$$\mu'^{+} \to e^{+} + \nu_e + \nu_\mu,\ \mu^{+} + 2\nu_\mu, \qquad (1)$$
$$\mu'^{+} \to n\pi + \nu_\mu, \qquad n = 1, 2, 3, \ldots, \qquad (2)$$
$$\mu'^{+} \to K^{+} + \nu_\mu,\ K + \pi + \nu_\mu. \qquad (3)$$

For the mass $m_l = 5\ m_\mu$ the partial lifetime against decay by the channels (1) is 4×10^{-10} sec, and it falls off as $1/m_l^5$. The Michel parameter for the decays (1), unlike that for the μ decay, is zero, $\rho = 0$.

In the present note we wish to call attention to the fact that the experiments with high-energy neutrinos carried out so far [5,6] evidently do not exclude the indicated possibility of the existence of a heavy lepton μ'^{+}, but farther improvement of the statistics in these experiments will make it possible either to exclude or to confirm this possibility for masses $m_l \sim 5$–$9\ m_\mu$. Estimates show that in this range of masses the main decay of the heavy lepton would be the pion decay

$$l \to \pi + \nu, \qquad (4)$$

which has a probability several times that of the leptonic decays (1). Assuming that the coupling constant between the lepton and pion currents is the same in the decays $\pi \to \mu + \nu$ and $l \to \pi + \nu$, we find

$$\tau(l \to \pi + \nu) = \frac{0{,}27}{(m_l/m_\pi)^2 - 2}\,\frac{m_\mu}{m_l}\,\tau_\pi. \qquad (5)$$

From this it follows, for example that $\tau(l \to \pi + \nu) = 1 \cdot 10^{-10}$ sec for $m_l = 5\ m_\mu$ and $\tau(l \to \pi + \nu) = 2.4 \cdot 10^{-11}$ sec for $m_l = 8\ m_\mu$. Inclusion of other decay channels can decrease the estimate of the over-all lifetime by as much as a factor of two.

This short lifetime shows that in the neutrino experiments it may not be possible to detect the production of the heavy lepton as a free particle (especially in a spark chamber), and only the decay products will be observed, for example

$$\nu_\mu + p \to n + l^{+} \to n + \pi^{+} + \nu_\mu, \qquad (6)$$
$$\bar{\nu}_\mu + n \to p + l^{-} \to p + \pi^{-} + \tilde{\nu}_\mu. \qquad (7)$$

Such events can be imitated by neutral lepton currents ("inelastic" cases), and also by the presence of background neutrons ("neutron stars"). In these latter cases, however, there should be observed in addition to the processes (6), for example, also the products of reactions of the types $\nu_\mu + n \to p + \pi^{-} + \nu_\mu$ and $\nu_\mu + N \to N + \pi^{0} + \nu_\mu$. If, on the other hand, the events are caused by heavy leptons, these latter processes will be absent. For the identification of the processes (6) and (7) it is important to study in detail the structure of the pion track in the immediate neighborhood of the vertex of the event. Events with pions but without visible leptons can raise suspicions of the presence of heavy leptons.

It is interesting that in a report in Sienna in October 1963 on "Preliminary Results in a Bubble Chamber" [6] it was indicated that 11 cases of events of the type $\nu_\mu + p \to n + \pi^{+} + \nu_\mu$ had been noted. This was about 8 percent of the total number of events. This number can be regarded as a high estimate of the probability of process (6) under the conditions of the experiment in question. We note that the appearance of solitary strange particles observed by these authors may also be due to the production of μ'^{+}.

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TRANSFER OF A NEGATIVE MUON FROM A PROTON TO CARBON

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WHEN negatively charged mesons are stopped in a hydrogen-containing compound, some of the mesons are captured by the mesic-atom orbits of the proton, forming a mesic-proton atom. In condensed media, owing to collisions with the atoms of the surrounding matter, a rapid transfer of the meson takes place to the lower energy levels of the mesic-proton atom, along with an intense pickup of mesons by atoms having charges $Z > 1$ (see, for example, [1]). Analogous processes occur also when negatively charged muons are stopped in gaseous hydrogen containing heavier chemical elements as impurities [2].

