

Relativity made relevant

**Relativistic Astrophysics,
Vol. 1: Stars and Relativity**

By Y. B. Zel'dovich,
I. D. Novikov

522 pp. Univ. of Chicago Press,
Chicago, Ill., 1971. \$24.00

Reviewed by Joseph Silk

This book presents a comprehensive review of a new field that has captured the attention of many outstanding astronomers and physicists. The birth of relativistic astrophysics may be placed in the year 1963, which marked the discovery of the first source of cosmic extra-solar x radiation, and the identification of 3C 273 as the first quasistellar radio source. The year 1963 culminated in the First Texas Symposium on Relativistic Astrophysics, an international gathering that drew together on an unprecedented scale the experts in general relativity theory and the observational astronomers. Indeed, the beauty of relativistic astrophysics is that it represents a fusion of these traditionally independent (and, with the passage of time, progressively more esoteric) areas into a single entity. The new discipline is replete with problems of the most basic variety, which have excited the imagination both of physicists and laymen.

In the simplest terms, relativistic astrophysics comprises the study of superdense or supermassive systems and systems of cosmic dimensions. In either extreme, the curvature of space-time plays an important role in determining the dynamic behavior of the system. Astronomical observations over a wide range of the electromagnetic spectrum provide both the problems and the solutions.

Ya. B. Zel'dovich and Igor D. Novikov are internationally eminent authorities on all aspects of relativistic astrophysics. Zel'dovich has had a remarkable career, which has spanned elementary-particle theory, nuclear physics, the theory of explosions, hydrodynamics, cosmology and astrophysics. It is widely believed by American physicists that, in collaboration with A. D. Sakharov, he played a major role in devel-

oping Soviet nuclear weapons. Sadly, as a consequence, Zel'dovich is unlikely ever to be able to attend a scientific meeting outside Eastern Europe or the USSR. About a decade ago, Zel'dovich became enthralled by astrophysics. At first his research methods were, in his own words, "like those of an elephant in an elegant china shop," but within a relatively short time the elephant-physicist emerged with a remarkable ability to penetrate to the core of many of the outstanding problems of astrophysics and isolate the underlying physical phenomena. Zel'dovich anticipated that general relativity would come to play a major role in astrophysical research, and he chose as his principal collaborator a brilliant young relativist, Igor D. Novikov. Today, Zel'dovich and Novikov, together with their students, constitute one of the world's most outstanding groups in theoretical astrophysics. Their research is noted for its deep physical insight, and it has made a major contribution to the present status of knowledge in relativistic and high-energy astrophysics.

Stars and Relativity is noteworthy for the manner in which it combines the abstractions of general relativity with the inevitability of stellar collapse. Here at last is a book on relativity that eschews mathematical rigor and elegance and achieves more prosaic but relevant goals. Relevance indeed is their clarion call, and what could be more relevant than black holes or neutron stars? If you doubt it, ask your neighbor! Before embarking on these exotic applications, Zel'dovich and Novikov devote the first half of the book to detailed expositions of the general theory of relativity and the thermodynamics of matter in an astrophysical environment. In particular, the section on general relativity is compulsory reading for any physicist who wishes to understand the physics of black holes. From an elementary level, Zel'dovich and Novikov guide the reader to sophisticated concepts, such as that of the event horizon (the Russian word for which translates as "gravitational self-locking"), with continual heavy em-

HALE OBSERVATORIES



Nebula NGC 147 in Cassiopeia showing resolution into stars. This picture was taken in red light with the 200-inch telescope.

phasis on the underlying physics. They often achieve this goal by making simple order-of-magnitude estimates, but still manage to retain sufficient detail to satisfy even the pundits of the field.

A nonspecialist may find the discussion of processes in superdense matter overly compact. One notable omission in their extensive section on the equation of state is the important work of Hagedorn and others on the concept of a "soft" equation of state at super-nuclear densities and the related implication of a limiting temperature for matter near 10^{12} K. Barely a paragraph in *Stars and Relativity* is devoted to this concept, which has in the past two years assumed increasing sig-

NEW AUTORANGING DIGITAL MULTIMETER... IN-PROBE DISPLAY, HIGH-SPEED READOUT, BATTERY OPERATION... \$325.



