

Review of the Experiments Related to the Radiative Neutron Decay

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The report gives an overview of the experiments related to the radiative decay of a neutron. Emphasis is placed on our 2005 experiment conducted at the Technical University of Munich at the FRMII research reactor. Our methodology is focused on measuring the spectra of triple coincidences of radiative gamma-quantum, beta electron, and recoil proton and double coincidences of beta electron and recoil proton. The peak on the spectrum of triple coincidences shows the number of radiative neutron decays, while the peak on the spectrum of double coincidences shows the number of regular neutron beta-decays. This methodology enabled us to become the first team to measure the branching ratio (B.R.) of radiative neutron decay $B.R. = (3.2 \pm 1.6)10^{-3}$ (where C.L. = 99.7% and gamma quanta energy exceeds 35 Kev) [1] in 2005 on our old experimental equipment.

We have now prepared a new experiment on radiative neutron decay with the aim of measuring B.R. with a high degree of precision. The precision of branching ratio measurement is determined using the value of the ion background. The spectrum of double coincidences obtained in our experiment shows a fairly significant ion background, the fluctuations of which indicate the precision of measurement for the number of recoil protons [1,2]. Because the ion background specifically is quite significant, it appears even under super deep vacuum as beta electrons ionize the highly rarified air inside the chamber. The value of the ion background very slowly decreases with decreasing density of air inside the equipment. For example, our experimental data lead to the conclusion that the value of the ionic background is significant when compared with the value of the proton peak and on the other hand decreases only by 5-6 times if the pressure within the chamber goes down by 2 orders of magnitude. Besides, we discovered an additional wide peak on the spectrum of triple coincidences. This peak consists of delayed gamma quanta created during the ionization of rare gas by beta-electrons.

Thus, this experiment allows us to study another important phenomenon, the ionization of rarified gas by beta electrons with emission of gamma quanta. Our last experiment showed that these two phenomena, radiative neutron decay and ionization with gamma quanta emission, are distinguishable in the case of high time resolution and can be studied separately. This is another important result of our last experiment and in this report we mention that the authors of articles [3, 4] registered namely the ionization with gamma radiation events.

This report is dedicated to a discussion of the computer experiment we conducted using the well-known GEANT4 software package. As a result of these calculations, we demonstrated that the value of the ionic background is proportional to the cubic root of the rarefied air density within the equipment, i.e. it changes very smoothly in relation to the pressure within the chamber. Besides, the report presents a comparison of our measurements of double coincidences [2] and triple coincidences [3, 4], with two other experimental groups.

[1] R.U. Khafizov et al. JETP Letters, **83**(1), 2006, p. 5.

[2] L.J. Lising, et al., Phys. Rev. C **6**, 2000, p. 055501.

[3] J.S. Nico, et al., Nature **444**, 2006, p.1059.

[4] R.L. Cooper, et al., Phys. Rev. C **81**, 2010, p.035503; M.J. Bales, et al., Phys. Rev. Lett. **116**, p. 242501 (2016).