

formulation of the no-cloning theorem. However, as Kaiser himself makes clear, things had changed from the mid 1970s to the early 1980s—for one, delayed-choice experiments, such as the one by Aspect and his collaborators, had become a central focus—and the thread of connection between the Fundamental Fysiks Group and quantum encryption had become much more tenuous.

The civil rights movement, the free speech movement, the Vietnam War, and the student rebellions of the 1960s and early 1970s undoubtedly mark a profound, multifaceted transitional period in US history. As in Weimar Germany, such social upheavals made possible creative, sometimes radical, new viewpoints. However, accounting for their impact on physics is not an easy matter. True, as Kaiser states, the Fundamental Fysiks Group did manage to parlay its interest into a widespread cultural phenomenon while “hovering on the margins of mainstream physics”—a reflection, no doubt, of the group’s public relations talents, particularly Sarfatti’s and Einhorn’s.

But being a member of the physics community demands that communal interests and standards be valued above the ego and self-absorption of the individual. In “The Depth and Breadth of John Bell’s Physics,” submitted to arXiv.org in 2001, Roman Jackiw and Shimony declared that with Bell’s death the world had lost “a man of exemplary dedication, integrity, courage, modesty, generosity, and humanity.” A more explicit comparison in *How the Hippies Saved Physics* of Fundamental Fysiks Group members to Bell, Wigner, and others involved would have been welcome.

Primordial Cosmology

Giovanni Montani, Marco Valerio Battisti, Riccardo Benini, and Giovanni Imponente
World Scientific, Hackensack, NJ, 2011. \$199.00 (591 pp.). ISBN 978-981-4271-00-4

The interdisciplinary nature of physical cosmology is responsible for its wide appeal; its breadth also poses a challenge to anyone who wants to write a comprehensive textbook on the subject. In particular, my specialty, early universe cosmology, necessitates interplay between general relativity, quantum field theory, particle theory, and some knowledge about the various approaches to quantum gravity.

The physics of the early universe helps to address the mysteries facing modern cosmology, such as dark matter and cosmic acceleration. Conversely, an understanding of the mysteries of the early universe, such as the nature and resolution of the Big Bang singularity, and the dynamics of cosmic inflation and alternative theories can provide a coherent microphysical mechanism for the origin of the large-scale structure we see today.

Currently there are only a few cosmology textbooks appropriate for a graduate level course; they include Scott Dodelson’s *Modern Cosmology* (Academic Press, 2003), Viatcheslav Mukhanov’s *Physical Foundations of Cosmology* (Cambridge University Press, 2005), and Steven Weinberg’s *Cosmology* (Oxford University Press, 2008). Each of the books features unique aspects of the field, and each is excellent and worthwhile for courses that emphasize its strengths. For example, Dodelson gives a particularly clear treatment of lensing and polarization, Mukhanov provides a concise and effective treatment of inflation and cosmological perturbation theory, and Weinberg presents a detailed and commanding derivation of the evolution of gauge-invariant cosmological perturbations. Each is a joy for the connoisseur.

Primordial Cosmology, by Giovanni Montani, Marco Valerio Battisti, Riccardo Benini, and Giovanni Imponente, is a much-welcomed addition. The book complements the treatments in the other cosmology texts. It was a pleasure to read. *Primordial Cosmology* is well structured, effective pedagogically, and self-contained.

The book begins with a thoughtful discussion of the history of cosmology that spans the cosmology of ancient cultures to the advent of Albert Einstein’s relativistic cosmology. I very much enjoyed that chapter. My only criticism is that the prose here, as in other places in the book, would have benefited from more careful editing. However, that is a minor problem considering the valuable historical and cultural information contained in the chapter.

Like other texts, *Primordial Cosmology* contains a solid review of general relativity, scalar field theory, and gauge field theory. The book goes beyond others by giving a coherent primer on the Hamiltonian and first-order formulation of general relativity, which is helpful for dealing with the more advanced topics in quantum cosmology near the end of the book. A clear and detailed derivation



of the kinematics and dynamics of the isotropic universe is discussed with a much-appreciated clarification of quantities such as the Hubble length, particle horizon, and the comoving horizon.

The book does a fair job of developing the technology of gauge-invariant perturbation theory, but the discussion is not as detailed as Mukhanov’s or Weinberg’s. I especially enjoyed the in-depth narrative of slow-roll inflation and the review of reheating in light of spontaneous symmetry breaking in the Higgs mechanism. The chapter on inflation effectively illustrates how quantum fluctuations during the inflationary epoch evolve to have a nearly scale-invariant power spectrum; the discussion is clear, without getting lost in too many details.

But *Primordial Cosmology* does not lack details, especially in the much-needed second half of the book. That part is particularly timely given recent activities in canonical quantum cosmology that use the Arnowitt-Deser-Misner Hamiltonian formalism. It serves both as a comprehensive introduction to anisotropic cosmologies for students and as a reliable reference for researchers. The section has the right level of mathematical rigor, combined with crucial physical insights useful for cosmologists who are interested in studying topics such as the Belinsky-Khalatnikov-Lifshitz conjecture and applications of Hamiltonian dynamics to cosmologically relevant spacetimes, for example Bianchi universes.

The last chapter, on loop quantum cosmology, will be useful for advanced graduate students and others who want to begin research in that field. Loop quantum cosmology avoids some old problems in the Wheeler-DeWitt formalism. *Primordial Cosmology* provides an enjoyable and clear treatment of the Wheeler-DeWitt equation and the technical and conceptual issues facing the Hamiltonian constraint. Some of the authors are experts in loop quantum cosmology, and the reader-friendly introduction to the field is one of the book’s strongest contributions.

Despite its having a few editorial lapses, I highly recommend *Primordial Cosmology*. It is a necessary upgrade to the library of any physicist—student or researcher—interested in understanding the big picture of early universe cosmology.

Stephon Alexander
*Haverford College
 Haverford, Pennsylvania*