together, creating density fluctuations that could collapse and form stars.



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The first stars formed from this dark matter, which provided the blueprint, the DNA, for cosmic structure and its rate of evolution. Ostriker and Steinhardt (p. 1909) discuss the possible types of dark matter (it is not a double helix) that may now account for about 26% of the universe. The "cold dark matter" model says that dark matter is made up of cold particles such as neutralinos or other weakly interacting massive particles (WIMPs). More sinister-sounding varieties, such as self-annihilating or repulsive dark matter, may also exist and battle against WIMPs to determine the fate of ordinary matter. Irion's News article (p. 1894) describes how researchers plan to map the distribution of dark matter throughout the universe by analyzing its subtle effects on the light from distant galaxies.

Nowadays, about 70% of the universe is dominated by dark energy, which is the dark-side component we understand the least. Evidence for dark energy comes from hundreds of type Ia supernovae, detected as far back as a redshift of 1.8. As Kirshner explains (p. 1914), supernovae show that the expansion of the universe has been accelerating over the past 7 billion years, and the acceleration is caused by dark energy. By extending observations of supernovae further back in time, we should be able to see when the universe shifted gears from deceleration caused by clumpy, gravitationally attractive dark matter to acceleration caused by less clumpy, gravitationally repulsive dark energy. As Seife reports (p. 1896), cosmologists hope that this cosmic tipping point, along with a better understanding of the physical properties of dark energy, will provide beachheads for future forays into this murkiest province of dark-side science.

Science Online sheds further light on darkness with links to missions, experiments, and papers bearing on various topics in cosmology (www.sciencemag.org/feature/data/darkside/).

May the dark energy be with you as we struggle to understand the darkness of space and time.

–LINDA ROWAN AND ROBERT COONTZ

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Science

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