PROGRESS IN COSMIC RAY PHYSICS

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IN

COSMIC RAY PHYSICS

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PREFACE

"Progress in Cosmic Ray Physics" is intended to provide a series of reviews covering, in particular, those aspects of the physics of cosmic radiation in which advances of broad significance are now being made.

It is a characteristic of cosmic ray physics that in spite of the extensive specialized research of the last five years, the separation of the subject into more or less independent topics has not gone very far. The main geophysical investigations remain among the most fruitful sources in which hitherto unknown interactions are identified, while the interpretation of these large scale phenomena must essentially depend on a detailed understanding of the single nucleon-nucleon encounter. Interrelations between the various geophysical features are still closer, while neither the relevance of the broad conclusions of fundamental particle theory to the experimental pursuit of these particles, nor the importance to the theorist of a balanced assessment of the changing experimental position, need be stressed. Up to date surveys of the state of knowledge in the various branches of the subject are accordingly likely to be of particular value to active workers on specialized problems, and the reviews of this volume, which in general give the standpoint of the early months of 1951, have this requirement in view. They aim also to cover the much wider need of workers in related subjects, particularly in nuclear physics and in astrophysics, for information about current trends in cosmic ray work.

It is not possible, in a single volume of moderate size, to survey all the main lines of cosmic ray investigations, and rather drastic selection has been necessary. It is hoped, however, to cover other subjects in later volumes, where further reports on topics in rapid development would also appear.

I am grateful to the various authors and to the publishers, for the very active co-operation which has made quick publication possible.

J. G. WILSON

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CHAPTER I

THE ANALYSIS OF ENERGETIC NUCLEAR ENCOUNTERS OCCURRING IN PHOTOGRAPHIC EMULSIONS

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INTRODUCTION

With the development of electron-sensitive emulsions, the field of research open to the emulsion technique has been greatly extended, and it has become possible to apply this method, with advantage, to the study of problems which had hitherto been the province of the geiger counter and the cloud chamber.

In particular, the method permits detailed observations on the penetrating showers of particles created in energetic nuclear encounters, and it is the purpose of this article to describe observations made in this field.

Before entering into a detailed discussion of the experimental results relating to penetrating showers, we shall outline the types of interaction which are believed to occur in the nucleon-nucleon encounters. This will be done in the order in which the processes are assumed to occur in the nucleus.

The incident high energy nucleon, which we shall call the primary, makes, within a time of the order of 10^{-23} sec. (the time of traversal of the nucleus) a series of collisions with the individual nucleons of the nucleus; collisions which may either be elastic or radiative. In the latter case various types of quanta may be radiated. It is generally believed that these are π-mesons, and possibly heavier mesons or nucleon pairs, but that direct creation of photons or μ-mesons does not occur. At present very little is known about the production of mesons heavier than π-mesons, and we shall therefore limit ourselves to interactions leading to creation of π-mesons only. The radiative processes will be discussed in Part I.

In both elastic and inelastic collisions recoil nucleons will be produced which, together with the primary and any mesons created, can interact further with the nucleus. In this process lower energy nucleons are generated and by further successive encounters these distribute part of their energy through the nucleus, although they will in general escape from it before losing all their kinetic energy. In this way a statistical distribution of energy will be attained in a time large compared with the interval