books

# An antidote to cosmic alienation

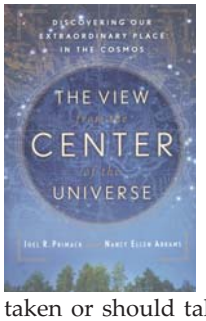
## The View from the Center of the Universe

### Discovering Our Extraordinary Place in the Cosmos

**Joel R. Primack and Nancy Ellen Abrams**
*Riverhead Books, New York, 2006. $26.95 (386 pp.). ISBN 1-59448-914-9*

*Reviewed by Michael S. Turner*

During graduate school, when I was shifting fields from particle physics to astrophysics, I decided to read an elementary book on astronomy to get the lay of the land. What I learned depressed me: We humans occupy an insignificant place in the grand scheme of things, and there is no evidence that the universe has taken or should take note of us. I suspect many other scientists, as well as nonscientists, have had a similar experience. Carl Sagan summed it up well: "We live on a hunk of rock and metal that orbits a humdrum star in the obscure outskirts of an ordinary galaxy"—and he said it before dark matter and dark energy were discovered and were found to account for 96% of the stuff in the universe.




In *The View from the Center of the Universe: Discovering Our Extraordinary Place in the Cosmos*, Joel Primack, a leading cosmologist and professor of physics at the University of California, Santa Cruz, and his wife Nancy Ellen Abrams, a lawyer, writer, and musician, tell us that this cosmic alienation has its roots in the Copernican and Newtonian revolutions and a Faustian deal brokered by René Descartes and Francis Bacon. In the wake of Galileo's bad experience with the Catholic Church, scientists adopted a policy of noninterference with religion, dividing the world into the material (realm of science) and the spiritual (realm of religion). This division allowed science to flourish unfettered. And flourish it did—with profound advances in our understanding of nature, from quarks to the cosmos, and dramatic advances in our quality of life, from electricity and medicine to science-based agriculture and today's quantum-based information economy.

Yet Primack and Abrams argue that the bargain had a significant downside: the severing of humankind's connection with the universe. They also contend that the present revolutionary period of cosmic discovery is the right time to reestablish a widely shared cosmological myth that connects us to the universe. Reconciliation 400 years after a messy divorce is not easy; but with their complementary backgrounds and a decade of jointly teaching a course on cosmology and culture at Santa Cruz, this husband-and-wife team is well qualified to start the conversation.

The book is divided into three parts. The first part is a review of the cosmological myths that preceded the divorce of science and religion, from the cosmology of ancient Egypt to the heavenly spheres that survived from Ptolemy to the Middle Ages. The second part is an exposition of our present understanding of the universe; it focuses on recent breakthroughs such as inflation, dark matter, and dark energy. The third part is an exploration of how we might take advantage of this quantum leap in our knowledge to reconnect with the universe, and even learn lessons from the universe. In the authors' words, "think cosmically, act globally." The book also contains 75 pages of notes that provide expanded discussion and references—both on cosmology and philosophy. These extensive notes are a testimony to the authors' scholarship and style.

The discussion of contemporary cosmology is built around five simple and engaging questions: What is the universe made of? What is the "center of the universe"? What size is the universe? Where do we come from? Are we alone? By and large, Primack and Abrams's approach works, yet I would fault this part of the book a bit for its brevity and lack of illustrations. The authors give short shrift to some important topics—for example, the origin of symmetry between matter and antimatter. I also have some quibbles, for instance, with odd assignments of credit for the introduction of supersymmetric dark matter and inflation. Given the brevity of this part of the book, I believe the authors would have better served readers by staying away from the always difficult and contentious area of saying who did what when.

The most interesting twist in their presentation, one well suited to their larger goal, is the re-centering of humankind in the story. Our physical size is the almost geometric mean of the largest thing we can imagine, the visible universe, and the smallest thing we can rationally discuss, the Planck scale. We are made of the rarest substance in the universe, atoms beyond helium, which accounts for less than 0.1% of the universe. Last but not least, the authors replace the heavenly spheres of Ptolemy with spheres of time, which is appropriate to our isotropic and homogeneous universe, and locate us at the center of time since both our galaxy and Sun are in their middle ages.

It is part three, on the quest to find meaning from our deepened knowledge of the cosmos, that sets the book apart from other popular accounts of the new cosmology. Primack and Abrams present three examples of how we might reconnect by learning from our cosmic evolution. One example involves gravity and wealth. Galaxies, stars, and all cosmic structures are around only because "matter-rich" (higher density) and "matter-poor" (lower density) regions in the universe existed early on. The attractive effect of gravity makes matter-rich regions richer and matter-poor regions poorer. After billions of years, the phenomenon led to bound structures such as our own Milky Way galaxy. Essential to the success of this process is the fact that the inequities were modest because gravity

**Michael S. Turner** is the Bruce V. and Diana M. Rauner Distinguished Service Professor in the departments of astronomy and astrophysics and physics at the University of Chicago in Illinois. His research interests are in theoretical astrophysics, cosmology, and elementary-particle physics.

would cause extremely overdense regions to immediately pinch off the space around them and form black holes.

