resolve was stiffened by the trial in Leningrad of Dymshitz and Kuznetsov and the demonstrations in the Visa Department offices in Moscow in 1971.

And so it was that in December 1972 he went to the Visa Department. He was not the first distinguished scientist to do so: that was probably Alexander Lerner who had applied a year earlier. Lerner is still a *refusenik* more than ten years later. Nor was he the last. Recent information suggests there are about 100 *refuseniks* with a scientific doctorate (roughly equivalent to DSc) in Moscow alone, another 200 with the degree of Candidate (roughly PhD). Voronel applied shortly before Azbel, and was allowed to leave at the end of 1974.

It must be understood that to apply to emigrate from the USSR is an act of the highest significance. It leads almost inevitably to social ostracism. And in most cases, certainly for scientists, it leads to dismissal from one's job. For a scientist this in turn means more than loss of livelihood (which can in turn lead to prosecution for "parasitism"); it means deprivation from contact with colleagues, from access to libraries and laboratories. It means "exclusion from science". To counter that exclusion, to provide mutual support and scientific sustenance, Voronel organized a seminar every Sunday noon at his apartment. These Sunday seminars continue to this day, despite a succession of attempts to disrupt or prevent them. They have multiplied: similar meetings are held in other Soviet cities, and in disciplines other than physics. The participants have received Western visitors in this way (a recent session learnt about Feigenbaum's work on frequency doubling and the transition to chaos): indeed they have held impressive international meetings. All of this has been under the watchful eyes of the KGB, and has been scrupulously within the law.

The legality (and to Western readers perhaps the normality) of private gatherings of scientists to discuss science has not prevented harrassment, and official attempts to disrupt their proceedings. These reached a climax when Voronel, Azbel and Victor Brailovsky decided in 1974 to hold an international scientific symposium, and again three years later when another international meeting, on collective phenomena in physics, was held to celebrate the fifth anniversary of the seminars. Both meetings were attended by numerous distinguished visitors from abroad. Both were heralded by oppressive KGB surveillance, questionings and indeed arrests — Azbel was himself imprisoned in 1974. After Azbel's emigration, Victor Brailovsky took over as chairman of the Sunday seminars from Azbel, who had succeeded Voronel. Brailovsky is now living in exile in Beineu, Kazakhstan.

Azbel's book speaks eloquently of the courage and resourcefulness of those scientists who persist in their legitimate aspirations to emigrate and of their motivation. It answers some but not all of the questions which must be raised about the reasons behind the Soviet policies towards them. It underlines their vital need for support from the international scientific community, which I believe to be an obligation upon us as scientists. The pursuit of science gives privileges and brings responsibilities: and it is not possible to separate those responsibilities from the wider relations between the pursuit of science and human affairs. This book should be read by all those who profess an interest in international scientific activities, and I would hope that would mean all scientists. □

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The quantum theory of space and time

C.J. Isham

Quantum Fields in Curved Space. By N.D. Birrell and P.C.W. Davies. Pp.340. ISBN 0-521-23385-2. (Cambridge University Press: 1982.) £27.50, $49.50.

THE problem of quantizing the gravitational field commands the attention of an increasing number of theoretical physicists who are attracted by the importance of the subject to studies of the early Universe, gravitational collapse, grand unification of all fundamental forces, and the Planck length structure of space and time. In spite of much effort a successful resolution remains elusive, and it seems natural to tackle first the simpler problem of the quantization of a field propagating in a curved, but fixed, background spacetime. It had been known for many years that a time dependent metric would transmute part of its energy through the medium of quantum particle production, but the subject became of widespread interest only after Hawking's announcement in 1974 of the production of particle pairs by the event horizon of a black hole.

The subsequent effort devoted to quantum field theory in a curved space has spawned a considerable literature of research papers, conference proceedings and review articles, but the text of Birrell and Davies is the first attempt to present the subject in a more permanent form. I can think of at least three quite different types of book that might be published under this title with the contents reflecting the individual approaches that have been developed by different researchers. The present authors have made a determined and commendable effort to cite most of the important papers that have appeared, but the final treatment sharply reflects their own personal contributions and methodology. Quantum field theory is introduced with heuristic methods involving mode function expansions; there is no discussion of the mathematical problems associated with such sums or of their resolution via the operator algebra techniques that form the backbone of most rigorous investigations into quantum fields with external sources. This simpler approach does however have the asset of rendering the book accessible to a postgraduate student who has attended any standard first course on quantum field theory, and the assumed knowledge of general relativity is no more demanding.

A significant application of the subject is to the physics of the early Universe; for example it has been suggested frequently that an initial anisotropy could be removed by the quantum production of particle pairs. Birrell and Davies are especially interested in this problem and provide a comprehensive discussion of quantum field theory in various cosmological backgrounds. Of particular value here is the careful account of the resolution, using model particle detectors, of the conceptual problems that arise concerning the operational status of a quantum particle.

Almost all work in quantum field theory is plagued by the infamous ultraviolet divergences and the addition of a curved background tends, if anything, to make matters worse. A particularly disturbing feature is the appearance of infinities in the matrix elements of the energy momentum tensor which, in a semiclassical limit, forms the source of the gravitational field. The regularization and renormalization of these divergences is a subtle problem and is discussed at length with most of the established techniques being given a respectable hearing; applications include an authoritative account of the Hawking effect and of the ensuing use of the stress tensor to isolate the origin of the particle pairs.

Professor Davies has rightfully earned a high reputation as an author of informative and well written semi-popular science books and this research monograph is presented in a similarly clear and attractive style. Quantum gravity is an active subject and it would be difficult to predict that all sections of the text will seem equally relevant in ten years time; nevertheless, the authors are to be congratulated on producing a timely work that should help to stimulate interest in this fascinating branch of theoretical physics. □

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