Comment on "Hypersharp Resonant Capture of Neutrinos as a Laboratory Probe of the Planck Length"

In [1], Raghavan claims that due to motional averaging by lattice vibrations, 18.6 keV $\bar{\nu}_e$ emitted or captured without recoil from two-body decay in the ^{3}H/^{3}He system embedded in Nb metal will be observable with natural width Γ_{nat}. In this Comment we argue that (i) stochastic relaxation processes and (ii) inhomogeneities in the metal matrices will prevent the generation of antineutrinos with Γ_{nat} in the ^{3}H/^{3}He system, (iii) the different lattice-deformation energies of ^{3}H and ^{3}He in the Nb matrix will drastically decrease the fraction of phononless emission or detection of antineutrinos, (iv) the age itself of the ^{3}H source does not affect the linewidth.

Harmonic lattice vibrational motions do not cause a broadening of the Mössbauer line. Raghavan demonstrates this by using a continuous frequency modulation (FM) model. However, for ^{3}H/^{3}He embedded in a metal (like Nb) there exist stochastic magnetic relaxation effects which are *not* connected to lattice vibrations. Spin-spin interactions between nuclear spins of ^{3}H and ^{3}He and with the spins of the Nb nuclei of the Nb metallic lattice lead to fluctuating magnetic fields. A simple relaxation model consists of the ground state and two excited hyperfine-split states (separation $\hbar\omega_0$). Stochastic processes are characterized by sudden and irregular transitions between these hyperfine-split states with an *average* rate ω. Stochastic transitions can not be described by a continuous FM model. It has been known for a long time (see, e.g., [2]) that stochastic relaxation processes do increase the linewidth if ω is comparable to ω_0. For typical magnetic hyperfine splittings due to nuclear spin-spin interactions in metallic lattices, $\omega_0 \approx 10^5\ \mathrm{s}^{-1}$, and typical relaxation times for ^{3}H and ^{3}He in a metallic Pd lattice are $T \approx 2$ ms, and for NbH, $T \approx 79\ \mu$s [3]. Thus, for the system ^{3}H/^{3}He in Nb metal, $\omega_0 \approx \omega = 2\pi/T$ and experimental linewidths of $\Gamma_{\mathrm{exp}} = \hbar\omega \approx 50 \times 10^{-12}$ eV $\approx 4 \times 10^{13}\Gamma_{\mathrm{nat}}$ have to be expected.

Inhomogeneities are caused by lattice defects, variations in the lattice constant, impurities, etc. Such inhomogeneities and, in particular, the highly different concentrations and random distributions of ^{3}H and ^{3}He in source and target will cause variations of the binding energies E_B of ^{3}H and ^{3}He atoms in Nb metal. With the conventional Mössbauer effect (ME), different E_B values due to inhomogeneities influence the photon energy only through the *difference* of the mean-square nuclear charge radius between the ground state and the excited state in the *same type* of nucleus in source and target. This causes a shift of the photon energy typical for hyperfine interactions ($\approx 10^{-8}$ eV). In the best single crystals, inhomogeneous broadening is 10^{-13} to 10^{-12} eV [4]. With $\bar{\nu}_e$ emission and capture, however, *nuclear transformations* occur. In the Nb lattice, E_B per atom for ^{3}H and ^{3}He is in the eV range [5], many orders of magnitude larger than hyperfine interaction energies. Since, in the nuclear transformations, the $\bar{\nu}_e$ energy is *directly* affected by variations of E_B, one has to expect a variation of the $\bar{\nu}_e$ energy by several orders of magnitude larger than 10^{-12} eV, i.e., larger than $10^{12}\Gamma_{\mathrm{nat}}$.

The different lattice-deformation energies E_L for ^{3}H and ^{3}He in the Nb lattice [5] have the consequence that E_L changes by ≈ 0.45 eV at the lattice site where the nuclear transformation occurs. If the lattice rearrangement is accompanied by phonon generation, the resonance condition for the ME to occur will be destroyed. An estimate gives a reduction factor of 1×10^{-6} for phononless emission and capture of the $\bar{\nu}_e$ [4]. The argument given in [1] that such lattice excitations are harmless since they occur only with the speed of sound does not hold for the conventional (photon) ME and is also not valid in the case of $\bar{\nu}_e$ interactions.

In a $\bar{\nu}_e$ Mössbauer experiment, the clock is started together with the measurement, i.e., at that moment when source and detector are arranged in their fixed positions. The measuring time, not the age itself of the ^{3}H source, is important for the linewidth.

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