On the Interaction of Elementary Particles in View of the Extended Particle Model - I.

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Summary. — A method to introduce the interactions of extended particles is studied. The method is a relativistic extension of the pseudopotential method of the nonrelativistic many-body problem with the hard core interaction. A difficulty which occurs in the treatment of the relativistic extended particles may be avoided by the use of suitable boundary conditions. A boundary condition which corresponds to the nonrelativistic rigid sphere leads us to the following interaction:

$$\frac{\pi \alpha_0}{m} [\overline{\psi} \gamma_\mu \psi]^2 + [\overline{\psi} \gamma_5 \gamma_\mu \psi]^2].$$

1. — Introduction.

After the discovery of Dirac's hole theory (1) and quantum theory of radiation (2), the dynamics of elementary particles has been studied as quantum theory of a system with infinite degrees of freedom or quantum field theory. And now, although we have a complete and beautiful formalism of quantum field theory with local interaction, it is almost impossible to understand in a unified way the proper characters of elementary particles; i.e. spin, mass, electric charge, isospin etc. Recently many physicists have tried to describe these proper characters of elementary particles in an unified way. Their attempts may be classified roughly as follows:

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1) **Continuous model** (3). In these theories, the concept of field is the most fundamental. For example, Heisenberg's fundamental (3) field which is called "Urmaterie" is a spinor field. And all real elementary particles such as proton, neutron, hyperons, heavy mesons, leptons and also photons are considered as different states of the Urmaterie.

2) **Extended particle model (point-like model).** In these theories, elementary particles are treated as having structures and their proper characters are considered as the internal motions of the particles. In my opinion, the most fundamental concept of these models is a "particle" or a "corpuscle" which is not a pure point, but has structures. Such a concept is called as "point-like" by Takabayashi (4) and he developed a general formalism of a point-like system in which many kinds of models such as rigid body models, droplet models etc., are unified. We can arrive at the field concept by treating many body problems of pointlike particles in the second quantized formalism (5).

Although the author's interest is in the extended particle model, we would like to criticize roughly the theories of Heisenberg (3), Nambu (6) and Okubo-Marshak (7). It is one of the most difficult points to define which is the dynamical law of the so-called "Urmaterie". In the present step, it is quite unclear in what way the old quantum field theory and the new dynamics are related. In the papers of Heisenberg and his collaborators, the dynamics of the Urmaterie is the quantum field theory with regularization procedures. In the continuous model, the regularization procedures are very important to study the new dynamical law of Urmaterie. Heisenberg uses an indefinite metric in a form of a so-called "dipole ghost". Nambu's regularization is a cut-off procedure. Although the former procedure is consistent with the invariant properties of the original Lagrangian, the latter is inconsistent with invariance and, hence, some conservation laws, which is easily seen from the invariance of the Lagrangian, should be reconsidered. Furthermore, all regularization procedures proposed to the present moment are quite arbitrary and seem to have no clear physical basis.

The general formalism of the pointlike system has been developed by

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(4) T. Takabayashi: *Prog. Theor. Phys.*, **25**, 901 (1961); **23**, 915 (1960) (see also the references (5-8)).