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TRENDS IN NUCLEAR PHYSICS — WHAT CAN WE LEARN FROM HIGH ENERGY INTERACTIONS?*

Maurice Goldhaber
Brookhaven National Laboratory
Upton, New York 11973

It is useful for scientists to pause from time to time, to look back at past achievements, to take note of the direction in which their field of research is going and to ask the perhaps elusive question: What are our goals? The interconnection of different fields of research may lead through unforeseen progress in one field to a redefinition of goals in another field, or to a more realistic restatement of those goals, which may turn out to be more complex and more ambitious than we had at first imagined. Thus nuclear physicists cannot ignore progress in the field of elementary particles, usually connected with high energy physics. High energy interactions with nuclei can help in the understanding of nuclear structure and in return help with the solution of problems in the elementary particle field. The walls which have been created between the low and high energy fields should be made as permeable as possible.

For practical reasons the low energy interactions of those new short-lived particles which are produced by high energy interactions, such as μ, π, K mesons, etc., may be considered as part of the high energy field. Like other high energy physics experimentation it implies, as a rule, that one first has to convince a committee of the value of an experiment before one can do it. Some think this is a little like going to confession before one has sinned.

When Rutherford first postulated the existence of a nucleus of the atom in 1911, he had in mind a massive, positively charged, point particle. Later it was realized that the nucleus must have finite extension, a shape that is not necessarily spherical, variable density of charge and matter, and, underlying all this, a complicated internal structure.

When a high energy particle interacts with a nucleus, it can produce, because of its rapid motion, an "instantaneous" picture of its constituents. High energy electrons and protons have been used to study the details of the distribution of charge and matter, or more specifically proton and neutron distribution, in the nucleus. Electrons, which measure the charge distribution, have the advantage that they do not interact strongly with nucleons, and there is therefore no need for higher-order corrections for multiple interactions. On the other hand, strongly interacting particles, e.g., protons or pions, give us information about the nucleon distribution. These are very complex and active fields of research, in which an important goal is comparison of the experimentally obtained distributions with those calculated from the nuclear shell model.

The charged particles produced by accelerators often show interesting interactions if they live long enough to come to rest in matter. In particular, if they are negatively charged, they may end up in atomic orbits of nuclei whose charge and mass number, Z^A, the experimenter can choose. The known negative particles that live long enough, because they do not decay by a strong or electromagnetic interaction, are, in order of increasing mass, μ^-, π^-, K^-, $\bar{p}$, Σ^-, Ξ^-, Ω^-. (Fig. 1) Exotic atoms formed by the first five have been studied and have yielded information about the charge and matter distribution in nuclei. The μ meson is the only one of these particles that does not interact strongly with nucleons. It therefore can reach the K-shell of an atom. From the exact energies of μ-orbits we have learned much about the charge distribution of nuclei.

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