Forward-backward asymmetry effect in the slow neutrons capture by Silver nucleus

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Abstract. Forward-backward asymmetry effect in the capture process of slow neutrons on Silver nucleus was investigated. Cross sections, angular distributions, and forward-backward effect were obtained in the frame of the mixing states of compound nucleus with the same spin and opposite parities formalism. Simulated gamma spectra, taking into account different type of target and gamma loss, were also evaluated. Using modeled gamma spectra, the influence of target properties (composition, target thickness) on the investigated effect were analyzed. Forward-backward effect together with other asymmetry and parity breaking effects allow to extract new information on neutrons and gamma reduced partial widths and matrix element of weak non-leptonic interaction.

FORWARD – BACKWARD EFFECT

$$\alpha_{FB} = \frac{W(\theta = 0) - W(\theta = \pi)}{W(\theta = 0) + W(\theta = \pi)}$$

RELATION OF DEFINITION

ANGULAR CORRELATION

$$W(\theta) = 1 + \alpha(\vec{n}_n \cdot \vec{n}_p) + \beta(\vec{n}_n \cdot \vec{n}_p)^2 = 1 + \alpha\cos(\theta) + \beta\cos^2(\theta)$$

FB EFFECT – UN POLARIZED NEUTRONS

$$W(\Omega) \sim \frac{d\sigma}{d\Omega} = |f|^2 = \sum_{i=1}^{4} |f_i|^2 + \sum_{i \neq j=1}^{4} 2\,\mathrm{Re}\, f_i^* f_j$$

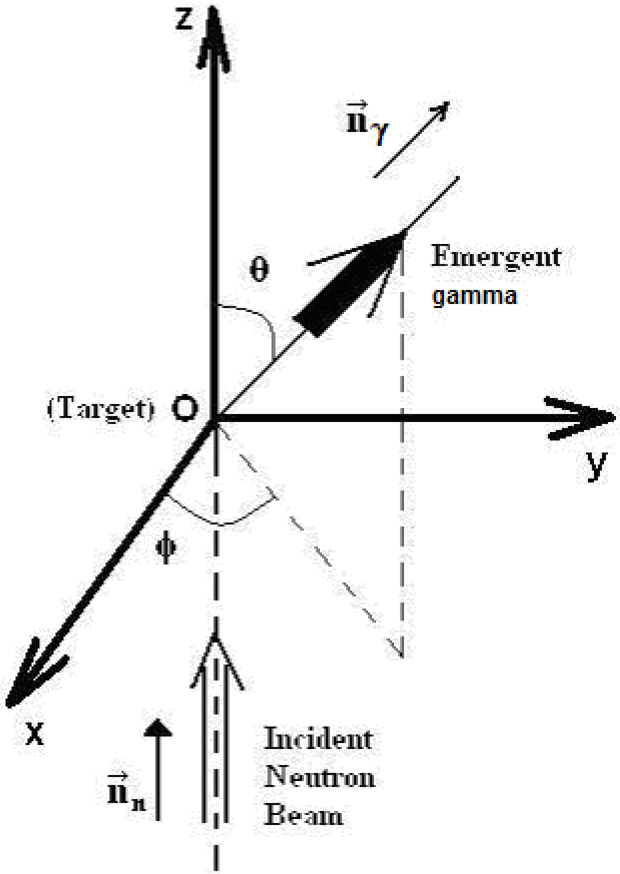
RELATION BETWEEN ANGULAR CORRELATION AND DIFF. CROSS-SECTION

$$f_1, f_2 - reaction\_amplitudes$$

FLAMBAUM-SUHKOV “RESONANCE-RESONANCE” FORMALISM

FORWARD – BACKWARD EFFECT

Geometry of the Experiment



Amplitudes of Reaction

$$f_1 = -\frac{1}{2k} C(I, I_z, a, a_n; J_S, J_{Sz}) C(I', I'_z, a, a_p; J_S, J_{Sz}) \cdot$$

$$\cdot \frac{T_S^n T_S^{p*}}{(E - E_S) + i\frac{\Gamma_S}{2}} Exp(-i\varphi_0)$$

