

## BOOKS &amp; ARTS

# Into the darkness

Cosmologists face some tough challenges as they explore the composition of the Universe.

## Dark Cosmos: In Search of our Universe's Missing Mass and Energy

by Dan Hooper

Smithsonian Institution: 2006. 256 pp.  
\$24.95

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Since the discoveries of Copernicus, astronomy has taught us that there is nothing special about the position of Earth in the Universe. The Sun lies in an unpretentious spiral arm of the Milky Way and is just an ordinary star among 100 billion others in our own Galaxy. Furthermore, the Milky Way itself is just one galaxy among billions of other similar stellar islands in the Universe around us. One cannot help but feel a sense of insignificance in the light of these myriad systems.

Some may find it comforting that the Milky Way is at least a beautiful spiral galaxy. However, any pride about this must surely be challenged by the revelations of modern cosmology. Over the past two decades it has become clear that all the rich cosmic structure we see in the form of luminous stellar systems accounts for only 0.5% of the cosmic energy density. Even including all the rest of the ordinary matter in the space between the stars — such as planets, moons, diffuse gas and interstellar dust — raises this fraction up to 5% at most. All the rest, a good 95%, is made up of two elusive components that astrophysicists call 'dark matter' and 'dark energy'. Galaxies mark only the peaks of the vast mountain ranges of cosmic structure present in the dark sector, and the ordinary baryonic matter is only a minor perturbation in the cosmic mix. In fact, even if we removed Earth, the Sun and every star in all the galaxies in our Universe, its evolution and fate would hardly be affected at all.

Although this could be viewed as yet another setback for human self-esteem, the discovery of dark matter and dark energy is undoubtedly one of science's most significant achievements. However, it is still rather incomplete, as we simply do not yet know the precise nature of dark matter and dark energy.

Particle physicist Dan Hooper addresses this fundamental puzzle in his book *Dark Cosmos*. He explains why astronomers believe that dark matter is made up of an as yet unidentified elementary particle, and tells how physicists around the world have embarked on a fascinating search for this mystery particle. He also discusses the disturbing discovery of a hidden



Galaxies such as the Milky Way make up just a tiny fraction of the structure of the Universe.

dark-energy field, which counteracts gravity and is responsible for an accelerated expansion of the Universe.

Before Hooper delves into the evidence for these two dark components and their physical interpretation, he takes the reader through a brief yet amazingly clear introduction to quantum physics, general relativity and even string theory. This entertaining and enlightening journey through much of modern physics is a tour de force, enriched with historical accounts of some of the key developments. It paints a colourful picture of the way physicists work and explains their passion for finding a final 'theory of everything'.

In his introductory remarks, Hooper recounts how popular physics books had sparked his scientific interest as a college freshman. He still enjoys reading them today, no longer to learn something new about physics, but for the inspiration and sense of awe that a clear exposition of the essence of scientific discoveries can provide. This is also how I read Hooper's book. Although I am familiar with dark matter and dark energy from my own work, I found Hooper's account of recent discoveries in cosmology refreshing; it reminded me how exciting and amazing these findings really are. Niels Bohr once said that anyone who

is not shocked by quantum mechanics has not understood it. The same could be said about the existence of dark matter and dark energy.

At the end of the book, Hooper makes an entertaining prediction, with an imaginary *Encyclopaedia Britannica* article written in the year 2100 reporting the history of cosmology in the twenty-first century. His article refers to the identification of the dark-matter particle in 2010, when a number of new elementary particles are discovered at the Large Hadron Collider at CERN, the European particle-physics laboratory near Geneva. This is followed by a direct detection of the particle in deep underground detectors some ten years later. The nature of dark energy proves more problematic, and is understood only after a unified theory of quantum gravity has finally been developed sometime in the 2070s.

Hooper also provides an alternative worst-case scenario for the future of cosmology in which little progress is made beyond what we know today. I agree with Hooper's more optimistic view; it is not only more attractive, but also more likely. If that's the case, the revolution in cosmology we have seen in recent decades is far from over. ■

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