Fifteen years later, Eleanor Wilson Orr published this book about Hawthorne's experiment. The 1997 reissue has a new introduction commenting on the Oakland 'Ebonics' furore (see *Nature* **386,** 321; 1997). Orr's thesis is that black children's mathematical misapprehensions are often due to contrasts between AAVE and standard English, particularly regarding grammatical function words (prepositions, comparative 'than', equative 'as').

The topic merits attention. Starting out with a different prepositional system might well interfere with acquisition of arithmetical concepts expressed in English through metaphorically extended preposition meanings: a quarter *of* 16 is obtained by dividing 16 *by* 4 or dividing 4 *into* 16 or dividing 16 *into* quarters, and so on. And there are indeed some prepositional use differences between AAVE and standard English. Orr offers thought-provoking transcriptions of student reasoning; and some of what they reveal might be traceable to translation problems. (This possibility was the grain of truth in the policy of acknowledging AAVE for which the Oakland school board was so mercilessly mocked.)

But Orr fails to establish AAVE's causal role. Superficial and anecdotal examples of AAVE are presented along with data from a different language, Guyanese Creole. No clear linguistic aetiologies for mathematical conceptualization difficulties emerge. For example, the attempt to link AAVE's negative concord rule to confusion of 'half' with 'twice' (equating 'half as small' with 'twice as small') is intriguing, but the proffered speculations about a determinative influence are less than convincing.

Some of the cited misunderstandings seem clearly nonlinguistic. For example, there is evidence of students thinking that to show why some abstract relationship holds one need only give an example in which it holds. We need not take AAVE to be implicated in such signs of unfamiliarity with abstract thinking. It is common today to find speakers of standard American English, even at college level, who reason similarly. □

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Detecting the undetectable

Cosmic Bullets
by Roger Clay and Bruce Dawson
Addison-Wesley/Allen and Unwin: 1998. $22 (hbk), £7.99 (pbk)

Peter L. Biermann

The most energetic particles we measure in the Universe come from outer space and hit the Earth at a rate of only about one particle per square kilometre per century. And yet we have now measured about a dozen such particles, with several detector systems, and their energy is near 10^{21} eV.

Roger Clay and Bruce Dawson have written a small book describing how these particles were discovered, how we became certain that their energy is really that high, and how the search for their origin and nature is heating up. The book nicely provides the setting of the discovery and explains why in theory such particles should not really be detectable: because they interact with the microwave background, there should be only negligible flux beyond about 5×10^{19} eV. The exciting finding is that no cut-off has yet been seen in the sparse data, with the highest energy events having values near 2×10^{20} eV and 3×10^{20} eV.

Fell to Earth: the Chicago Air Shower Array is aimed at detecting high-energy cosmic and gamma rays.

UNIVERSITY OF CHICAGO

The authors trace the excitement of the research community in 1996, even telling the story of the possible correlation of the particles with the supergalactic plane. This plane is the locus in the sky where most cosmologically nearby galaxies and radio galaxies are, so one might expect that the high-energy particles can be traced to at least this distribution. Sadly, the authors just missed the events of May 1997, when the brightest gamma-ray burst so far was seen at gamma, X-ray, optical and radio wavelengths. Gamma-ray bursts may or may not be related to the highest energy particles, but they are surely good candidates to investigate.

As described in the book, the idea with the longest staying power in the whole story would seem to be that these particles arise from acceleration in gigantic shockwaves in powerful radio galaxies. As we have studied radio galaxies for many decades it is surprising that we have not confirmed or refuted such a concept and moved on to the more challenging possibilities such as tracing the high-energy particles to topological defects created in the Big Bang or — perhaps even more exciting — tracing them to supersymmetric partners of normal particles.

A book of this type must, of necessity, make compromises in elucidating the physics. But I think that some of its shortcuts are a little odd. For example, of Max Planck's discovery, the authors write: "he developed a mathematical technique for explaining the spectra of heated bodies". The reader needs to have a good knowledge of the history of science to understand what they are referring to.

Also, although the book conveys well the excitement of some of the steps in the stony path of discovery, it seems that the delight of detecting something new is virtually impossible to capture in mere dry words. (I speak as one of the participants in the story.) On the whole, however, the book is eminently readable for both experts and laypeople, particularly a young readership.

The basic nature of matter is commonly explored in expensive large accelerators such as those at Stanford, Fermilab and the European Laboratory for Particle Physics. The high-energy events now observed through air-showers are far beyond any energy obtainable in these machines on the ground. The book culminates in describing the Auger project, the ambitious plan to erect two gigantic air-shower arrays in Earth's northern and southern hemispheres. These air-shower arrays will be sufficiently large for us to be able to observe many high-energy events, and so eventually do physics at energies of 10^{21} eV and possibly higher. □

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