$$f_2 = -\frac{2\pi}{k} \sum_{\substack{j_n, j_{nz}, \nu_n \\ j_p, j_{pz}, \nu_p}} C(I, I_z, j_n, j_{nz}; J_P, J_{Pz}) C(1, \nu_n, \frac{1}{2}, a_n; j_n, j_{nz}) \cdot$$

$$C(I', I'_z, j_p, j_{pz}; J_P, J_{Pz}) C(1, \nu_p, \frac{1}{2}, a_p; j_p, j_{pz}) \frac{T_P^n(j_n) T_P^{p*}(j_p)}{(E - E_P) + i\frac{\Gamma_P}{2}} \cdot$$

$$Y^*_{1\nu_n}(\vec{n}_n) Y_{1\nu_p}(\vec{n}_p) Exp(-i\varphi_1)$$

$$W(\Omega) \sim \frac{d\sigma}{d\Omega} = |f|^2 = \sum_{i=1}^{4} |f_i|^2 + \sum_{i \neq j = 1}^{4} 2\,\mathrm{Re}\, f_i^* f_j$$

FORWARD – BACKWARD EFFECT

^{109}Ag Nucleus – 2 Levels (S and P)

Type	Spin	Parity	Energy
S	1	+	30.6 eV
P	1	-	32.7 eV

OBS. 109Ag – a large number of resonance

DIFFERENTIAL CROSS-SECTION

$$\frac{d\sigma}{d\Omega}(E_n,\theta)=\frac{g\lambda_n^2}{4}\left[\frac{\Gamma_n^S\Gamma_\gamma^S}{S[E_n]}+\frac{\Gamma_n^P\Gamma_\gamma^P}{P[E_n]}\right]+\frac{3\lambda_n^2}{80\sqrt{7}}\left[\frac{\Gamma_n^P\Gamma_\gamma^P}{P[E_n]}\left(4X_nY_n+\sqrt{2}Y_n^2\right)Y_n^2P_2(\cos\theta)\right]+$$

$$+\frac{3\lambda_n^2}{10}cfb1(E_n)\left[\left(\frac{Y_n}{\sqrt{2}}-X_n\right)\left(\frac{X_\gamma}{\sqrt{3}}-Y\gamma\right)\right]$$

$$cfb1(E_n)=\frac{\left(2\Gamma_n^S\Gamma_\gamma^S\Gamma_n^P\Gamma_\gamma^P\right)^{1/2}}{P[E_n]S[E_n]}\left\{\left[(E_n-E_S)(E_n-E_P)+\frac{\Gamma_S\Gamma_P}{4}\right]\cos\phi-\left[(E_n-E_S)\frac{\Gamma_P}{2}-(E_n-E_P)\frac{\Gamma_S}{2}\right]\sin\phi\right\}$$

$$S[E_n]=(E_n-E_S)^2+\frac{\Gamma_S^2}{4};P[E_n]=(E_n-E_P)^2+\frac{\Gamma_P^2}{4}$$

$$\Gamma_{S,P}=\Gamma_n^{S,P}+\Gamma_\gamma^{S,P}+\Gamma_p^{S,P}+\Gamma_\alpha^{S,P}+\ldots$$

FORWARD-BACKWARD COEFFICIENT

$$\alpha_{FB}(E_n) = \frac{\left(\frac{Y_n}{\sqrt{2}} - X_n\right)\left(\frac{X_\gamma}{\sqrt{3}} + Y_\gamma\right) cfb1(E_n)}{cf2(E_n) + cf3(E_n)\left(4X_nY_n + Y_n^2\right)Y_\gamma^2}$$

$$cf2(E_n) = \frac{\Gamma_n^S\Gamma_\gamma^S}{S[E_n]} + \frac{\Gamma_n^P\Gamma_\gamma^P}{P[E_n]}; cf3(E_n) = \frac{1}{5\sqrt{7}} \cdot \frac{\Gamma_n^P\Gamma_\gamma^P}{P[E_n]}$$

