

## Looking into it

Joseph Silk

**The Fifth Essence: The Search for Dark Matter in the Universe.** By Lawrence M. Krauss. *Basic Books*: 1989. 342 pp. \$19.95. Distributed in Britain by *Hutchinson/Radius*, £14.95.

**Invisible Matter and the Fate of the Universe.** By Barry Parker. *Plenum*: 1989. 297 pp. \$28.20, £17.63.

DARK matter is cosmology's paradigm for the 1990s. Depending on who does the book-keeping, 90 per cent, or even 99 per cent, of the Universe has resolutely resisted all attempts by astronomers to detect it. One view is that the Newton-Einstein theory of gravity, which has worked so well over the scale of the Solar System, will be superseded in the remote depths of intergalactic space. The dark halos that are inferred to surround galaxies would then turn out to be a mere illusion. The overwhelming majority of cosmologists, however, are convinced by the reality of the dark matter. No longer is the epithet "missing" matter appropriate: the gravitational probes developed by taking spectra of gas clouds and dwarf galaxies in remote circumgalactic orbits confirm the inexorable tug of the dark matter. An impressive array of experiments has been developed in recent years to search for this pervasive but elusive component of the Universe.

These two books are devoted to describing the theory of dark matter. *The Fifth Essence* is by Lawrence M. Krauss, a pioneer of the evolving discipline of particle astrophysics. This new field is at the interface of particle physics and astronomy, and has provided a major industry for astrophysicists. The search for dark matter is a prime example of what drives particle astrophysics. Hints abound from cosmologists that something new is needed to explain their observations. Particle physicists, impatiently awaiting the construction of ever larger and more expensive particle accelerators, eagerly seize the opportunity provided by the astrophysical laboratory for testing their newest theories. And with good reason: energies achieved routinely in the very early Universe exceed by many orders of magnitude those attainable in the more grandiose accelerators now being planned. Dark matter may plausibly consist of some exotic weakly interacting particle, thereby naturally accounting for its domination of the outermost, low-density environs of galaxies, whereas the strongly interacting stuff of which stars are made dissipates freely and is concentrated in the inner luminous cores of galaxies.

Naturalness does not by any means stop here if you are a particle theorist.

Krauss embarks on a meandering journey through the various symmetries of the fundamental interactions. The going is not easy, but I found the description of the axion, named after a laundry detergent for reasons that he does not explain, a brave and lucid attempt to clarify some of the more esoteric aspects of elementary physics. Krauss does have a tendency to launder the language ("that's piddling", "it's a snap"), and tells us on three separate occasions (all neatly indexed) that Alan Guth is a young particle physicist. The astronomical aspects of cosmology are well covered: we learn about the microwave background and the puzzles of large-scale structure. Some mysteries remain: for example, the reader is left wondering why two Nobel laureates thought pigeon droppings might be a source of omnidirectional radio noise. Occasional errors creep in: the excess of high-frequency energy in the microwave background was reported by a rocket-flown, not a satellite-based, experiment. But the highlights include enthralling descriptions of the direct searches for dark matter being mounted deep underground by several groups around the world.

*Invisible Matter and the Fate of the Universe*, by Barry Parker, provides a very different approach to dark matter. Parker makes no pretence of explaining the arcane mysteries of particle physics, but provides capsule summaries of practically all important astronomical discoveries even remotely related to dark matter. His style emphasizes personalities, to the extent of incorporating informal quotations from many of the featured astrophysicists, together with their photographs. His journalistic approach provides the flavour of current research while allowing him to avoid getting bogged down in the technical background. Gaps are inevitable, but Parker succeeds in making the latest ideas accessible.

The author's principal weakness is that he is uncritical. He quotes Arp on discordant redshifts, and Tifft on their quantization, with the same emphasis that he places on less controversial theories. "We don't know" summarizes his reaction. Fair enough, but the naive reader will stumble inadvertently into a minefield of controversy without more guidance.

Some cosmologists get short shrift, Fred Hoyle in particular. But it was Hoyle who first conjectured that the angular momentum of galaxies may arise from tidal torques between protogalaxies, and it was Hoyle who, with Roger Tayler, resurrected Gamow's idea that primordial nucleosynthesis formed helium in the hot Big Bang. I was left puzzled by some remarks. Why should dark matter in the form of dwarf stars (red, white, brown and black) make galaxy halos any "stickier" than alternative forms of dark matter?

The discussion of black holes is confusing. John Mitchell and Pierre Laplace noticed in the eighteenth century that a star equal in mass to the Sun but one-hundred-thousandth of its radius would possess a gravitational field so strong that light could not leave it. Very large, but still finite, pressure is attained by gravitational contraction of sphere to its Schwarzschild radius. No infinity there, contrary to what Parker states. He seems to be unaware of the gallium experiments now being mounted to search for neutrinos from the Sun. And what is the meaning of the claim that Dirac's monopole has a tail, or a string, attached? In summary, despite the breathless style, the book is fun to read.

These two volumes make a good combination. The concept of a Universe dominated by dark matter is difficult to swallow, but the evidence is conclusive. Try *Invisible Matter* for an aperitif, and *The Fifth Essence* to provide the entrée. □

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## Protecting all interests?

Barry Cross

**Animal Patents: The Legal, Economic and Social Issues.** Edited by William H. Lesser. *Stockton, New York*: 1989. Pp. 369. £55, \$100.

FEW issues are more fiercely argued today than those surrounding the creation of new varieties of animal life in the test tube. Shortly before Christmas, a much publicised debate on BBC television in Britain ended in a two-to-one vote in favour of a bill of rights for animals. The notion of patenting animals is anathema to many, and the Patents Act of 1977 precludes this practice for animals bred in the normal way, although whether genetically engineered animals can be patented has not been tested in the British courts. The European Patent Office, however, seems to be moving in the direction of recognizing the patentability of living matter. If biotechnology companies, which invest heavily in new developments in animal breeding, are not given patent protection they will be unable to compete in international markets. So we are witnessing the familiar conflict between economic advantage and moral objection, and it is quite possible that the European Parliament will take a different view from that of the European Patent Office.

*Animal Patents* is not for the faint-hearted. Half the pages are devoted to thirteen essays on legal, technical,