# STUDY OF THE BEHAVIOR OF MUONIUM IN SCINTILLATING PLASTIC

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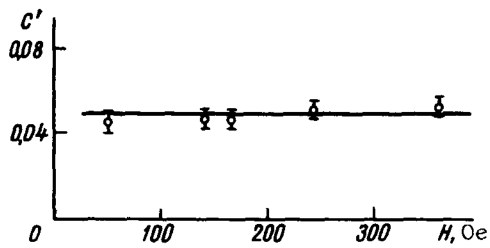
Zichichi et al. [1] observed that an increase in the magnetic field intensity causes an appreciable increase in the asymmetry coefficient of the angular distribution of the decay positrons produced when $\mu^+$ mesons are stopped in a scintillating plastic. These measurements, made in a longitudinal magnetic field, have shown that the asymmetry coefficient nearly quadruples in the 0 - 400 G range, reaching ~80% of the asymmetry coefficient in carbon. An important fact is that the magnetic field employed is insufficient to reconstruct the polarization of muonium [2].

We used a previously described procedure [3] to measure the asymmetry coefficients (c') for precession in a transverse magnetic field at a frequency corresponding to the "free" $\mu^+$ meson, which is identical with the precession of a meson contained in a chemical compound with a covalent bond between a pair of compensated electrons (mesonic component) [4,5]. As seen from Table I and from the figure, within the limits of experimental errors, the quantity $c'_{\mu^+}$ remains constant. The presented values were obtained at a bromoform (standard substance) polarization equal to c' = 0.280 ± 0.006. The observed difference between the asymmetry coefficients in longitudinal and transverse magnetic fields greatly exceeds the limits of errors and cannot be attributed to experimental errors.



Dependence of asymmetry coefficients in scintillating plastic on intensity of transverse magnetic field.

Table I

Asymmetry coefficients (mesonic component $c'_{\mu^+}$) in scintillating plastic at different intensities of the transverse magnetic field (H)

| T°C | H, Oe | $c'_{\mu^+}$ |
|---|---|---|
| 25 | 50 | 0.045±0,005 |
| 25 | 140 | 0,047±0,005 |
| 25 | 164 | 0,047±0,005 |
| 25 | 240 | 0.052±0,005 |
| 25 | 360 | 0,054±0,005 |

This question is essential for the understanding of the physical nature of muonium formation and of its chemical interactions. The indicated fact cannot be explained on the basis of existing views, and requires a theoretical foundation. It is not excluded that a decisive role is played by the effect of the magnetic field on the rate of the chemical reactions at a distinct direction of the meson spin - one of the components of the chemical interaction.

Zichichi et al. [6] indicate the presence of precession of atomic triplet muonium (muonium component) in scintillating plastic at liquid-nitrogen temperature, with an initial asymmetry coefficient ~0.17. The measurements were made in a transverse magnetic field of 10 G intensity (period ~70 - 80 nsec at a channel width 20 nsec). The statistics in this experiment amounted to 450 - 500 counts/channel. Similar experiments were made with the JINR synchrocyclotron. The beam-intensity peak used was "stretched" in time [7], since the fine structure of the unstretched accelerator pulse resulted in modulation of the intensity with a period of 71 nsec, corresponding to the acceleration frequency, thereby distorting the observed picture [8]. Precautions were taken to conserve the glass-like structure of the scintillator at -196°C. The intensity of the transverse magnetic field was 7.23 ± 0.08 Oe, and the channel width was 9.97 ± 0.04 nsec. The statistics in each series of measurements reached 2500 - 2700 counts/channel. Individual experiments have shown that when modulation stretching is used, the intensities of the random coincidence background are considerably lower than the statistical errors of the experiment. Observation, under the same conditions, of the precession of triplet muonium in crystalline and fused quartz or solid carbon dioxide at different temperatures can serve as control measurements.

