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B. Pontecorvo

HEAVY LEPTON AND NEUTRINO ASTRONOMY

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Several authors[1-6] have discussed the possible existence of heavy leptons, that is, the possibility that, in addition to the charged leptons $e^{\pm}$, $\mu^{\pm}$ there exist also heavier charged leptons. References[4-6] comment on the feasibility of experiments apt to reveal such new charged leptons. Heavy electrons e' in the reaction $e + p \to e' + p$ were searched for at electron accelerator laboratories, but the negative results of such experiments do not throw light on the possible existence of charged leptons non-excitable by the electromagnetic interaction. It is natural to think that such new leptons, if they exist, will take part in weak interactions together with neutrinos. I have been kindly informed by Yu.Prokoshkin and I.Chuvilo that the group of Schwartz in Stanford is looking for the production of new charged leptons by high energy electrons according to a proposal of Schwartz[4] and the author[10]: a neutrino detector is exposed to neutrino-like particles which are the decay products of short life particles (heavy leptons?) in conditions where the flux of "ordinary" neutrinos from the decay of long life particles (pions and kaons) is strongly suppressed.

Below I shall suppose that actually new charged leptons do exist and discuss some consequences of such a hypothesis in the field of observational neutrino astronomy.

The possible existence of oscillations between different neutrino states has been already discussed[11]. The oscillations might arise if the neutrino mass is different from zero and the lepton charge is not exactly conserved. The existence of oscillations would have far reaching consequences, first, in the field of observational neutrino astronomy and, secondly, for the experimental investigation of important neutrino properties[10].

The conditions necessary for the existence of neutrino oscillations and the equations describing such oscillations were given in ref.[12] for the case when in nature there are only four independent neutrino states. The diagonal states are two Majorana neutrinos with different masses (that is four states, when the two spin directions are taken into account). Below I shall discuss the neutrino oscillation problem under the assumption that heavy charged leptons exist and consider only 3 possibilities.

1. For every "new" charged lepton Λ there is a corresponding neutrino ν_Λ, all neutrinos being strictly longitudinal[13].

Every type of neutrino has two states and clearly there will be no oscillations.

2. Although there are a number of charged leptons, there exist only two, already known, types of neutrinos (four neutrino states).

The neutrinos are not strictly longitudinal, their mass is not exactly equal to zero and we have a four component neutrino with parity violation[14-15]. This scheme is especially attractive and simple in presence of a number of charged leptons. If the lepton charge conservation is also violated, there will arise the oscillations $\nu_e \rightleftarrows \nu_\mu$, which were discussed in ref.[12]. Here the ordinary notations for the "phenomenological" particles (ν_e and ν_μ) are used. The average flux of solar neutrinos which is detectable at sufficiently large distances will be twice as small as the neutrino flux detectable under strict lepton

charge conservation[11-12] (here I am not considering refined experiments capable of revealing [10,12,16,17] the actual cosinusoidal variation).

3. There are N types of charged leptons and N types of neutrinos, but contrary to (1), neutrinos are not strictly longitudinal, and in addition, lepton charges are not strictly conserved. In such a case the diagonalization of the states is rather cumbersome but some physical consequences of this scheme can be seen immediately. At sufficiently large distances from the source of a given type of neutrinos, let us say electron neutrinos, the existence of oscillations has the effect of "deluting" them among the N existing. Low energy neutrinos (such as solar neutrinos) in a way are singular: at sufficiently large distances from the Sun, a considerable fraction of them, namely, the fraction N-1/N, will be sterile. In fact, their energy is smaller than the mass of all the charged leptons excepting the electron. Consequently, with the exception of the process $\nu_e + n \rightarrow e^- + p$, all the processes which are typical for their registration are not possible. Thus, there arises the possibility (of great importance in neutrino astronomy) that solar neutrinos will be detected at the Earth surface very inefficiently. Thus, even if it should turn out in the future that the flux of detectable neutrinos is extremely small (in comparison with theoretical estimates) it will be nevertheless unreasonable to draw definite conclusions, revolutionary from an astrophysical point of view, before the neutrino properties at issue are better understood (here I do not have in mind the negative result of Davis et al.[18], the interpretation of which,

in my opinion, is still within the limits of the known physics and astrophysics).

True, the theoretical scheme which might lead to such sad consequences for observational neutrino astronomy is not attractive from an aesthetical point of view and one may hope that such a scheme does not take place in nature.

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