On Non-local Form Factors.

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Summary. — A non-local formalism is suggested for relating classical ideas about unitary fields with the current methods of making calculations about elementary particles. In the proposed scheme the form factors and masses of all particles are obtained from a single invariant through a classical lagrangian principle.

1. — Introduction.

It is possible to give a simple covariant description of extended particles in a classical, nonlinear field theory. Although this simplicity does not survive quantization, the complications result from formal rules which are very indirectly related to experiment. As a consequence it is not known at the present time whether the simple concepts of a classical unitary theory are in unavoidable conflict with experiment.

The following properties of such a theory may be recalled. Elementary particles are regarded as non-singular concentrations of field and correspond to classical eigensolutions of the field equations; as a consequence their masses are calculable and discrete. It is quite possible in principle to describe all particles of spin $h/2$ by the different eigensolutions of the same classical eigenproblem $^{(1)}$.

The fundamental difficulties in this procedure become obvious when one asks a typical question: for example, about the decay of one particle into several others, or about the collision of two of them with or without multiple production. Here the mathematical difficulties exclude any expectation of a

rigorous solution. Moreover, even though the field equations do in principle answer these questions, one is faced with an extreme case of the mathematical situation made familiar by kinetic theory: even if the differential equations could be solved, one still would have to resort to statistical methods because the boundary conditions are not controllable. The field structure representing a single particle is analogous to a gas — but with a continuously infinite instead of only a finite number of degrees of freedom. The representative point of a gas or particle describes an almost unrestricted motion in phase space; in the former case only the temperature, pressure, and volume, may be known and in the latter, only the charge, mass, and spin. The particle as well as the gas may be represented by a Gibbs ensemble. It is clear that any realistic classical theory of the elementary particles would rest on statistical foundations.

Indeed, it is possible, according to a well known conjecture (2), that quantal formulas are statistically abbreviated ways of describing classical interactions between the classical field structures which represent the elementary particles. Here this view will be formulated in the following statements:

a) the structure of an isolated particle is determined by classical field equations;

b) the observable interactions of the elementary particles with each other and with macroscopic objects are described by quantal equations.

If the classical theory is given, then it is possible in principle to establish the truth or falsity of b), and ultimately this would have to be done. But there may be a simpler tentative approach which attempts only to relate, through a set of mutually consistent postulates, classical ideas about unitary fields with the usual methods of doing calculations about elementary particles.

If a) and b) were in fact correct, then one might expect that the empirical masses (and other self properties) which appear in the usual quantal equations are at least approximately the same as the masses which characterize isolated classical particles. Furthermore one might also expect that the classical eigen-solutions play an important role in the quantal equations. For example if an isolated particle decays, then according to the picture underlying a) and b) the quantal description of the decay must somehow depend upon the classical eigensolutions which characterize the initial and final particles. In this spirit one may then try to find the simplest formal way of introducing these classical eigenfunctions into quantum field theory without getting into any new experimental conflicts. We have attempted to do this with a non-local formalism which may have the merit of being suggestive.

(2) This point of view has been discussed by Einstein, de Broglie, Bohm and others. See, for example, L. de Broglie: *Nuovo Cimento*, 1, 37 (1955).