Solar neutrino capture cross-section for $^{76}$Ge nuclei
Almaz Fazliakhmetov$^{1,2}$, Lev Inzhechik$^1$, Grigory Koroteev$^1$, Yury Lutostansky$^3$, Victor Tikhonov$^2$, Andrey Vyborov$^{1,2}$

$^1$Moscow Institute of Physics and Technology, Russia; $^2$Institute of Nuclear Research, Russian Academy of Sciences; $^3$National research center "Kurchatov Institute", Russia

Introduction

In the experiments of GERDA and LEGEND studying the double beta decay of the $^{76}$Ge isotope, the absorption of solar neutrinos by the $^{76}$Ge nucleus as a result of successive reactions

$$\nu_e + \frac{76}{28}Ge \rightarrow \frac{74}{26}As + e^-$$

induces background events indistinguishable from the studied beta decay. In this paper, the neutrino capture rate was calculated from the formula:

$$R = \int_0^\infty \rho_{\text{Solar}}(E_\nu) \sigma_{\text{total}}(E_\nu) dE_\nu$$

Taking into account the transitions to both discrete and continuous (resonant) states of the daughter nucleus (fig. 1).

Cross-section calculations

To calculate the neutrino capture cross-section both discrete and continuous (resonant) states of the $^{76}$As nucleus were considered.

$$\sigma_{\text{total}}(E_\nu) = \sigma_{\text{discrete}}(E_\nu) + \sigma_{\text{continous}}(E_\nu)$$

$$\sigma_{\text{continous}}(E_\nu) = \frac{\sum \frac{\sigma_{\text{Gamow-Teller}}(\Delta E)}{\Delta E}}{\sum \frac{\sigma_{\text{Gamow-Teller}}(\Delta E)}{\Delta E} + \sum \frac{\sigma_{\text{Gamma radiation}}(\Delta E)}{\Delta E}}$$

The peculiarity of this work composed in taking into account the contribution of both resonances (isobaric analog and Gamow-Teller) [4]:

$$\sigma(E) = \sigma_{\text{IAAS}}(E) - \sigma_{\text{IAAS}}(E)$$

This work was done on the assumption that at excitation energies of the $^{76}$As nucleus above $E_{\text{dep}}$, neutron emission takes place with the formation of a stable nucleus of $^{76}$As isotope (fig. 1), so such transitions to states with energies higher than $E_{\text{dep}}$ were not considered. Fig. 4 presents the spectrum of the $^{76}$As nucleus excitation energy, which repeats the shape of the experimental strength function [5]. The narrow IAS peak lies above $E_{\text{dep}}$ and therefore the IAS does not contribute to the total capture cross section. The calculation took only the tail of the GTR (Gaussian distribution), lying below the level of $E_{\text{dep}}$ (on the graph it is marked with a dashed line).

The strength function describing the probability of transition to one or another excited state takes into account the contribution of both resonances (isobaric analog and giant Gamow-Teller) [6]:

$$\sigma(E) = \sigma_{\text{IAAS}}(E) - \sigma_{\text{IAAS}}(E)$$

Conclusion

In the present work the contribution of the Gamow-Teller resonance below the neutron separation energy was considered. It increased the estimation of the neutrino capture rate by the $^{76}$Ge nucleus by 10% as compared with [3]. On the next stage it is proposed to estimate the contribution of the resonance states above $E_{\text{dep}}$ requiring further development of the theory. In addition, it is planned to study the process (*) as a solar neutrino background for the GERDA and LEGEND experiment taking into account the real geometry of the detectors.

Table 1. Rate of solar neutrino capture

<table>
<thead>
<tr>
<th>Capture (in SNU)</th>
<th>pep</th>
<th>hep</th>
<th>N</th>
<th>F</th>
<th>O</th>
<th>B</th>
<th>total</th>
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</thead>
<tbody>
<tr>
<td>only discrete states</td>
<td>1.369</td>
<td>0.0451</td>
<td>0.102</td>
<td>0.021</td>
<td>0.828</td>
<td>13.54</td>
<td>15.9</td>
</tr>
<tr>
<td>discrete states and GTR</td>
<td>1.369</td>
<td>0.0568</td>
<td>0.102</td>
<td>0.021</td>
<td>0.828</td>
<td>15.22</td>
<td>17.59</td>
</tr>
<tr>
<td>GTR contribution</td>
<td>0%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>11%</td>
</tr>
</tbody>
</table>

References


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Contact

Andrey Vyborov
MIPT, INR RAS
Email: vyborov94@gmail.com
Phone: +7 (968) 628-13-73