bution and character of andesitic volcanism beginning in or extending into the Cenozoic. There are separate papers on the Aleutians, the Cascades province, Mexico, Central America, the Lesser Antilles, the Andes (at last!), Indonesia, Papua and New Guinea, Tonga-Kermadec-New Zealand, Japan, the Mariana and Volcano islands, the Mediterranean arcs, Anatolia and northwest Iran, Sardinia, and Antarctica, all by authors with extensive experience in the areas concerned. There are also papers on Archaean andesites and on those of the British Caledonian, as well as admirable summaries of the physical characteristics of andesite eruptive activity as a whole and of andesite pyroclastic flows. A few of these essays are rather sketchy, with strong emphasis on speculation rather than information. Most, however, are well above average for this difficult form of exposition, and many are very fine indeed. In the nature of the case, most of the information in them is not new—at least three, including what seem to me the two best, are in fact revisions of reviews already published elsewhere—but the material is unusually widely scattered, and it is a major service to gather it together in one place. Unfortunately, the remarkable andesitic and related volcanism of the Kuriles, Kamchatka, and the Carpathian arc (or arcs) is not included in the survey. Perhaps this deficiency can be remedied in a later edition, when Soviet bloc petrologists no longer feel obliged to consider plate tectonics the work of the devil and the rest of us are prepared to admit that it is something less than divine revelation.

The remainder of the book is a potpourri of papers of variable but often slight relevance. An essay about the relation of calcalkaline intrusives to volcanic arcs reads rather like a distended undergraduate lecture on the relation between volcanic and plutonic rocks. In a discussion of mineral deposits associated with calcalkaline rocks the word "andesite" does not appear at all and nearly all the deposits mentioned are associated with plutonic rocks. An engaging discussion of the possible syntectic origin of andesite contains no mention of pre-1971 work on or opinion about this hoary hypothesis. A highly speculative paper on the relation between andesitic volcanism and continental growth concludes that there really isn't much. An interesting review of procedures for estimating the sulfur and chlorine budgets of explosive volcanoes has nothing whatever to say about andesite or andesitic volcanism per se. A remarkable exercise in megathought about pan-African calcalkaline magmatism says very little about andesite. In a pair of essays on trace element and isotope characteristics of "lavas from destructive plate boundaries" all manner of other rocks are discussed but andesites rate only occasional mention. Complex and diffuse contributions by two well-known experimental petrologists are concerned not with andesites but with the nature of the material from which the magma that gives rise to them may perhaps have been formed. For this grandparental role hydrated mafic crust is preferred by one experimentalist, metasomatized mantle by the other.

Nearly all the material in the last 260 pages of the book deserves and repeatedly receives extended discussion in the current periodical literature. Very little of it is yet of sufficient stature to warrant inclusion in a standard reference work or textbook, and most of it is not of sufficient relevance to warrant inclusion in a book bearing the title of this particular "reference text." Omission of undefinitive or irrelevant material would have considerably reduced the size and perhaps also the cost of the book, making its ownership a less unreasonable indulgence for those constrained to read reviews rather than write them.

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Mathematical Physics

Quantum Fields in Curved Space. N. D. BIRRELL and P. C. W. DAVIES. Cambridge University Press, New York, 1982. x, 340 pp. $49.50. Cambridge Monographs on Mathematical Physics.

Constructing a quantum field theory in curved space-time is an enterprise distinct from the much more ambitious one of constructing a quantum field theory of the gravitational field (curvature) itself. Unlike the latter theory, the former has recently passed from confusion into a state where at least the fundamentals are understood and agreed upon. In fact, after decades of gestation, the subject went through a remarkable vogue in the mid-'70's, attracting the attention of "classical" general relativists, "flat" particle and field theorists, and people who had previously worked on quantum gravity proper; recently, many of these have returned to their former pursuits or turned to supergravity, gauge theories, or pure mathematics, and the publication rate has fallen off. We are clearly at the optimal time for the first book on the subject, which will surely become a classic reference.