Table II

Asymmetry coefficients (muonium component $c'_{Mu}$) in scintillating plastic and in polystyrene

| T° C | Substance | $c'_{Mu}$ |
|---|---|---|
| − 196 | Scintillating plastic | 0.005±0.010 |
| − 196 | " " | 0.008±0.011 |
| − 196 | Polystyrene | 0.009±0.024 |

The performed series of experiments have demonstrated the absence of precession of triplet muonium in the scintillator (Table II). To clarify the role of impurities in the scintillation plastic (polystyrene plus 2% terphenyl), measurements were made in polystyrene, and again demonstrated the absence of precession of triplet muonium. Such a discrepancy of the experimental data can be connected apparently only with methodological features of the experiment.

[1] A. Buhler, T. Massam, Th. Muller, M. Schneegans, and A. Zichichi, Nuovo Cimento 39, 812 (1965).

[2] A. O. Vaisenberg, Myu-mezon (The Muon), Nauka, M., 1964.
[3] A. I. Babaev, M. Ya. Balatz, G. G. Myasishcheva, Yu. B. Obukhov, V. S. Roganov, and V. G. Firsov, JETP 50, 877 (1966), Soviet Phys. JETP 23, 1583 (1966).
[4] V. G. Nosov and I. V. Yakovleva, JETP 43, 1750 (1962), Soviet Phys. JETP 16, 1236 (1963).
[5] V. G. Firsov and V. M. Byakov, JETP 47, 1074 (1964), Soviet Phys. JETP 20, 719 (1965).
[6] A. Buhler, T. Massam, Th. Muller, M. Schneegans, and A. Zichichi, Twelfth Intern. Conf. on High-energy Physics (Dubna 1964) 1, 944 (1966).
[7] V. G. Zinov, S. V. Medved', and E. B. Ozerov, JINR Preprint R-2657, 1966.
[8] A. I. Babaev, M. Ya. Balats, G. G. Myasishcheva, Yu. V. Obukhov, V. S. Roganov, and V. G. Firsov, JETP Letters 3, 3 (1966), transl. p. 1.

## DETERMINATION OF THE ADIABATICITY PARAMETER $\rho_L/R$ FOR AN ELECTRON MOVING IN AN AXIALLY-SYMMETRICAL MAGNETIC TRAP

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We have investigated experimentally the dependence of the lifetime $\tau$ of electrons captured in a magnetic trap on the magnetic field. S. N. Rodionov [1] has shown that at certain magnetic-field configurations the electron lifetime is large ($\sim 10^7$ oscillations). However, the physical picture of the motion of a charged particle in a magnetic trap over very long time intervals remained quite unclear. Chirikov [2,3] was among the first to investigate this picture, and found it to be, in the most general outline, as follows: There exists a certain critical value $(\rho_L/R)_1$ at which the motion becomes stochastic, and when $\rho_L/R < (\rho_L/R)_1$ the motion is stable, i.e., it differs little from the motion with constant magnetic moment ($\rho_L$ - Larmor radius, R - radius of curvature of the force line). However, the question of how long stability is maintained during the course of the motion remained open.

Hope of rigorously explaining this question was raised by the papers of Kolmogorov [4] and Arnol'd [5], in which the conditions were obtained for absolute stability, i.e., for stability at a finite value of $\rho_L/R$. Arnol'd [5] formulated a theorem that at a certain finite value of the adiabaticity parameter ($\rho_L/R$ in our case) the charged particle should exist in the trap forever, i.e., it should never leave the volume, if there are no additional loss sources. However, the theory could not determine the value of the parameter $(\rho_L/R)_1$. In our experiments we attempted to find the numerical critical value of the parameter $(\rho_L/R)_1$.

The maximum lifetime during the time of our experiments, at $\rho_L/R < (\rho_L/R)_1$ was 410 sec ($5 \times 10^{11}$ Larmor revolutions) and was determined by scattering by the residual gas.

The experimental setup was a magnetic trap of mirror configuration. The maximum magnetic field at the center of each of the mirrors reached 1500 Oe at a mirror ratio ranging