Supernova Nucleosynthesis of ^{26}Al and Nuclear Structure of ^{26}Si [1]

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The level scheme above the proton threshold in ^{26}Si is crucial for evaluating the $^{25}\mathrm{Al}(p,\gamma)^{26}\mathrm{Si}$ stellar reaction, which is important for understanding the astrophysical origin of the long-lived cosmic radioactivity ^{26}Al ($T_{1/2} = 7.17\times10^5$ y) in the Galaxy. The β-delayed γ-ray from the ^{26}Al was measured by satellite γ-ray telescope. Therefore, the ^{26}Al is considered to be created in supernovae, classical novae, and massive stars. Because the half-life of this isotope is much shorter than the age of the Galaxy, it has been continuously created reached equilibrium value.

The isotope ^{26}Al is produced the nucleosynthesis flow of $^{25}\mathrm{Al}(e^+\nu)^{25}\mathrm{Mg}(p,\gamma)^{26}\mathrm{Al}$. There is a bypass flow $^{25}\mathrm{Al}(p,\gamma)^{26}\mathrm{Si}(e^+\nu)^{26m}\mathrm{Al}(e^+\nu)^{26}\mathrm{Mg}$, that does not emit the characteristic γ-ray. Therefore, the $^{25}\mathrm{Al}(p,\gamma)^{26}\mathrm{Si}$ reaction is a key reaction to evaluate the production of the ^{26}Al. The reaction rate of the (p,γ) reaction is dominated by narrow-resonant reactions with 0^+, 1^+, and 3^+ states. Those are sensitive to their excitation energies above the proton threshold in ^{26}Si.

The excited states in ^{26}Si have been studied using an in-beam γ-ray spectroscopy technique with the $^{24}\mathrm{Mg}(^3\mathrm{He},n\gamma)^{26}\mathrm{Si}$ reaction. γ-rays emitted from excited states in ^{26}Si have been measured using large volume HPGe detectors. As the result of the experiments the level scheme of ^{26}Si is shown in Figure 1. The 0^+ and 1^+ states were well observed above the proton threshold. The spin-parity of one of the most important states at 5890.0-keV has been assigned as 0^+ by $\gamma-\gamma$ angular correlation measurements in this work.

According to the newly determined excitation energies the astrophysical nuclear reaction rate is calculated as a function of temperature T_9 as shown in Figure 2. The contribution of the 0^+ resonance is modestly increased; however, the role of the 3^+ level is still dominant as discussion [2]. In order to elucidate the abundance of galactic ^{26}Al more extensive effort might be essential to observe the crucial 3^+ state just above the proton threshold.

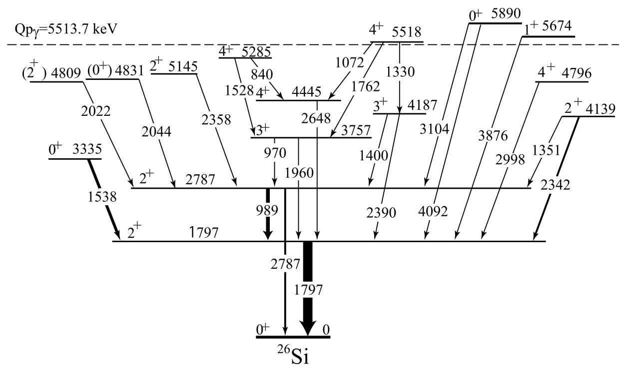

Figure 1: Level scheme of ^{26}Si. The 0^+ level at 5890 keV above the proton threshold has been observed with present work.

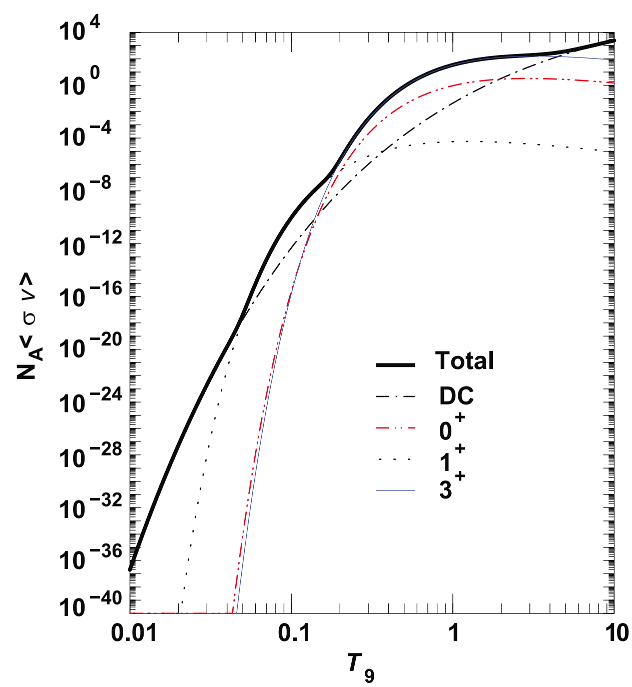

Figure 2: Astrophysical reaction rate $N_A<\sigma v>$ for the $^{25}\mathrm{Al}(p,\gamma)^{26}\mathrm{Si}$ reaction. Resonance reactions through 0^+, 1^+, and 3^+ are shown as well as the direct component DC. Contribution by the 3^+ is dominant at high temperature.

References

[1] Komatsubara, T., et al.: 2014, *Euro. Phys. Jour. A*, **50**, 136.

[2] Parikh, A., José, J.: 2013, *Phys. Rev. C*, **88**, 048801.