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Experimental Study toward Atomic Neutrino Spectroscopy

Recently Yoshimura has pointed out a feasibility of neutrino par emission from excited atoms [1]. An atomic electron lying in excited state decays to lower state accompanying with the neutrino pair through the weak interaction.
The basic strategy of using atoms instead of nuclei is the closeness of neutrino masses to atomic energy levels. The low-lying metastable states may undergo radiative neutrino pair emission (RNPE) $|i\rangle_A \to |f\rangle_A + \gamma + \nu_i\nu_j$. A single photon spectrum will give us various information about neutrino mass. However the neutrino pair emission rate in atoms is too small to reach experimentally. It is necessary to enhance such small process to realize the neutrino mass spectroscopy using atoms.

A collection of the atoms can cooperatively emits photons owing to a correlation
between the atomic dipole moments. Such cooperative radiation is known as super-radiance [2]. The decay time of the super-radiance is proportional to $1/N$, and the radiation intensity is proportional to the square of the number of atoms N^2. Yoshimura {\it et al.} have proposed a macro-coherent amplification mechanism which is an extension of the idea of super-radiance of a single photon emission [3].
In Okayama University, we have started a project of neutrino spectroscopy for measuring the absolute magnitude and the nature of neutrino masses based on the principle. Since this is a newly proposed principle, we like to start verifying it experimentally. To this end, we employ two photon emission process, instead of photon and neutrino pair emission
$|i\rangle_A \to |f\rangle_A + \gamma + \gamma$.
The advantage is that the process is much bigger in rates since it is a pure QED process. There is one important mile stone to carry out this proof-of-principle
experiment; namely we need to make an ensemble of atoms that is
in a pure quantum coherent state, the necessary condition to realize
both super-radiance and macro-coherent amplification process.
We report the current status of our preliminary experiments.

[1] M. Yoshimura, Phys. Rev. D 75, 113007 (2007).
[2] R. H. Dicke, Phys. Rev. 93, 99 (1954);
[3] M. Yoshimura, C. Ohae, A. Fukumi, K. Nakajima, I. Nakano, H. Nanjo, and N. Sasao,
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