

letters

There are an infinite number of stars in a spatially infinite universe, but around each observer only the finite number N is needed to cover the entire sky. In Allen's mathematical model we have $\sigma = 0$ and $N = \infty$, and quite rightly in this particular case it is then questionable whether a bright sky is in principle possible. (For instance, if S is the radius of the universe and we keep the product SR constant as $S \rightarrow \infty$, it then follows that $\lambda/S \rightarrow \infty$, and a bright sky is impossible.) The value of N is estimated as follows: Let $\rho \approx 10^{-30} \text{ g cm}^{-3}$ be the average density of stellar material in the universe and let also $\rho^* \approx 1 \text{ g cm}^{-3}$ be the average density of matter within stars; we then obtain

$$N = \left(\frac{4}{3}\right) \left(\frac{\rho^*}{\rho}\right)^2 = 10^{60}$$

and this is the number of stars required to create a bright sky. A spatially closed homogeneous and isotropic static universe contains a finite number N' , say, of stars that may be less than N . In this case light circumnavigates the universe $(N/N')^{1/3}$ times to create a bright sky.

One can criticize many of the original physical assumptions of the bright-sky theory, but I do not think the paradox it poses can be dismissed or resolved by mathematical arguments of the kind raised by Allen. Many have criticized the paradox on the grounds that it is basically meaningless, and it is therefore important to realize that it is quite easy to construct models in which the night sky is not dark. An Einstein static model of density $\rho > 10^{-17} \text{ g cm}^{-3}$, for example, has a thermodynamic time scale (in which light circumnavigates more than 10^6 times) that is less than the luminous lifetime of stars, and in such a model the night sky is bright. At the risk of cluttering up the argument with details, I should perhaps also mention that the Einstein model is dynamically unstable. The time scale of this instability is approximately the time it takes for light to circumnavigate only once. We therefore require an Einstein static model of density $\rho > 10^{-5} \text{ g cm}^{-3}$ in order that the thermodynamic time scale be less than the instability time scale. It is then quite easy to show that this particular bright-sky model contains only 10^4 stars of solar mass.

E. R. HARRISON
University of Massachusetts
Amherst, Massachusetts

Models of the sun

At the end of Barbara Levi's account of the solar-oblateness measurements by Henry Hill and his collaborators at the University of Arizona (September, page

17), there is mention of the possible relation of these measurements with the problem of solar neutrinos. It is remarked that the low neutrino flux is consistent with models of the Sun with a rotating core such as Robert Dicke's model.

In the context of solar neutrinos, it is misleading to lump all solar models with a rotating interior under a single heading. In fact, Dicke's model of the Sun, in which most of the mass rotates rigidly with a period of about one day, yields practically the same high neutrino flux as a nonrotating model.¹ Among models with a rotating interior, of which a variety have been discussed during the last few decades, it appears that only those including a *small* rotating core (of the order of one tenth of a solar mass) in a state of *rapid* rotation (in the sense that rotation affects appreciably the pressure gradient in the model, corresponding to a period of the order of one hour) can produce the desired reduction in neutrino flux.²

Whatever the merits and drawbacks of this class of models, which have been discussed in recent literature,³ they imply an internal structure and rotational history for the Sun sufficiently different from that proposed by Dicke to make them definitely distinct.

References

1. R. K. Ulrich, *Astrophys. J.* 158, 427 (1969).
2. P. Demarque, J. G. Mengel, A. V. Sweigart, *Astrophys. J.* 183, 997 (1973); *Nature Physical Science* 246, 33 (1973).
3. I. W. Roxburgh, *Nature* 248, 209 (1974); R. K. Ulrich, *Astrophys. J.* 188, 369 (1974).

PIERRE DEMARQUE
JOHN G. MENGEL
ALLEN V. SWEIGART
Yale University
New Haven, Connecticut

Reactor safety study

"State and Society" in the November issue (page 87) reports on a \$3-million 14-volume reactor-safety study just released by the AEC. The overall conclusion is "the risks to the public from potential accidents in nuclear-power plants are very small." This is, if I remember correctly, the n -plus-one-th study by the AEC with the same conclusion in the past several years.

I call to your attention an article starting on page one of *The New York Times* of 10 November 1974. The title of the article is "AEC Files Show Effort to Conceal Safety Perils," and the article, written by David Burnham from an examination of letters and memos written by industry and commission officials in the past ten years, bears out the title.

NEW

DUAL THEORY

edited by M. JACOB, TH. Division,
CERN, Geneva, Switzerland.

1975 400 pages.

Price: US \$24.50 / Dfl. 63.50.

The papers contained in this book review clearly and precisely the whole development of dual theory up to the present time.

Written by some of the leading contributors to the theory and updated since their appearance in *Physics Reports*, these papers provide a general introduction for the newcomer to the field as well as keeping the expert abreast of current research.

REACTIONS BETWEEN COMPLEX NUCLEI.

Proceedings of the International Conference on Reactions between Complex Nuclei, Vanderbilt University, Nashville, Tenn., June 10-14, 1974

edited by R. L. ROBINSON, F. K. McGOWAN, J. B. BALL, Oak Ridge National Laboratory, and H. HAMILTON, Vanderbilt University.

Volume 1 - contributed papers,
1974 211 pages.

Price: US \$16.95 / Dfl. 44.00.

Volume 2 - invited papers,
1975 680 pages.

Price: US \$50.00 / Dfl. 130.00.

Set price for both volumes:
US \$60.00 / Dfl. 156.00.

The proceedings of this international conference on reactions between complex nuclei are published in two volumes. The first contains contributed papers while this, the second, presents the invited talks.

Together these volumes survey the whole area of heavy-ion nuclear physics. Emphasis is placed on the nuclear physics of heavy-ion ($A > 4$) induced reactions, including elastic and inelastic scattering, compound nuclear reactions, fission, high-spin states, transfer reactions, Coulomb excitation and production of nuclei far from stability including heavy and super-heavy elements.

NORTH-HOLLAND PUBLISHING CO.

P.O. Box 211
AMSTERDAM, The Netherlands

Sole distributors for the U.S.A. and
Canada
American Elsevier Publ. Co.
52 Vanderbilt Avenue
NEW YORK, N.Y. 10017

Circle No. 56 on Reader Service Card