According to the theoretical prediction [3] the transfer of a meson from a proton to heavy atoms in condensed media occurs principally at high excited levels. Thus, even in the case of the pickup of a muon from the ground state of the $p\mu$ atom by carbon, the principal role is played by the transition to the level with $n = 4$; in the case of oxygen—to the level with $n = 5$.

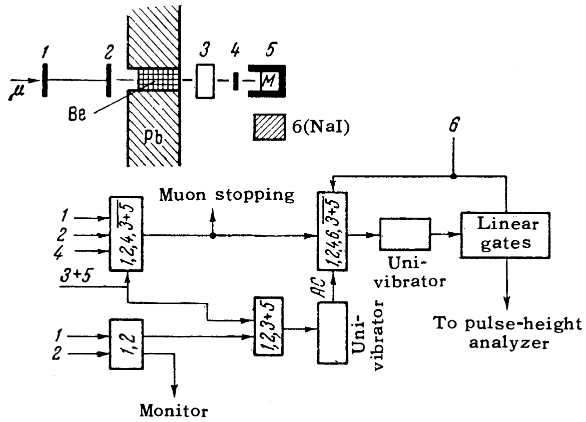

Diagram of experiment and block diagram of electronic circuitry; Pb – lead shield, Be – beryllium filter, M – sample (C or CH_2).

The presently available experimental data do not exclude, however, the possibility that a considerable fraction of the mesons is transferred from the proton to the Z nucleus at lower energy states, including the ground state. Thus, the data of Dzhelepov et al. [2] presuppose that the fraction of the muons which is picked up by heavy nuclei (carbon or oxygen) at the ground level can reach 10%. Less definite conclusions with respect to this process can be drawn from the experiment carried out with liquid hydrogen [4].

In addition to being of theoretical interest, the question of transfer of muons exclusively at excited levels of the $Z\mu$-mesic atom with further cascade transition of the system to the ground state with emission of a K-mesic x-ray series is of interest, because this process could serve as an instrument for the investigation of several mesic-atom processes which occur in compounds or mixtures containing hydrogen.

The experimental investigation method consists in comparing the intensities of the K series from mesic atoms of carbon, produced when negatively charged muons are stopped in carbon (graphite) and in polyethylene (CH_2). The transfer of a muon from a $p\mu$ atom directly in the lower energy state of the $C\mu$ atom will lead to a loss of K-series mesic x-radiation

The figure shows a block diagram of an experiment as well as the electronic circuitry. Plastic scintillators were used in counters 1, 2, 4, and 5; counter 3 contains a plexiglas Cerenkov radiator to eliminate the beam electrons. The x-ray quanta were registered in counter 6 in a NaI crystal 30 mm in diameter and 12 mm thick.

Samples of C and CH_2 30 mm in diameter and 20 mm thick were placed in the scintillation container of the counter 5. The density of the carbon in the graphite and polyethylene targets was approximately the same.

Measurement series	Sample	Number of muons stopped in the target	N_X – number of x-ray quanta of K series	$R = N_X(CH_2)/N_X(C)$
I	CH_2	328255	11919	0.993 ± 0.012
	C	335680	12269	
II	CH_2	622144	20471	0.998 ± 0.009
	C	654213	21567	
		Total of two series:		0.996 ± 0.007

The results of the two series of measurements are shown in the table. The last two columns of the table give the ratio of the yield of the x-quanta from the polyethylene and graphite targets, normalized to the number of stopped muons.

If we assume that the probability of the muon landing on C and H is proportional to their charge, then the muons which jump over from the proton to the carbon in the cascade transitions give a K-mesic x-ray series whose intensity is 0.98 ± 0.03 of the intensity occurring in the case of direct landing of the muons on the carbon.

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