Time Reversal Invariance in Resonance Neutron Capture: A Possible Experiment for SNS

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We consider a study of the Time Reversal Violating (TRI) milliweak interactions via TRI odd, Parity (P) odd correlations in resonance neutron capture reactions as suggested by Flambaum and Sushkov [1]. The experiment consists of measuring the zero-crossing energy shift in the (n,γ) analyzing power. The zero-crossing energy appears only in P-violating resonances while its shift (relative to the resonance energy) is produced by TRI breaking; the ratio, $< \lambda >$, of the TRI-violating to P-violating matrix elements can be inferred from this shift. The measurements can be performed with epithermal neutrons at the SNS using an array of high purity germanium detectors with a neutron polarizer and/or a circular polarization analyzer. TRI violating effects in neutron *p*-wave resonances (with P-mixing of compound states) are expected to be enhanced by several orders of magnitude. The advantage of this method over the polarized target/polarized beam technique is that experiments can be performed on several targets, and on different resonances per nuclide, and for several γ transitions per resonance. The goal is obtaining an experimental upper limit on the TRI breaking rms matrix element and, correspondly, on the the ratio $\lambda = g_{TRI}/g_{PNC}$, which is the ratio of TRI violating to PNC violating weak coupling constants. The expected sensitivity for $< \lambda >$ is at the level of 10^{-3}.

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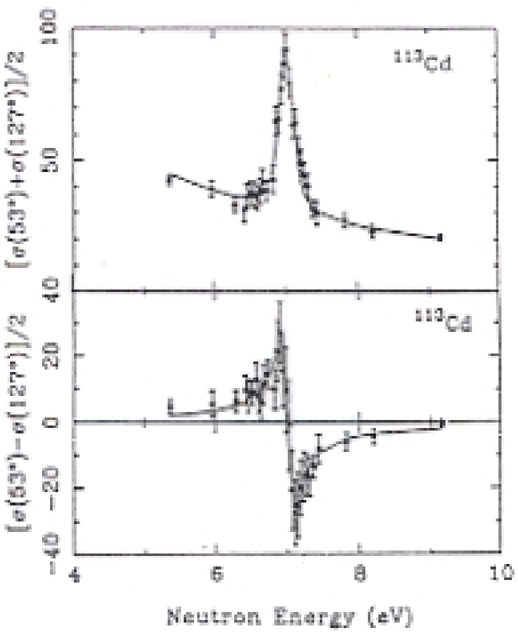
[1] V. V. Flambaum and O. P. Sushkov, Nucl. Phys. A435, 352 (1985)

A possible experimental arrangement at SNS:

- The SNS epithermal neutron beam
- An evacuated flight path of 25 m long
- He^3 polarized filter as a neutron polarizer
- An array of eight high purity germanium detectors
- Electronics for two dimensional tof—pulse-height analysis

An estimate of an upper limit for zero-crossing shift:



A correlation $(\vec{\sigma}_n \cdot \vec{k}_\gamma)$ if measured in a *p*-wave neutron resonance for an individual γ transition as a function of neutron energy E is:

$$\frac{N^+ - N^-}{N^+ + N^-} = 2\ W_P \sqrt{\frac{\Gamma_\gamma(E1)}{\Gamma_\gamma(M1)}}\ \frac{(E - E_p + \Delta E)}{(E - E_p)^2 + \Gamma_{eff}^2/4}$$

$\Delta E \leq 6$ meV (Fig.) is measured in [2]. Scaling this result to the SNS beam: $\Delta E_{TRI} \leq 0.13$ meV for 1000 hours.

The sensitivity of the experiment in terms of λ:

$$\Delta E_{TRI} = \frac{W_{TRI}}{W_P}\Gamma_p = \lambda_{exp}\Gamma_p/2$$

with Γ_p=150 meV $\Rightarrow$ $\lambda_{exp} \leq 1.8\text{x}10^{-3}$ for 1000 hours.

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[2]A. L. Barabanov, E. I. Sharapov, V. R. Skoy, and C. M. Frankle, Phys. Rev. Lett. 70, 1216 (1993).