been already recognized by SCHRÖDINGER, it was first shown by HÖNL [11] that the spin can be hereby understood as the result of the superposition of a positive mass with a virtual positive-negative mass dipole. In the classical limit, the translation of a mass dipole produces an angular momentum and it is this fact which leads to the spin phenomenon. This of course is of no surprise, since the Dirac equation describing the spin phenomenon is connected to states of negative energy and hence negative mass.

The occurrence of negative masses in quantum theory is different from the one in classical mechanics. Since the Klein-Gordon equation describing Bose particles is obtained from the squared expression for the relativistic energy equation thus removing the ambiguity of the two signatures in eq. (1), it is here assumed that Bose particles, and which in the classical limit are associated with real force fields, can only occur with positive mass. In contrast the Dirac equation is derived from the unsquared relativistic energy equation thus permitting both signs in eq. (1) and it is therefore assumed that Fermi particles can occur with both positive or negative mass.

In his model of dually charged quarks SCHWINGER [1] assumes the following quantization condition:

$$eg_0/\hbar c = 2n\,, \qquad n = 1, 2, \ldots, \tag{3}$$

where $e^2/\hbar c$ is the electric and $g_0^2/\hbar c$ the magnetic coupling constant resulting from the electric monopole of charge e and the magnetic monopole of charge g_0. Since from observation $e^2/\hbar c \simeq 1/137$, a unit of magnetic charge g_0 is deduced by putting in eq. (3) $n = 1$ hence

$$g_0^2/\hbar c \simeq 4 \times 137 = 548\,. \tag{4}$$

The quark hypothesis assumes fractionally charged particles in units of e given by $\frac{2}{3}, -\frac{1}{3}, -\frac{1}{3}$. If one therefore redefines the fundamental electric charge by $e_0 = \frac{1}{3}e$, the electric charge of the quarks in units of e_0 would be $2, -1, -1$. According to SCHWINGER the magnetic charge of the quarks in units of g_0 would then be $2, -1, -1$.

Electric and magnetic charges, like electric and magnetic fields, behave opposite under spatial reflection, whereas the equations of electromagnetism are symmetric between positive and negative charges, when both types are considered together. Hence, if the dually charged particles and their antiparticles have a certain fixed ratio between their electric and magnetic charge, but not its negative value, the rule of CP invariance is broken. However, the weakness of the observed CP violation suggests the existence of large magnetic charge exchange currents flowing in between the dually charged particles. Large magnetic charge exchange currents are also consistent with our negative-mass hypothesis for the quarks, since it seems that only a magnetic charge exchange force can account for the binding of oppositely charged negative-mass magnetic monopoles. As it was stated, forces which are attractive in between positive-mass particles will be repulsive for negative-mass particles. Neglecting the much smaller electric charge for the dually charged particles it follows that the magnetic force will predominate. Since this magnetic Coulomb force for oppositely charged magnetic monopoles would be attractive for positive-mass particles, it would be repulsive for negative-mass particles and would not lead to a bound state. If, however, the magnetic interaction is accompanied by a large magnetic charge exchange current, a Heisenberg-type magnetic charge exchange force will result and which can become larger than the ordinary Wigner-type force. A Heisenberg-type charge exchange force is repulsive for oppositely charged positive-mass particles and hence attractive for negative-mass

(11) H. HÖNL: *Ergeb. exak. Naturwiss.*, **26**, 291 (1952).