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EXPLORING THE DARK UNIVERSE

By Jonathan L. Feng

A college classmate of mine went to work for a prestigious management-consulting firm right after we graduated. Every month or so he would head out to advise a different Fortune 500 company. When I ran into him a year after he took the job, I asked him how he could possibly provide insights to top business executives when these same people had often spent entire careers immersed in their company's work. His response? "I usually have no idea how to improve these companies, but they do. And when I come into their office and close the door, they'll say things to me that they would never tell their colleagues."

In *The 4% Universe*, Richard Panek has done something similar, not with business executives, but with physicists and astronomers who are confronting some of the biggest questions in science today. Want to hear a codiscoverer of dark matter say what she truly thinks of her legendary mentor? Want to be a fly on the wall as scientific history is shaped by the backroom dealings of a good-old-boy network? Want to read the e-mails scientists send as they jockey for position in the Nobel Prize queue? Scientists usually share such information only with their closest colleagues, but it's all in Panek's book, and it's placed in enough historical and scientific context to be both intelligible and riveting.

The topic of *The 4% Universe* is nothing less than the search for an understanding of the

contents, history and future of the cosmos. Until recently, the field of cosmology had little theoretical foundation, and its observational uncertainties made it the butt of jokes from those in more established fields. Over the past few decades, though, and especially in the past 15 years, cosmology has been transformed into cutting-edge science by a host of breakthroughs, including those recognized by the 2011 Nobel Prize in Physics. We now know that the elements of the periodic table make up only 4 percent of the universe, with another 23 percent composed of dark matter, and the remaining 73 percent made of dark energy. The properties of dark matter and dark energy are becoming increasingly constrained, but what exactly they are remains an open question, and Panek's book takes the reader through the period of transformation and up to the current frontiers of the field.

The book begins with portraits of some of cosmology's pioneers, going all the way back to Isaac Newton. Panek reminds us that Newton tried valiantly to describe the state of the universe, eventually worrying over the fact that his law of universal gravitation required "that all the particles in an infinite space should be so accurately poised one among another as to stand still in a perfect equilibrium," something he said was as difficult as making an "infinite number" of needles stand "poised upon their points." This same concern (often accompanied by the same analogy) continues to worry modern

researchers (who decry the “fine-tuning” and “unnaturalness” of modern theories), and it motivates some of the leading speculations in cosmology and particle physics today.

Moving to the modern era, Panek tells the story of how Jim Peebles, a founding father of theoretical cosmology, used a “supercomputer” at Los Alamos National Laboratory in 1969 to simulate the motion of 300 galaxies to see how clusters of galaxies form. Such “N-body” simulations remain a staple of the field, but today’s supercomputers now track not hundreds but billions of bodies. Later, Panek describes Brian Schmidt (one of the 2011 Nobel laureates) in 1995 downloading images of supernovae, which would soon provide evidence for dark energy, at a rate of 100 bytes per second. The hurdles he and his colleagues confronted back then seem almost ludicrous as we download our YouTube videos over the Web just a decade and a half later. Panek’s historical anecdotes provide an interesting perspective both on how far we’ve come and on how the same basic questions have perplexed leading scientists throughout history.

Panek has a talent for elucidating difficult concepts. For example, his account of the history of dark energy, including Einstein’s famous blunder of removing the cosmological constant, is explained beautifully and in some detail. Panek also does a good job of explaining the difference between hot and cold dark matter. And he knows how to turn a phrase. After mentioning that in high school Saul Perlmutter (another of the 2011 Nobel Prize winners) had wanted “to learn how to think like a writer” but in college had majored in physics and ultimately chose to study supernovae, Panek makes this observation: “Instead of the nature of narrative, Perlmutter would be exploring the narrative of nature.” These and many other little gems make for fun reading.

The book is not completely error-free. On page 192, for example, *gauge boson* and *gaugino* are misspelled, we read that the supersymmetric partner of the neutrino is the neutralino (it’s actually the sneutrino), and Panek appears to imply that the neutralino was proposed as dark matter before the axion (in fact, the possibility of axion dark matter was noted by three independent research groups just before neutralino dark matter was proposed in 1983 by Haim Goldberg). Such mistakes are very few and far between, however, and do little to diminish Panek’s significant accomplishment of explaining complicated concepts in new and enlightening ways.

Spectacular progress has been made on dark matter and dark energy in recent years, and as a result, the genre of popular books on cosmology is becoming a crowded field. Some recent offerings have violated Einstein’s edict to make everything as simple as possible, but not simpler. In *The 4% Universe*, however, the ideas are explained clearly for an intelligent nonexpert audience; little previous knowledge is required, and the science has not been distorted beyond recognition by the use of poetic license. Along the way, the book sheds light not only on our current understanding of the universe, but also on the people studying it. The result is a fascinating picture of humankind’s never-ending journey to comprehend the cosmos.

Jonathan L. Feng is professor of physics and astronomy at the University of California, Irvine, working at the interface of theoretical particle physics and cosmology. He is coauthor, with Mark Trodden, of the November 2010 Scientific American cover story on cosmology, and he recently narrated, with Daniel Whiteson, an animated PhD Comics strip by Jorge Cham on the topic of dark matter.