Enhancement of the Fundamental Symmetry Breaking Effects in Neutron Resonances: Kinematic or Resonance?

Bunakov V.E.

Petersburg Nuclear Physics Institute, National Research Center Kurchatov Institute, Gatchina, 188300 Russia

E-mail: vadim.bunakov@mail.ru

As an example of P-violation in polarized neutron transmission through the sample we consider the longitudinal asymmetry:

$$P_{\exp} = \frac{N_+ - N_-}{N_+ + N_-} \approx \frac{\Delta^P_{tot}}{\sigma_{tot}},$$

where $N_\pm$ is the number of neutrons with opposite helicities transmitted through the target sample, while the corresponding total cross-section for such neutrons is

$$\sigma^{\pm}_{tot} = \sigma_{tot} \pm \frac{\Delta^P_{tot}}{2}.$$

There are two different theoretical approaches to the problem. One of them (see, e.g. [1, 2]) claims that the quantity $P_{\exp} \approx 2\sqrt{\frac{\Gamma^n_s}{\Gamma^n_p}}\frac{W_p}{D}$ in the vicinity of the p-wave resonance contains a "kinematical" enhancement factor $\sqrt{\frac{\Gamma^n_s}{\Gamma^n_p}} \approx \frac{1}{kR}$, where $\Gamma^n_{s,p}$ are s- or p-resonance neutron widths (W_p is the weak interaction matrix element between the s- and p-resonance wave functions, D is the spacing between the neighboring s- an p-levels of the compound nucleus).

Another approach (see, e.g. [3, 4]) gives the expression:

$$P_{\exp}(E) \approx \frac{4\pi}{k^2\sigma_{tot}(E)}\frac{W_p}{D}\frac{\sqrt{\Gamma^n_s\Gamma^n_p}\cdot\Gamma_p}{(E-E_p)^2+\Gamma^2_p/4},$$

containing "resonance" enhancement factor

$$\frac{\Gamma_p}{(E-E_p)^2+\Gamma^2_p/4} = \frac{T(E)}{\hbar},$$

where $T(E)$ is the "delay time" spent by the neutron in the weak field of the target nucleus. It might give a factor of $(D/\Gamma)^2$ enhancement in the maxima of p-resonance.

Analysis is given of both approaches showing that the former one might lead to quite meaningless conclusions. Similar enhancements are present in all the quantities revealing parity or time invariance violation in polarized neutron transmission.

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