Chandrasekhar on black holes

Roger Penrose

The Mathematical Theory of Black Holes.
By S. Chandrasekhar.
Oxford University Press: 1983. Pp.646. £55, $110.

SINCE the discovery of quasars roughly twenty years ago, black holes have become increasingly accepted as real physical objects. Theoretical discussion of them has shifted from general arguments (e.g. singularity theorems), aimed at proving their existence from very broad assumptions, to detailed consideration of their structure.

The very possibility of such detailed studies stems from some remarkable mathematical results concerning black-hole solutions of Einstein's equations. In 1963, Roy Kerr found the relevant solutions of Einstein's equations. In 1968, Israel's result concerning the uniqueness of Schwartzschild's solution led some people to conjecture that Kerr's solutions actually represent the most general possible end-points of gravitational collapse to a black hole. In the years 1972–1975, primarily through the work of Carter, Hawking and Robinson, this conjecture was established in its essentials. We have thus been presented with an astonishing situation, perhaps almost unique in science, where a virtually complete theoretical description exists for a class of physical objects (black holes), while definitive observations are, as yet, almost non-existent.

It is fitting, therefore, that Chandrasekhar's new book *The Mathematical Theory of Black Holes* should concern itself, to a very considerable extent, with the geometry of Kerr's solutions and the many astonishing mathematical properties they exhibit. There is no doubt in my mind that this book is a masterpiece. Chandrasekhar has become the established world expert in the sort of material it is largely concerned with: perturbation analysis, separability of the equations, scattering of incident waves, etc. The equations are often extremely complicated, but the book is, nevertheless, extremely readable. The author's enthusiasm and wonder at the many remarkable properties his equations possess is infectious, and serves to carry us through the more difficult passages. He does not hesitate to wax poetic where appropriate; ". . . properties which have endowed the Kerr metric with an aura of the miraculous"; or ". . . the analysis has led us into a realm of the rococo: splendorous, joyful, and immensely ornate".

The book makes no attempt to cover all aspects of black holes. Observational matters, accretion disc theory, etc. are not considered, nor are the more esoteric mathematical techniques needed for, e.g., singularity theorems. But in all other respects it is remarkably complete and thorough. There are numerous tables of numerical data, graphs and diagrams, as well as equations. It is beautifully written and well-presented — and clearly intended to last a long time. It will. □

Roger Penrose is Rouse Ball Professor of Mathematics at the University of Oxford.

Second light

Peter Knight

The Quantum Theory of Light, 2nd Edn.
By Rodney Loudon.
Oxford University Press: 1983. Pp.393. Hbk £30, $59.95; pbk £15, $24.95.

IT is a pleasure to welcome a new edition of Rodney Loudon's standard text on the quantum theory of light. In the ten years since the first edition appeared, this book has become essential reading for anyone working in the new and dynamic field of quantum optics. A whole generation of students has been brought up on its clear and down-to-earth approach. The early chapters of the book can be read with profit by final year undergraduates interested in modern optics with only a modest prior undergraduate knowledge. Later chapters present a unified view of the quantum theory of coherence, photon counting, light scattering, laser action and nonlinear optics suitable for students beginning research. Some experimental details intrude where necessary although it remains a pedagogic text on the basic theory of photon physics. An experimentalist would need to supplement his reading with a more device-orientated text.

In the past decade, the great changes in the field have been stimulated by the development of narrow bandwidth tunable lasers. The dynamical evolution of atoms strongly and coherently coupled to radiation fields was hardly touched in the first edition. The new edition contains a careful discussion of Rabi population oscillations, Optical Bloch equations, strong-field resonance fluorescence, photon antibunching and much else. A large number of new figures and references appear in this edition. Problems and exercises are scattered throughout the text. The discussion of quantum damping theory in the first edition has been much improved by the inclusion of the Heisenberg picture theory of radiative interactions as developed in Rochester and elsewhere.

I would have liked the author to elaborate a little on the usefulness of coherent states of the radiation field in dynamical problems in quantum optics, particularly in understanding the semi-classical limit. The diagonal coherent state representation, Fokker–Planck equations and master equations are not included, perhaps in keeping with the author's desire to use the simplest reliable techniques. The effects of laser bandwidths on resonant excitation are also ignored, which I think is unfortunate as I am sure the complicated subject of multiplicative stochastic processes in nonlinear optics could have been presented here with the author's usual flair. Perhaps he could consider these for the third edition? The sections on photon statistics in nonlinear optics, a field to which Professor Loudon has made notable contributions, has been largely re-written and expanded. A discussion of the nonclassical aspects of light and of the photon description of interference are welcome additions, and demonstrate how hard it is to observe the true quantum nature of photons.

With a paperback edition of this well-printed book available at a reasonable price, I expect the second edition to be as popular with students as the first. New research students are lucky to have such a clear guide to their field when compared with the deadly quantum field theory texts of twenty years ago, with which my generation had to cope. □

Peter Knight is a Lecturer in Physics in the Blackett Laboratory of Imperial College, London.