Search for Decay Rate Oscillations in EC Decays: the Case of Neutral ^{180}Re

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With participation of MLL physicists two-body electron capture decays of highly ionized ions have been studied at the Experimental Storage Ring (ESR) of GSI Darmstadt [1-3]. In these decays the mother and daughter ions have the same charge and only slightly changed mass, such that they both can be observed and separated in the Fourier analysis of their Schottky noise signal. This is possible for single ions in time intervals shorter than 1s. In electron capture (EC) decays of ^{140}Pr, ^{142}Pm and ^{122}I nuclei with just one atomic electron the spectrum of decay times after creation showed an oscillation with an amplitude of between 0.1 and 0.2 and a period of about 6-7s, inversely proportional to the mass of the recoiling ion [4-6]. As a hypothesis such oscillations were brought into connection with an interference of decay amplitudes because of the different recoil energies when neutrinos with different masses are emitted. In order to investigate, whether such a phenomenon occurs also for radioactivities in a solid environment but has been overlooked in earlier experiments, we produced ^{180}Re with a ^{3}He beam from the MLL tandem in single short irradiations of <1s duration [7]. After EC decay with a half-life of 2.44(6) min a prompt gamma ray is emitted that served as time marker for the decay. From the oscillations observed in ^{122}I, ^{140}Pr and ^{142}Pm [4-6], scaled with the mass, one would expect a frequency of 0.158 s^{-1}. Fits or Fourier analyses of these time spectra between production and decay did not show an oscillation with corresponding frequency and an amplitude larger than 0.03. Fig. 1 shows Fourier transform spectra of four such irradiations. Thus we concluded that our experiment did not produce the effect of the ESR experiment. It differed from the ESR experiment however by the solid environment of the decaying nucleus and because the daughter state is short lived. Thus the daughter nucleus does not assume a sharp state of momentum and energy.

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Figure 1: Fast Fourier Transform of four decay time spectra of ^{180}Re. There is no pronounced frequency signal with 0.158 Hz observed.