

Inside the black box

Werner Israel

Kinetic Theory in the Expanding Universe.

By Jeremy Bernstein. Cambridge University Press: 1988. Pp. 149. £22.50, \$37.50.

THROUGH much of its early history, the expanding Universe passed uneventfully through a succession of thermal equilibrium states, its equilibrium maintained by interactions which kept all constituents strongly coupled. But there were interludes when things became livelier. Many distinctive features observable today stem from episodes when equilibrium was upset because a declining reaction rate began to lag behind the expansion or the temperature dropped below the threshold for pair creation of some key particle. Most familiar is the three-minute episode of helium production at the end of the lepton era, but this kind of picture is pervasive in present-day cosmological theories.

Because a nonequilibrium episode is generally not brief compared to the expansion time, determination of the resulting cosmic abundances confronts the physicist with a genuine nonequilibrium problem, involving integration of an intricate system of reaction-rate equations. Understandably, the details have increasingly taken on a 'black-box' aspect, accessible only to specialists with elaborate computer codes. Bernstein's little book is a fine pedagogical introduction to this class of problems which demonstrates that this need not be so. By judicious approximations, one can derive analytical formulae that reproduce the computer results to within a few per cent. More important, they offer a ready way to estimate the effects of changing the many more-or-less uncertain parameters that enter the calculation: cross-sections and half-lives, the photon-to-baryon ratio, the degree of isotropy, the cosmological constant and modifications of general relativity.

The first section (35 pages) aims to provide thumbnail introductions to Friedmann–Robertson–Walker (FRW) models and to relativistic kinetic theory. It begins inauspiciously with a newtonian derivation of the FRW dynamical laws that is seriously flawed. (The proper starting point is not Newton's law of motion but the newtonian law of energy conservation: they are equivalent only for pressureless models.) The treatment of kinetic theory betrays no hint that general relativity is a geometrical theory, and the algebra is heavy-handed and opaque. A beginner, wishing to understand intuitively the "important remark" (p. 6) that an expanding Universe has no timelike

Killing vector, is none the wiser for being told that a Killing vector is a solution of a partial differential equation of unspecified provenance.

One should not make too much of such cavils. The book is otherwise a unique and valuable addition to the literature on cosmo-particle physics, and this introductory material is easily accessible elsewhere. Nevertheless, from an author with Jeremy Bernstein's gifts for lucid exposition one is entitled to expect more. Please Mr Bernstein: can we have a rewrite of these pages in the next edition? □

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Bedtime reading

Ian Oswald

Sleep and Dreaming. By Jacob Empson. Faber & Faber: 1989. Pp. 258. £12.99.

"THE favours of the strictest ladies will be wholly won for you, at the moment you become the sympathetic interpreter of their dreams" — this is just one wish-fulfilling idea from the many historical nuggets that Jacob Empson offers us in *Sleep and Dreaming*. Dreams have traditionally been regarded as prophetic, and from Empson we learn that 50 per cent of those possessed of the benefits of modern higher education still accept that dreams foretell the future.

Divergent-minded writers always have been able to let themselves go on dreams, but solid scientific knowledge about the physiology of sleep is recent. As in past centuries, however, the theorists of today reflect the ideas of their time. Empson gives a good summary of recent dream theories, such as those of Crick and Mitchison, or Hobson and McCarley, which ride upon the back of physiology. To my mind, Empson could have brought home more sharply to the reader that the new theories (alas, no more open to objective verification than those of past centuries) fail to take account of the continuum in mental life as it is experienced in day-dreaming, in drowsiness and in all the stages of sleep. The theorists over-emphasize visual imagery, rather than recognize the dream as an experience of living in a fantasy world, and they forget that people blind from birth dream as much as anyone else.

Dreams are not eye movements, nor electrical discharges from the hind brain. True enough, if people are wakened from periods of rapid eye movement (REM or paradoxical) sleep, there is a good chance that a dream will be described, but it is

only twice the chance of an equally rich dream being described after rousing someone who had merely become drowsy. The most intense of all dreams are night terrors, and they are not related in time to REM sleep.

In order for us to lay down information in our memory store we have to pay attention. While we sleep we are not keenly paying attention, and afterwards we remember hardly anything of the dreams that occupied a large part of the night. As Empson says, if dreaming really were a means of finding solutions to life's problems, as some would claim, it would be a bit pointless when the dreams are almost entirely forgotten within minutes.

Readers will not find the book spoiled by attempts at over-inclusiveness, nor will they be wearied by any personal hobby horse. There is sensible advice to those who are dissatisfied with their sleep, to relax and forgive their enemies, and to get up earlier in the morning in order to make sure of swift falling asleep at night. I was, however, foxed by the remark about infants who wake their parents at night: "It is important not to allow these sleep problems to continue after the age of two". I'm afraid that some child psychologists, who make claims of being able to help desperate parents, do not bring with them evidence from parallel-group controlled trials. Normal maturation means that most children become good sleepers by school age without 'treatment', but they will not oblige by promptly doing so at the third birthday. Empson's compact book is well written, the best of its kind, and one that deserves to be widely bought. □

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• A book that appeared after preparation of the review of Empson's monograph is *Sleep* by J. Allan Hobson, a beautifully produced volume in the Scientific American Library series (W.H. Freeman; \$32.95, £14.95). Hobson has been a distinguished researcher into the activity of cells in the brainstem of laboratory animals. Here he writes in a highly personal way, the first page setting the tone: "the study of sleep and especially dreaming is changing humankind's view of itself". Moreover, "The new psychology of dreaming could help all of us, mentally ill or sane, function better". Assertions such as this are recurrent. The mechanism of sleep is that "the thalamus and cortex become susceptible to the normal loss of consciousness": in my view this statement would be no more comprehensible to most neurophysiologists than to psychologists. I don't think human sleep problems are really explained by "the ratio of aminergic to cholinergic neuronal firing level". The photographs of sleeping animals are lovely, but otherwise I was disappointed. Ian Oswald