PARTIAL REDUCED WIDTHS

$$X_n^2 + Y_n^2 = 1; X_\gamma^2 + Y_\gamma^2 = 1$$

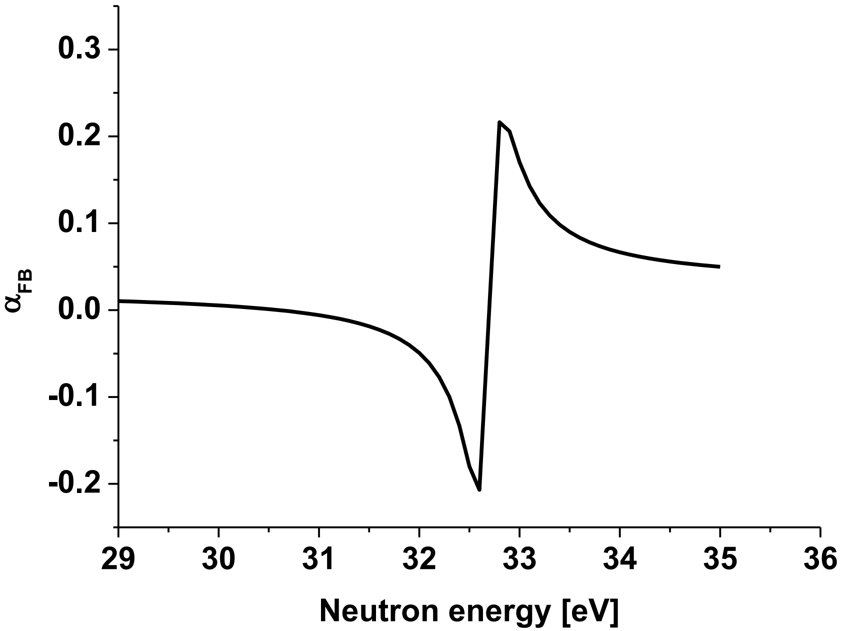
$$X_n = \pm\sqrt{\frac{\Gamma_n^S\left(\frac{1}{2}\right)}{\Gamma_n^S}}; Y_n = \pm\sqrt{\frac{\Gamma_n^P\left(\frac{3}{2}\right)}{\Gamma_n^P}}$$

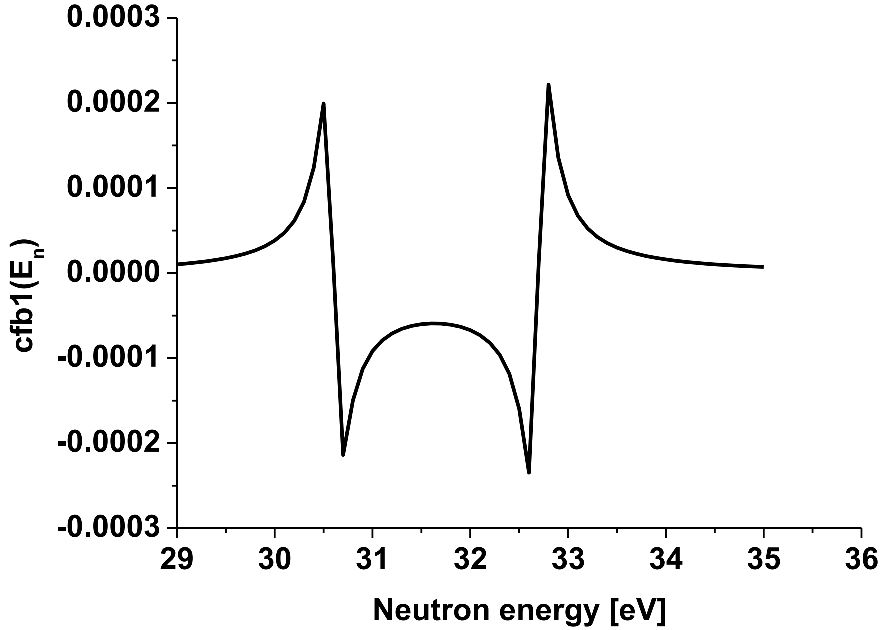
$$X_\gamma = \pm\sqrt{\frac{\Gamma_\gamma^S(l_\gamma)}{\Gamma_\gamma^S}}; Y_n = \pm\sqrt{\frac{\Gamma_\gamma^P(l_\gamma)}{\Gamma_\gamma^P}}$$

