Beta-delayed γ-ray emission from ^{9}Li

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The β-decay of ^{9}Li to the γ+^{9}Be channel was studied at the GSI-ISOL facility. By using an 135 MeV beam of ^{12}C on a carbon target, ^{9}Li and ^{8}Li nuclei were produced with mass-separated beam intensities up to $6{\cdot}10^4$ and $1.5{\cdot}10^5$ s^{-1}, respectively.We searched for the γ-decay of excited $1/2^+$, $5/2^-$ and $1/2^-$ states in ^{9}Be, which are strongly populated in the β decay of ^{9}Li. The respective partial γ-widths are of astrophysical interest in order to reliably estimate the rates of the thermonuclear reaction $\alpha\alpha$(n,γ)^{9}Be, which may open the way for the synthesis of heavier elements in supernovae explosions [1].

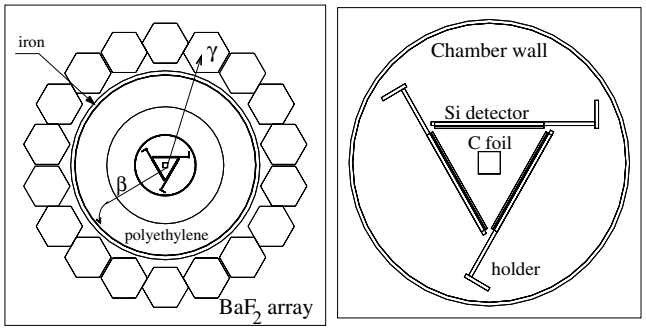

Figure 1: Front view of the detector set-up (left), and zoom of its central part (right).

The experimental set-up is sketched in Fig. 1. The ^{9}Li atoms were implanted into a thin carbon foil viewed by β and γ detectors. We registered β particles with three large 32-strip silicon detectors covering 65% of 4π solid angle. Spectra of β-delayed γ rays were measured with 32 scintillation detectors positioned around the silicon array. The γ detectors, composed of hexagonal 6x30 cm BaF_2 crystals developed in LLN Legnaro, had ~100% registration efficiency for γ-rays with energies up to 5 MeV. The β-α and γ-neutron discriminations were implemented by using the pulse-shape analysis of signals from the silicon and BaF_2 detectors. Low-Z absorbers (polyethylene and boron) were used to stop β-particles and neutrons. The iron shield absorbed bremsstrahlung X-rays.

The response of our setup to β-delayed radiation of ^{8,9}Li has been simulated using the code GEANT. In particular, the simulations of β-γ correlations from ^{9}Li have shown that the ratio of two components, due to β-delayed γ-rays from excited states in ^{9}Be and due to background processes, can dramatically be increased by selecting large β-γ angles. The simulated γ-spectra from the $1/2^+$ and $1/2^-$ states in ^{9}Be are shown in Fig. 2 together with the respective γ background. All spectra are selected from β-γ coincidences with the condition that the β-γ angle is larger than 150°.

The shape of the pure γ-background was measured by using the β decay of ^{8}Li, as its daughter ^{8}Be* is known to have no γ de-excitation channels. The γ-ray spectra from β decays of ^{9}Li and ^{8}Li measured with the above-mentioned β-γ condition are compared in Fig. 3. The figure shows also the 1.63 MeV γ-ray peak from β decay of ^{20}Na, obtained in a calibration ISOL measurement.

As can be seen from Fig. 3, the peak from the $5/2^-$ state in ^{9}Be was observed. The intensity of this transition known to be $4.2(5){\cdot}10^{-5}$ provides a reference point for branching ratio estimates. With the statistics obtained, there is no clear indication for γ-rays de-exciting the $1/2^-$ and $1/2^+$ states in ^{9}Be. The corresponding upper limit of the $1/2^-$ partial γ-width, which is estimated by comparing the potential intensity of a $1/2^-$ γ-peak to the 3σ level of background fluctuations to be $7{\cdot}10^{-6}$ MeV, still exceeds the theoretically predicted value $5{\cdot}10^{-7}$ MeV [2].

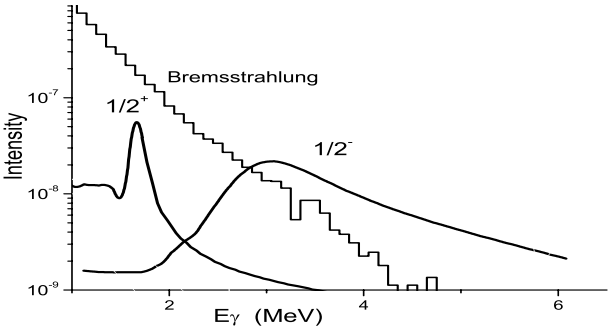

Figure 2: Simulation of γ-ray spectra due to β decay of ^{9}Li to the $1/2^-$ and $1/2^+$ states in ^{9}Be as well as due to bremsstrahlung. The spectra (thick lines) were obtained by selecting β-γ angles above 150°. The respective γ-background simulation is shown by the histogram.

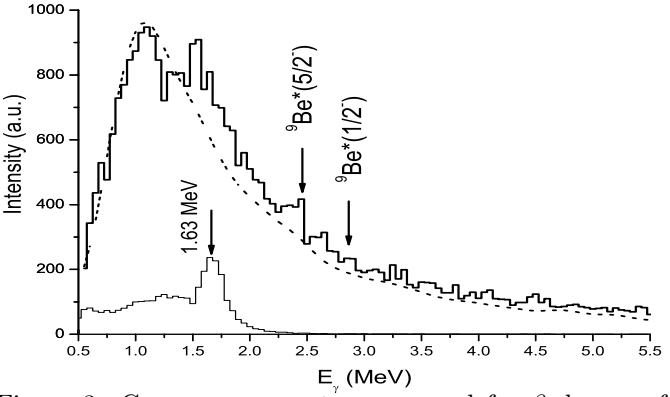

Figure 3: Gamma-ray spectra measured for β decays of ^{9}Li (solid-line), ^{8}Li (dashed-line) and ^{20}Na (thin solid-line) obtained by using the same β-γ condition as in Fig. 2.

References

[1] S.E. Woosley and R.D. Hoffman, *Astrophys. J.* **395** (1992) 202.

[2] P. Descouvemont, *Phys. Rev.* C**39** (1989) 1557.