The authors of this book state their intentions to be "both pedagogical and archival." They have succeeded reasonably well on both counts, although the two goals interfere at times. The authors have chosen to produce a broad review of the literature rather than a systematic presentation from a personal point of view.

The first half of the book has been provided with a unifying theme, "particle detectors." Curved-space quantum field theory is an extrapolation of conventional quantum theory into a regime where experimental verification is, at best, very indirect. Consequently, a basic problem has always been to identify the physical content of the mathematical formalism. The aspect of the subject that has been best developed is the analysis of operators representing local field observables—particularly energy density, energy flux, and pressure—and their expectation values in particular quantum states. The authors have wisely delayed a discussion of this rather technical topic until the second half of the book. Furthermore, there is room for debate over whether these local densities are accessible to experiments, even of the Gedanken variety. In their place W. G. Unruh proposed to study a model detector in which the quantum field is allowed to interact with another field and the resulting excitation probability is calculated by perturbation theory. This analysis provides insight into the physical content of various quantum states that is complementary to that provided by energy-density calculations. Birrell and Davies introduce the idealized detector very early and keep returning to it in various physical contexts, several of which have not previously been analyzed in this way. This feature makes the early chapters more coherent than they otherwise would have been.

The third quarter of the book is a single chapter devoted to calculation of the stress tensor (which comprises the energy density and related quantities mentioned above). Here the attempt to review the entire literature even-handedly does get in the way of clear exposition. At first the chapter concentrates on effective Lagrangians and dimensional regularization, the favorite tools of the Loyal Opposition. Then it turns to the approach developed by Davies and his students (and this reviewer), the direct calculation of the stress tensor from an expansion of the field in normal modes, with the aid of regularization by "point-

splitting." Finally, in a section entitled "Physical significance of the stress-tensor," we are informed of relatively recent work by R. M. Wald, which establishes the general properties of the stress tensor on abstract principles and provides a solid foundation for the point-splitting method. This section should have come first; the reader would then be better prepared to understand the detailed point-splitting calculations, which could be further clarified by passing immediately to the concrete examples in the next chapter (on applications of renormalization techniques). This organization would also allow certain ambiguities that arise in stress-tensor renormalization to be resolved by appeal to the fundamental requirement that the renormalized tensor be covariantly conserved rather than by a lame-sounding "desire to achieve equivalence with a result [for the tensor's trace] obtained by renormalization of the effective Lagrangian." The discussion of the effective Lagrangian could well be delayed to a separate chapter leading into a treatment of interacting fields and the implications of the theory for quantization of gravity. I urge the reader to give the book a second reading from this reordered perspective.

After a review of quantum effects near black holes, the book concludes with a chapter on interacting fields in curved space. This subject is still in its infancy. What work has been done seems to be tied to the Procrustean bed of flat-space quantum field theory much more than is the noninteracting theory. I missed any mention of the rigorous ("axiomatic") formulation of general quantum field theory in curved space due to C. J. Isham and to J. Dimock. Admittedly this is still just a kinematical framework, not a theory; but I suspect that it will be of more lasting interest than the three or four alternative S-matrix formalisms that are presented right after the admission that S-matrix concepts are inadequate for formulating physics in most curved spacetimes. This is a criticism not of the book but of the rigidity of thought patterns in the physics community.

The reader who will find this book most useful is a graduate student who wants to start thesis research in this field (or a mature researcher coming to the field from the outside), already knowing something about standard quantum field theory and general relativity. Almost every significant paper in the literature is summarized and put in perspective. (The book's usefulness in this regard could have been greatly enhanced by indicating after each item in the 14-page reference list where in the text it is discussed.) Because of the unavoidable brevity of the book's treatment, the student will need to go to the original article for a full understanding.

I hope that a few such readers will be led on to complete the obvious unfinished business: a sound theory of interacting fields; a more complete and (physically) rigorous theory of detectors; practical methods of calculating expectation values of the stress tensor in generic space-times; serious applications of the theory in cosmology and astrophysics; and quantizing gravity.

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