PHASES

$$\varphi = \varphi_{neutron} = ArcTan\left(\frac{R}{\lambda_n}\right)$$

FORWARD – BACKWARD EFFECT





$$X_n = \frac{1}{\sqrt{2}}; Y_n = -\frac{1}{\sqrt{2}}; X_\gamma = \frac{1}{\sqrt{2}}; Y_\gamma = -\frac{1}{\sqrt{2}}$$

$$\alpha_{FB}(E_n) = \frac{\left(\frac{Y_n}{\sqrt{2}} - X_n\right)\left(\frac{X_\gamma}{\sqrt{3}} + Y_\gamma\right) cfb1(E_n)}{cf2(E_n) + cf3(E_n)\left(4X_nY_n + Y_n^2\right)Y_\gamma^2}$$

$$cfb1(E_n) = \frac{\left(2\Gamma_n^S\Gamma_\gamma^S\Gamma_n^P\Gamma_\gamma^P\right)^{1/2}}{P[E_n]S[E_n]}$$

$$\left\{\left[(E_n - E_S)(E_n - E_P) + \frac{\Gamma_S\Gamma_P}{4}\right]\cos\phi - \\ -\left[(E_n - E_S)\frac{\Gamma_P}{2} - (E_n - E_P)\frac{\Gamma_S}{2}\right]\sin\phi\right\}$$

$$\alpha_{FB}^{\max} \cong 0.2$$

FORWARD – BACKWARD EFFECT. COMPUTER SIMULATION

ATTENUATION OF GAMMA QUANTA IN THE TARGET

$$N = N_0 \cdot Exp(-\mu \cdot x)$$

$$\mu = 0.4cm^{-1} - Ag$$

GENERATION OF POLAR ANGLE

$$\frac{d\sigma}{d\Omega} \sim W(\Omega) = 1 + \alpha'_{FB}\cos(\theta) + \beta\cos^2(\theta) = 1 + \alpha'_{FB}\vec{n}_n \cdot \vec{n}_p + \beta(\vec{n}_n \cdot \vec{n}_p)^2$$

$$\theta = \pm ArcCos\left[\frac{-2+\beta}{2(\alpha'_{FB}+\beta)}\left(1 \pm \sqrt{\frac{(-2+\beta)^2}{4(\alpha'_{FB}+\beta)^2} \pm \frac{2+\alpha'_{FB}-4r}{\alpha'_{FB}+\beta}}\right)\right]$$

GENERATION OF AZIMUTH ANGLE

$$\varphi = 2 \cdot \pi \cdot r'$$

$$r, r' \in [0,1) - random\_numbers$$

$$d = 2cm - target\_thickness$$

$$\Rightarrow$$

$$N_0 = 100000 events$$

$$N_F = 35200; N_B = 28800$$

$$N_{Lost} = 36000$$

$$\alpha_{FB}^{SIM} \cong 0.1$$

CONCLUSIONS

INVESTIGATED PROCESS $^{109}Ag(n,g)^{110}Ag$ – with slow neutrons
- FORWARD – BACKWARD EFFET WAS OBTAINED APPLYING FLAMBAUM – SUSHKOV RESONANT – RESONANT FORMALISM
- ANGULAR DISTRIBUTION WAS EVALUATED
- OTHER AUXILIARY FUNCTIONS WERE ALSO EVALUATED
- SIMULATED FB-EFFECT WAS EVALUATED FOR POINT-LIKE TARGET AND FOR TARGET WITH FINITE DIMENSIONS CONSIDERING THE ATTENUATION OF GAMMA QUANTA

FOR FUTURE
- THE INFLUENCE OF OTHER RESONANCES TO THE FB EFFECT
- EVALUATION OF OTHER ASYMMETRY AND PARITY NON CONSERVING EFFECTS -> NECESSARY TO EXTRACT NON-LEPTONIC WEAK MATRIX ELEMENT
- BACKGROUND EVALUATON

PRESENT RESULTS - IMPORTANCE
- PREPARATION OF FB AND OTHER EFFECTS MEASUREMENTS AT FLNP