SPAN – Spectroscopy by Atomic Neutrinos

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We propose a new novel method to measure fundamental parameters associated with neutrinos[1]. It utilizes the neutrino pair emission from atomic levels.

One of the important questions left in the particle physics is related to the neutrino parameters. These involve their mass nature, Dirac or Majorana, absolute mass values, and their mixing parameters which appear in the weak interactions. As is well known, the recent oscillation experiments firmly established neutrinos' finite masses. However, these experiments can determine only mass-squared differences of three neutrino species. One naive view is to take two heavier neutrinos have masses suggested by the mass scales of the atmospheric and solar oscillation experiments, respectively, and the lightest one much smaller than the two;

$$m_3 \sim 50 \text{ meV}, \qquad m_2 \sim 10 \text{ meV}, \qquad m_1 \ll m_2. \tag{1}$$

How to measure such small masses and how to determine their mass nature? Experiments so far aiming to answer these questions tend to utilize nuclear processes, which usually involve much larger energy scale; for example the tritium beta decay end point energy is 18.6 keV.

We propose to employ neutrino pair emissions from atomic levels to determine neutrino absolute masses;atomic level spacings are much closer to expected neutrino mass scale. As will be discussed, other parameters can be measured simultaneously with the mass determination. The main difficulty in the method lies in the smallness of weak processes. Typically neutrino emission rate scales with $G_F^2 Q^5$, where G_F is the Fermi coupling constant and Q is the available energy in the process. The rate is usually very small and we need some enhancing mechanism to realize such experiments.

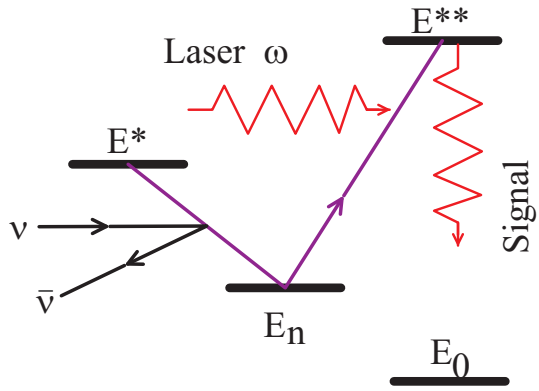

Figure 1: Laser irradiated neutrino pair emission level scheme.

We employ several methods for this purpose; one is a laser irradiated pair emission which use a resonance effect for enhancement. The relevant scheme is shown in fig.1. The other is to make use of collective nature of atoms. We discuss the prospect of Spectroscopy by Atomic Neutrinos[2].

References

[1] M. Yoshimura, Phys. Rev. D **75**, 113007 (2007).

[2] On behalf of the SPAN group; A.Fukumi, K.Nakajima, I.Nakano, H.Nanjo, N.Sasao, and M.Yoshimura.