The early universe

Ya. A. Smorodinskiĭ

Usp. Fiz. Nauk **159**, 393–394 (October 1989)

G. Börner. *The Early Universe. Facts and Fiction.* Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1988. 439 pp. (Physics Texts and Monographs).

The Universe retains a memory of its history in an amazing manner. Just as archeologists dig up evidence concerning the history of the Earth, so astronomers extract history from observations of the sky. While archeologists reconstruct terrestrial history on the scale of millions of years, the astronomers penetrate into the past for billions of years. But almost all the events of this ancient history occupy a very small interval of time near the birth of the Universe. The title of S. Weinberg's book "The First Three Minutes"[1] has become a popular saying. All the most important events from the "moment of birth" of the Universe up to the moment of birth of galaxies are well contained within this framework. The beginning of the early history is determined by the "Planck second"—the unit of time $T_{\text{Pl}} \sim 10^{-43}$ s, which can be made up of three quantities,—the gravitational constant G, the Planck constant $\hbar$, and the velocity of light c. Such a time scale determined, most likely, the course of events when no particles were present in the Universe. One can say that the early history being reconstructed now begins at a somewhat conventional point to $\approx 10^{-43}$ s, measured from the not too well understood instant of the Big Bang.[2]

But if one leaves out of consideration the time $t < t_0$, then beyond that what we know about the history of the Universe is even less than what we know about the history of the Earth.

Börner's book—the most recent of the monographs—is a textbook on the early history of the Universe, sufficiently complete to serve a reference book for specialists, and sufficiently simple to become an instructional aid for a beginner. It is very important that the author in following an old tradition wrote the book by himself, basing it on numerous discussions with colleagues. By following this procedure he achieved a homogeneous (and a good literary) level of the book which is often lost in the currently fashionable collections of individual articles.

The book consists of three parts approximately equal in length: I. Standard model of the Big Bang. II. Particle physics and cosmology. III. Dark matter and formation of Galaxies.[3] An appendix concerning gauge-invariant perturbation theory completes the book.

While even a few years ago one had to call attention to inadequacies in presenting results of Soviet science, Börner is well acquainted with them and devotes sufficient space to them. The only point which should have been noted is the old paper by E. Gliner—the first one who pointed to the possible equation of state in the early Universe $\varepsilon + p = 0$, which cleared the way for the idea of the inflationary Universe.

The presentation of the history of the inflationary Universe could have been made more interesting. The arguments surrounding the small Leningrad school deserve being remembered. Also of interest is the work of the Leningrad physicist G. Mandel' on the theory of the Kaluza-Klein model which have almost been forgotten even in our country.

The first third of the book contains an almost digest-like presentation of the theory of Friedmann's expanding Universe, and a critical discussion of the fundamental constants: the Hubble constant, the average baryon density, age, etc.

The second third of the book is devoted to the modern theory of elementary particles. This is a condensed, but very informative account, which, of course, cannot teach one how to make the necessary calculations, but which does give a clear idea of the different directions of the theory right up to the unified theory (the supersymmetric universal theory). A brief presentation is given of such hypothetical particles, as monopoles, axions, gravitons, etc. A discussion of the baryon asymmetry also finds it deserved place.

The last third of the book will be read with considerable advantage by specialists on particle theory. This part is devoted to the history of galaxies. Here another direction of modern thought enters cosmology—nonlinear processes and stability. The distribution of galaxies in the Universe and the giant voids are results of complex processes leading to chaos. Perhaps here we have encountered the most fascinating direction in cosmology.

So what can one say in conclusion? Börner's book is pure fantasy, which, however, has an entirely real foundation.

[1] S. Weinberg, The First Three Minutes, Fontana: Collins, 1978 [Russian transl. Energoatomizdat, M., 1981, second ed. 1988].

[2] The bold fantastic ideas concerning what happened prior to the Big Bang are discussed in Hawking's book "A Brief History of Time," the translation of which is in preparation by "Mir" publishing house.

[3] I would like to note a certain similarity of the problem of dark matter (what is it?) and the problem of the missing link in the origin of man (who was he?).

Translated by G. M. Volkoff