The lesson the authors glean about wealth concentration from their discussion of the effect of gravity is clear: modest wealth concentration can lead to good consequences; excessive wealth concentration can have disastrous effects. As Primack and Abrams aspire to obtain deeper meaning from our knowledge of the universe, they recognize they are battling an existential alternative, the one that depressed me as a graduate student and is well articulated in Steven Weinberg's influential text *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity* (Wiley, 1972): "The more comprehensible the universe becomes, the more pointless it seems."

*The View from the Center of the Universe* has big ambitions and a novel approach for conveying the content and excitement of the current revolution in cosmology. I know of no other book that explains eternal inflation using a Las Vegas analogy, quotes freely from cosmologist Andrei Linde and mythologist Joseph Campbell, and discusses the neurological basis of the human use of metaphor. This book may disappoint the most ardent followers of cosmology who are interested in reading more about the latest developments in the field. And when it comes to reconnecting humankind with the universe, it is still very much a work in progress. Nonetheless, Primack and Abrams's book is well written and thought provoking. *The View from the Center of the Universe* may even add significantly to ongoing discussions of the proper relationship between science and everything else—including religion.

# Astroparticle Physics

**Claus Grupen**
*Springer, New York, 2005. $59.95 (441 pp.). ISBN 3-540-25312-2*

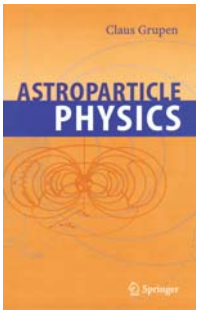
*Astroparticle Physics* by Claus Grupen attempts to provide a broad overview of particle astrophysics, from studies of cosmic rays to the early universe. A book with such a broad scope would challenge any author. It should present a unified picture of the subjects and a reason why each is included. Unfortunately Grupen does not meet the challenges. Instead, his *Astroparticle Physics* is a set of disconnected short articles introducing disparate topics, often with no clear progression of material.

The book's lack of development results in repetition and little in-depth coverage. The deficiencies are most noticeable in the first half of the book, which covers high-energy gamma-ray and cosmic-ray astrophysics. The second portion, on cosmology, is substantially better, which left me wondering why the author dealt with many of the topics in the first half. One major complaint is the paucity of references, an especially problematic feature because the author includes controversial results that have proved to be incorrect, sometimes even before the book was written.

With the recent results from the high-energy stereoscopic system telescope (HESS) in Namibia, the field of high-energy gamma-ray astrophysics is now undergoing a revolution. Unfortunately, Grupen's book was written before that development, and only minor updates were made during the English translation. Although not completely the author's fault, the omission leaves the reader with a somewhat obsolete view of the field.

Remarkably, the discussion of high-energy gamma-ray astrophysics makes no mention of the Whipple telescope. The telescope's imaging technique enabled researchers to witness the first convincing observation of a source of TeV gamma rays—the Crab Nebula. The results were published by Trevor C. Weekes's group in 1989, and the discovery came after decades of struggle over false and contradictory results. The author does offer an abbreviated version of some of the more controversial claims from early work involving the observations of Cygnus X-3. But the discussion is so perfunctory that it does not do justice to the story. Similar problems arise in Grupen's coverage of ultra-high-energy cosmic rays. Some suspicious results—"hints" of an excess from the supergalactic plane—are discussed without an appropriate level of skepticism. Why are results of questionable credibility included in a graduate textbook?

The book omits many topics, and some that it includes are of dubious value. One notable omission is any discussion of the absorption of TeV gamma rays through interactions with optical and infrared photons as those rays propagate through the universe. Although Grupen presents a detailed study on absorption of higher-energy gamma rays via interactions with the cosmic microwave background radiation, the figure demonstrating the effect is misleading because it shows the lower-energy photons as unattenuated. In fact this is an active area of research, and the absorption spectra from active galaxies have been used to set stringent limits on the density of infrared photons in intergalactic space.




The author states that no measurements of the cosmic-ray composition have been made above the energy reach of satellite-borne detectors, about $10^{15}$ eV. That statement completely ignores the important 1990 results from the High Resolution Fly's Eye (HiRes) group in Utah, which measured a changing composition from heavy nuclei to light nuclei at energies near $10^{17.5}$ eV. Moreover, in chapter 7 there is a rather detailed discussion of radiation belts and the composition of the secondary cosmic-ray particles produced in the atmosphere. Although the information is of some interest, it bears little relation to the remainder of the book. The space could have been better used to further develop the theoretical aspects of high-energy astrophysics.

Beginning with the chapter discussing cosmology and the early universe, many of the problems mentioned above disappear. These later chapters present a unified view and a straightforward topical progression of the field. From the Big Bang to the development of the Friedmann equations, Grupen takes readers on a quick but relatively complete tour of the state of the field. His treatment of inflation is a good introduction for the nonexpert, as is his coverage of Big Bang nucleosynthesis and the classic derivation of the limit to the number of neutrino flavors—though the last is without reference or attribution to the pioneering work of Gary Steigman, David Schramm, and James Gunn. The author completes the overview in the penultimate chapter with a discussion of dark matter—and that is where the book should have ended. Unfortunately, an additional four-page chapter on astrobiology reminds readers of the problems in the first part of the book. Again, I wondered—Why?

The second half of *Astroparticle Physics* could be used as an introduction to cosmology in an undergraduate class. Exercises at the end of each chapter contain useful information and are an important part of the book. For an introduction to high-energy astrophysics, it is difficult to do better than Malcolm Longair's *High Energy Astrophysics*