rian, hardly presents any serious descriptions of Newton's scientific work. Only in the case of Newton's early optical research does he attempt anything beyond a brief sketch, and even this is superficial and misleading, for by considering Newton's theory of color as presented in his 1672 paper to be "unassailable," he misses the excitement of following Newton's refinements and extensions of his theory. Similarly, when he suggests that one of the causes of Newton's breakdown in 1693 was continual overwork in the period following the publication of *Principia* in 1687, he does not tell us what in fact was so occupying Newton. Besides revising *Principia* and continuing his mathematical and chemical–alchemical studies, Newton was writing *Opticks*, but nowhere does Christianson describe this undertaking, which must surely be judged a significant event in his life. Not only is Newton's science the principal reason we want to know about his life, but his intellectual pursuits were his primary activity during his long creative period at Cambridge, where he remained until 1696, when, at the age of 53, he left for London and the Mint.

While Newton's mechanics, mathematics and optics are often profound and difficult, they are by now so fully assimilated into the western intellectual tradition that there should be no difficulty in describing them at a popular scientific level. Christianson's aim of presenting Newton's scientific genius and creativity is admirable, but his vivid descriptions of Newton's long labors, moments of elation and state of mind—"a mind every bit as subtle and elastic as the universal ether" (page 190)—are no substitute for full accounts of his formulation of classical scientific problems and his subsequent struggles, solutions and even failures. The recent scholarly biography of Newton, *Never at Rest* (Cambridge U. P., 1981), by the historian of science Richard S. Westfall, with its 900 pages is not light reading, but it should be the biography of choice for physicists: It directly confronts Newton's scientific endeavors.

Violent Phenomena in the Universe

J. Narlikar
218 pp. Oxford, New York, 1982.
$19.95

Introduction to Cosmology

J. Narlikar
470 pp. Jones & Bartlett, Boston, 1983.
$30.00

During the last two decades new "windows" to the universe opened up, and we can now observe the universe practically in the whole range of the electromagnetic spectrum. The new capabilities led to the exciting discoveries of quasars, pulsars, x-ray sources and the microwave background radiation, just to mention a few.

Some quasars are believed to be the most distant objects in the universe. On photographic plates they form starlike images and their spectra contain strongly redshifted emission lines. Typically, the absolute luminosity of a quasar is enormous, exceeding by two orders of magnitude the luminosity of our whole galaxy. This energy is generated in a very small volume of a few cubic light-years. Soon after the discovery of quasars it became apparent that thermonuclear reactions are not efficient enough to explain the observed energy output, and it is suspected that strong gravitational fields may be at the basis of the energy-generation mechanism. It turns out that strong gravitational fields play an important role in most of the recently discovered

exotic objects. To construct models of these objects it is therefore necessary to use Einstein's general theory of relativity.

Violent Phenomena in the Universe by Jayant V. Narlikar provides a readable and interesting account of recent advances in astronomy. I am not aware of any other book covering the same material at the same popular level. To discuss properties of black holes, Narlikar gives a fairly extensive introduction to general relativity. According to general relativity, a black hole is the endpoint of the evolution of a massive star.

General relativity plays an important role in two extreme areas of astronomy. It allows one to determine the properties both of collapsed small objects and of the largest object—the whole universe. In the last two chapters of *Violent Phenomena in the Universe*, Narlikar describes the observational basis for the standard cosmological model (the Big Bang and expanding universe), and he indicates the reasons why one can doubt the commonly accepted views on the evolution of the universe.

These problems are thoroughly discussed in Narlikar's *Introduction to Cosmology*. Physical cosmology is now a very popular branch of astrophysics. There are many new models and new ideas. In *Introduction to Cosmology* Narlikar presents only the well-established views, and I understand and sympathize with his rather conservative attitude. The far-reaching consequences of the standard cosmological model are based on numerous assumptions and extrapolations, and it is worthwhile to study alternative possibilities. At the moment, the standard scenario gives the most complete and coherent description of the evolution of the universe. There are, however, weak points; we do not, for example, have a satisfactory theory of galaxy formation. I was not surprised that a whole part of the book is devoted to nonstandard cosmology because Narlikar is a co-founder of the Hoyle–Narlikar (steady-state) cosmology.

The final test of any cosmological theory is comparison with observational data. In the last part of his book, Narlikar discusses the main observational data and he points out the difficulties, limitations and complications we have to face.

I can recommend *Violent Phenomena in the Universe* to anybody interested in recent advances in astronomy. This book can be used as a text for a one-semester survey course of modern astronomy.

In my opinion, *Introduction to Cosmology* is a very good introductory textbook for a one-semester course, competing only with Steven Weinberg's excellent but already decade-old *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*. Narlikar does not assume that the reader is familiar with differential geometry and general relativity, and introduces them in the first part of the book. Interesting problems supplement every chapter. The pedagogical value of the book is increased by hints of how to solve the more difficult problems.

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Review of U.S. Military Research and Development 1984

Edited by Kosta Tsipis and Penny Janeway
229 pp. Pergamon, Washington, D.C., 1984. $25.00

This is apparently the second in a series of reviews of US military R&D. The first was titled *Annual Review of U.S. Military R&D: 1982*, published in 1983 by Praeger; Kosta Tsipis was one of the editors for that volume also. The fact that this new series appears to be the first attempt to provide an overview for the public of US military R&D activities underlines the extent that, despite teach-ins and mass movements, the arms race remains the province of the specialized participants. The present volume contains two overview chapters plus articles on military-funded R&D in six specific areas: very-high-speed integrated circuits, antisatellite weapons, ballistic-missile reentry vehicles, ballistic missile defense and antisubmarine warfare.

The first overview chapter, by Franklin Long and Judith Reppy of Cornell, informs the reader that the US spends about one dollar for military R&D for every three dollars it spends on procurement. This reflects the fact that we actually buy a relatively small number of copies of major weapons systems—typically hundreds of each type of aircraft, for example. The weapons systems have become so expensive that the nation cannot buy them in much larger numbers. This fact seems to cause little concern, however, either on the part of the public or within the military–industrial complex. Since, in the nuclear era, war between the superpowers has become unwinnable, only a relative few care about what would happen if our weapons were used on a large scale. The arms race has increasingly developed the appearance of a weapons development race in which hundreds of thousands of scientists and engineers on both sides work endlessly to advance the state of the art.

This is also the impression that one