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THE ENRICO FERMI INSTITUTE
FOR NUCLEAR STUDIES

Nov. 25

Dear Pega:

This letter will mean little to you unless it is read in conjunction with the abstract of my paper, a copy of which should reach you soon. For the first time in my life I am somewhat excited about my own theory. I think, even if it turns out to be wrong in the end, we should try to work on it. The theory is so aesthetically appealing, and there are some empirical indications in favor. I regard the approach of Yang and Mills (on which the theory is based) as ~~one of~~ the most profound ideas in theoretical physics since the invention of the Dirac theory. Compared to that Lee and Yang's suggestion on parity ~~con~~ nonconservation is but a phenomenology.

Some of the ideas in my paper, as you will recognize, originated in conversations I had with you about a year ago, and your contributions are explicitly mentioned throughout the paper.

Quite apart from my theory, now I am strongly convinced that all the past symmetry approaches are mere mental exercises, and are completely on the wrong track. I believe that there are no simple patterns in Yukawa-type Lagrangians in which π, K (and possibly D?) are coupled to baryons. Nature is essentially simple, but simplicity will reveal itself only after we have learned how to look at Nature.

Do you believe in $D^{\pm}$ mesons? I think they exist. What happens to $|\text{hypercharge}| \leq 1$ of d'Espagnat & Prentki and of Schwinger? And then there are all these formulas like

$$\frac{m_N + m_\Xi}{2} = \frac{m_\Lambda + 3m_\Sigma}{4}$$

derived under the assumption that no other particles exist. If there ~~is a doublet~~ are

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doubly-hypercharged particles, why aren't there doubly electrically charged particles? Isn't Nature mysterious?

What have you been doing? Are there new physically interesting ideas?

As for my nonphysics activities my summer was really pleasant. I spent a month and half at Boulder, and then drove through 12 National Parks. Chicago is not as bad as people think. I have a fairly elegant modern apartment overlooking the campus. I'm still a bachelor, but the probability for me to remain single for a long time is gradually diminishing.

Please give my best regards to Suhz. The hospitable atmosphere you and your wife created while I was at Princeton is warmly remembered and appreciated.

Greetings to people at the Institute, especially to Pais, Sandri and Chiu, and also to Nishijima who should be visiting there this weekend.

I have no plan to go to the East in the near future (unless I get invited). So I'll probably see you in New York.

Regards,
John
J. J. Sakurai

November 23, 1959

Since there will be some time interval before pre-prints of the paper entitled "A Theory of Strong Interactions" become available, I have thought that you might be interested in this preliminary form of the abstract.

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All those symmetry models of strong interactions which have been proposed up to the present are devoid of deep physical foundations. It is suggested that, instead of postulating artificial " higher" symmetries which must be broken anyway within the realm of strong interactions, we take the existing exact symmetries of strong interactions more seriously than before. A new theory of strong interactions is proposed on this basis.

Following Yang and Mills we require that the gauge transformations that lead to the three "internal" conservation laws (baryon conservation, hypercharge conservation, and isospin conservation) be " consistent with the local field concept that underlies the usual physical theories." In analogy with electromagnetism there emerge three kinds of couplings such that in each case a massive vector field is coupled linearly to the conserved current in question. Each of the three fundamental couplings is characterized by a single universal constant. Since, as Pais has shown, there are no other internal symmetries that are exact, and since any successful theory must be simple, there are no other "fundamental" strong couplings. Parity conservation in strong interactions follows as the direct consequence of parity conservation of the fundamental vector couplings. The three vector couplings give rise to corresponding current-current interactions. Yukawa-type couplings of pions and K particles to baryons are "phenomenological," and may arise, for instance, out of four-baryon current-current interactions along the lines suggested by Fermi and Yang. All the successful features of Chew-Low type meson theories and of relativistic dispersion relations can, in principle, be in accordance with the theory whereas none of the predictions based on relativistic Yukawa-type Lagrangians are meaningful unless ω/M is considerably less than unity.

Simple and direct experimental tests of the theory should be looked for in those phenomena in which phenomenological Yukawa-type couplings are likely to play unimportant roles. The fundamental isospin current coupling in static limits gives rise to a short-range repulsion (attraction) between two particles whenever the isospins are parallel (antiparallel). Thus the low energy s wave πN interaction should be repulsive in the $T = \frac{3}{2}$ state and attractive in the $T = \frac{1}{2}$ state in agreement with observation. In $\pi\Sigma$ s wave scattering the $T = 0$ state is strongly attractive, and there definitely exists the possibility of a s wave resonance at energies of the order of the K^-p threshold, whereas the $T = 1$ $\pi\Sigma$ phase shift is likely to remain small; using the K matrix formalism of Dalitz and Tuan, we might be able to compare the "ideal" phase shifts derived in this manner with the "actual" phase shifts derived from K^-p reactions. The fundamental hypercharge current coupling gives rise to a short-range repulsion (attraction) between two charge-doublet particles when their hypercharges are opposite (like). If the isospin current coupling is effectively weaker than the hypercharge current coupling, the KN "potential" should be repulsive and the $\bar{K}N$ "potential" should be attractive, and the charge-exchange scattering cross sections of K^+ and K^- should be small at least in s states. All these features seem to be in agreement with current experiments. Conditions for the validity of Pais' doublet approximation are discussed. The theory offers a possible explanation for the long standing problem as to why associated production cross sections are small and K^- cross sections are large. The fundamental baryonic current coupling gives rise to a short-range repulsion for baryon-baryon interactions and an attraction for baryon-antibaryon interactions. There should be effects similar to those expected from "repulsive cores" in both the $T = 1$ and $T = 0$ NN interactions at short distances though the $T = 1$ state may be more repulsive. A simple Thomas-type calculation gives a spinorbit force of the right sign with not unreasonable order of magnitude. The ΛN and ΣN interactions at short distances should be less repulsive than the NN interaction.

Because of the strong short-range attraction between a baryon and an antibaryon there exists a mechanism for a baryon-antibaryon pair to form a meson. The dynamical basis of the Fermi-Yang-Sakata-Okun model as well as that of the Goldhaber-Christy model follows naturally from the theory; all the ad hoc assumptions that must be made in order that the compound models work at all can be explained from first principles. It is suggested that one should not ask which elementary particles are "more elementary than others," and which compound model is right, but rather characterize each particle only by its internal properties such as total hypercharge and mean-square baryonic radius. Although the fundamental couplings of the theory are highly symmetric and universal, it is possible for the three fundamental couplings alone to account for the observed ~~baryon~~ mass-spectrum. The theory can explain, in a trivial manner, why there are no "elementary" particles with baryon number greater than unity provided that the baryonic current coupling is sufficiently strong. The question of whether or not a $|S|=2$ meson exists is a dynamical one that depends on the strength of the hypercharge current coupling.

Finally it is conjectured that there is a deep connection between the law of conservation of fermions and the universal V-A weak coupling. In the absence of strong and electromagnetic interactions, baryonic charge, hypercharge and electric charge all disappear, and only the sign of γ_5 can distinguish a fermion from an antifermion, the fermionic charge operator being diagonalized by γ_5; hence $1 + \gamma_5$ appears naturally in weak interactions. Parity conservation in strong interactions, parity conservation in electromagnetic interactions and parity nonconservation in weak interactions can all be understood from the single common principle of generalized gauge invariance. It appears that in the future ultimate theory of elementary particles all interactions will be manifestations of the five fundamental vector-type couplings corresponding to the five conservation laws of "internal attributes" -- baryonic charge, hypercharge, isospin, electric charge and fermionic charge.