How Did the First Stars and Galaxies Form? Abraham Loeb. 193 pp. Princeton U.P., 2010. Price: $24.95 (paper) ISBN 978-0-691-14515-0. (Milan M. Ćirković, Reviewer.)

We inhabit a very, very small part of the universe which grew larger (epistemically speaking) in revolutionary shocks and convulsions: with Copernicus in 1543, Hubble in 1924, and probably also with Alan Guth, Andrei Linde and other cosmologists in the 1980s. Somewhat ironically, we exist owing to minuscule deviations of our universe from its original almost-perfect uniformity (the latter is, already somewhat quaintly, referred to as the Cosmological Principle) -- deviations that grew into the *structure* we perceive: most prominently, galaxies and stars. If one wanted to describe in one phrase the single most important process that has happened in the entire 13.7 billion years of cosmic history, the correct answer would undoubtedly be "the formation of structure". Most of the actual research in astrophysics and cosmology is concentrated on the elaboration of this process, which made gigantic strides in the last quarter of a century. Anyone interested in an introduction to this dramatic story, be they academic or educated nonprofessional, would do well to start with Loeb's book. It contains only the most important equations in the field, and its general level of mathematical sophistication is compatible with introductory courses in calculus or mathematical physics.

This small book is a gem belonging to an almost extinct genre: intermediate-level monographs that are both *accessible* to educated non-specialists in the field and *tightly focused* on a problem. Apart from its intrinsic pedagogical value, this "middle kingdom" of scientific books is precious for an additional reason: it enables quick entry to people who are working in interdisciplinary fields or wish to switch to a related field. This is certainly not a luxury, as has for too long been assumed -- on the contrary, early 3rd millennium science shows more and more that true interdisciplinary work is a necessity, be it in astrobiology, climate science, evolutionary computing, or countless other fields. There is a distinct and important advantage in being able to discuss, as Loeb does, the power spectrum of primordial density perturbations without either explaining Fourier transforms on the one hand, or tacitly assuming (say) that inflation suppresses higher-order tensor perturbations on the other. Instead, the author is free to zoom in upon presentation of the key issues which elude both highbrow monographs and wide-ranging massive textbooks. An example of that is a true educational pearl of wisdom to be found in Chapter 3: a brilliantly accessible presentation of the Press-Schechter formalism for predicting the number of dark matter haloes in a given mass interval at a particular cosmological epoch. This, one of the hardest topics in astrophysical cosmology for explaining to an entering audience, is dealt with elegantly and clearly in a couple of pages -- a true *tour de force*.

Covered topics include the gravitational growth of perturbations in an expanding universe, the abundance and properties of dark matter halos and galaxies, early stars and early black holes, re-ionization, the observational methods used to detect the earliest galaxies and probe the diffuse gas between them -- and much more. In addition, the book shows how tightly connected seemingly distinct fields, such as cosmology and the physics of star-formation, actually are. As Loeb points out, the actual process of star formation taking place in the Milky Way at this very moment still involves many uncertainties; the analogous process at early cosmological epochs is much less well established. He describes the results from numerical simulations that have followed the collapse of protostellar clouds to near stellar densities. However, this computational effort is still a long way from predicting phenomena such as the initial mass distribution of both present-day and first stars, which is so critical to their detectability and their feedback influence on subsequent galaxy evolution.

A particular strength of the book is following a tight interplay between theoretical and observational work. A particularly good example is the exposition of the process of re-ionization of the intergalactic matter (chapters 5-7) where, interwoven with theoretical foundations of the problem, we find clear descriptions of the observational methods used to detect both the earliest galaxies and the tenuous web of ionized/neutral gas between them, accompanied by some nice pictures (sadly, in monochrome) of the new and future instruments such as the *James Webb Space Telescope* and new huge ground-based instruments, like the *Thirty-Meter Telescope*, currently under development. This gives a fine context for future discoveries in this exciting field.

The thoroughness of Loeb's instructional approach is demonstrated by, among other things, the presence of both a primary-source bibliography *and* a list of references suggested for further reading and study. There are also a table of useful numbers, a glossary of major astrophysical and cosmological terms, and a comprehensive index.

Probably the worst one can say about this book is to list items which could be, subjectively speaking of course, classified as omissions. Section 7.2 discusses the Gunn-Peterson effect, but does so rather briefly and only for neutral hydrogen HI; it lacks the discussion of the analogous effect for helium (HeII). In addition, the discrete absorption in the "Lyα forest" lines is somewhat neglected, although it arguably still presents the most important tool for understanding both inter- and intragalactic matter at high redshift. Also missing is a discussion of the integrated starlight emission from early stellar populations, a modern-day rendering of what puzzled Olbers and other early cosmologists, which could tell us much about the early generations of stars and the elusive Population III (metal-free "first stars" of the book title). On the other hand, very much detail -- perhaps disproportionally so in comparison to the results thus far -- is devoted to a rather limited 21cm technique of searching for neutral hydrogen at early epochs which came in vogue in recent years. All these, I re-emphasize, are subjective and limited qualms, which disregard the obvious fact that in such an appealingly compact format important choices of discussion and omission are necessary.

Selfishly, the interested reader will find this book too short, especially since Loeb has found space and audacity at the very end for a beautiful and teasing vignette on the future of the universe. It touches upon some of the most interesting of his own research in physical eschatology, and begins with a wonderful sentence: "Every time an American president delivers the 'State of the Union' address, I imagine what it would be like to hear a supplementary comment about the 'State of the Universe' surrounding the Union." One may only hope that the author will find time and energy for more books like *How Did the First Stars and Galaxies Form?* And that, in more general terms, the very same style and spirit of bold, non-parochial, non-compromising science writing will endure.

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