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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 Wein-

berg'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

gets from the chapter by Tsipis, who attempts to understand why the high-technology products that are being developed by the enormous US military R&D establishment are so often found in tests to be lacking in battle worthiness. Billions are spent upon weapons systems, such as the new naval-fleet Aegis air-defense system, before their obvious vulnerabilities to attacks or countermeasures are seriously considered. Once again, it seems as if few are concerned about whether these systems would actually be effective in battle.

There also appears to be little concern about where the arms race may be taking us—just as long as the US is ahead. This fact is even exemplified in one of the chapters of the present book, the one on the Very-High-Speed Integrated Circuit program of DOD, written by William J. Perry, Under-Secretary of Defense for Research and Engineering during the Carter administration, and Larry Sumney, former director of the VHSIC program. From a policy perspective we are given the traditional rationale for the DOD emphasis on high technology:

To deal with [the Soviet] challenge—large numbers and increasing technical sophistication—we must put our emphasis on *force multipliers*, that is, on developing those technologies which give our weapons systems qualitative leverage over comparable Soviet systems.

The development of the VHSIC is, of course, at the core of the thrust towards "qualitative leverage" because it will enable the US to deploy ever "smarter" weapons systems. It is with the opportunities for developing such smarter weapons systems that most of the remaining chapters are concerned.

For those concerned about the future survivability of US and Soviet strategic weapons systems, the chapter by Matthew Bunn on US R&D relating to the accuracy of ballistic missile reentry vehicles and that by Randolph J. Steer on R&D relating to antisubmarine warfare will be particularly interesting. Each of these chapters suggests both the difficulty of the technical challenges involved and the great opportunities for incremental improvements that are being opened up by the progress of technology—especially in compact sensors and information processing.

Although useful, this volume could use a great deal of improvement in a number of respects. Perhaps most notably, only three of the eight articles have more than a few references to sources. Two have none at all.

Another surprise, in view of the other involvements of the editors and

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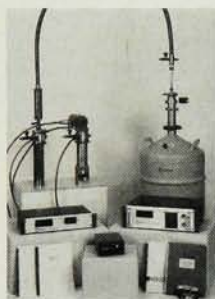
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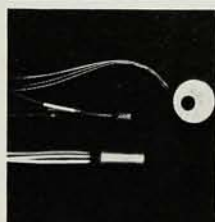
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some of the authors, is that so little attention is devoted to the possibilities for imposing constraints on some of the more destabilizing R&D programs that are currently causing so much public concern. The only new idea put forward in the volume is Matthew Bunn's proposal to ban the further testing of maneuverable reentry vehicles.

According to Bunn, the US has already developed (but not deployed) maneuverable reentry vehicles for its strategic missiles as a potential countermeasure to any future Soviet ballistic missile defense system. In addition, a maneuverable reentry vehicle with radar terminal guidance has been developed for the Pershing II. The Pershing II reentry vehicle, however, weighs 1362 kg according to Bunn (no reference)—several times more than the MIRVs on US strategic missiles. Because the Soviets have apparently not yet tested a maneuverable reentry vehicle on a long-range missile, a test ban on maneuverable reentry vehicles at this time would at least impede the development by both sides of lightweight, terminally guided, super-accurate reentry vehicles.

In summary, the topics covered in this volume are well-chosen. Their treatment is quite uneven and the policy implications are in general not developed. However, the quality of this volume is high enough that the editors should be encouraged to continue to develop the series. A high-quality review series on military R&D would be an extremely useful "early warning" device for those concerned about detecting opportunities and dangers at as early a stage in the R&D process as possible.

FRANK VON HIPPEL  
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## new books

### Quantum Electronics and Lasers

**Laser Physics.** L. V. Tarasov, 357 pp. MIR, Moscow (US dist. Imported Publications, Chicago) 1984. \$10.95. *Text*

**Optical Bistability 2.** C. M. Bowden, H. M. Gibbs, S. L. McCall, eds. 512 pp. Plenum, New York, 1984. \$69.50. *Compendium*

**Advances in Electronics and Electron Physics.** Vol. 62. P. W. Hawkes, ed. 304 pp. Academic, New York, 1984. \$54.00. *Compendium*

**Introduction to Laser Physics.** Springer Series in Optical Sciences. K. Shimoda. 211 pp. Springer-Verlag, New York, 1984. \$25.00. *Text*

**Laser Dyes: Properties of Organic Compounds for Dye Lasers.** M. Maeda. 335 pp.

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