For AC or DC voltage, resistance and even current, our Model 167 with unique in-probe readout lets you make time-saving measurements directly at the point of measurement. With up to 3-month battery life. The Model 167's combination probe/readout, with 3½ digit LED display, automatically indicates decimal point, polarity, range and function. Front panel terminals and probe receptacle allow alternative use as a bench instrument. The neat, sweet-to-hold 167 Auto-Probe DMM is only \$325 (less in quantity). Check it out and get our latest "How Sweet" button.

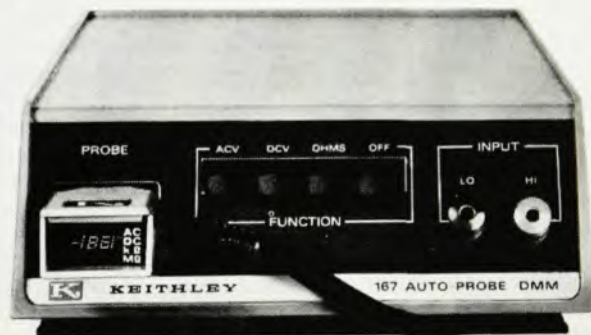
Measures easily ... 1 mV to 1000 VDC
• 1 mV to 500 VAC RMS • 1 ohm to 20 megohms

with the convenience of ... 55 megohms input resistance • 2-sec. reading time to rated accuracy • 1200 volts overload protection • Complete choice of accessories.



**KEITHLEY
INSTRUMENTS**

U.S.A.: 28775 AURORA ROAD, CLEVELAND, OHIO 44139
EUROPE: 14, AVENUE VILLARDIN, 1009 PULY, SUISSE



The Model 167... another how-sweet-it-is Keithley Multimeter

Circle No. 29 on Reader Service Card

nificance in the study both of neutron stars and of the early universe. Let us hope that the second volume (devoted to cosmology) makes amends for this omission. As Zel'dovich and Novikov emphasize in their introduction, they were well aware of the rapid rate of evolution of theoretical astrophysics, and it is perhaps remarkable that so much of this book (sent to press early in 1970) remains topical. Inevitably, slowly but sadly, this book will become outdated, but it promises to remain vigorous and stimulating, if not for perpetuity, then for at least the doubling time in the growth rate of this active field. This we estimate to be somewhat less than eight years, the doubling time for the number of pages published per year in all American Institute of Physics journals.

The second half of *Stars and Relativity* is devoted to astrophysical applications of the earlier results to relativistic stages of evolution of a variety of cosmic objects, ranging from white dwarfs, neutron stars and black holes to quasars and star clusters. An exhaustive treatment is given of the equilibrium and stability of evolved stars. Attempts are made to incorporate rotation into the discussions of equilibrium situations, in particular for black holes and for supermassive stars, although curiously there is no mention of the effect of rotation on the stability of neutron stars or white dwarfs.

The scientific editors, Kip S. Thorne (California Institute of Technology) and W. David Arnett (University of Texas, Austin), are to be commended on an admirable outcome of their joint endeavors with Zel'dovich and Novikov. At the authors' request, Thorne has added sections dealing with his own specialties. The net result, when volume II on cosmology is published, will be an outstanding and complete review of the entire field of relativistic astrophysics. It is unique in this respect and is essential reading for anyone seeking to enter the field.

Perhaps one of the greatest assets of this book is the range of unsolved problems and speculative suggestions that are hurled at the unsuspecting reader. Any physicist unexcited by current trends in physics or bored with his present research is urged to peruse this work: If he does not emerge from his encounter with Zel'dovich and Novikov in a state of extreme euphoria, he should apply for his Social Security benefits.

* * *

Joseph Silk is an astrophysicist specializing in the areas of cosmology and high-energy astrophysics. He is presently assistant professor in the department of astronomy, University of California, Berkeley.