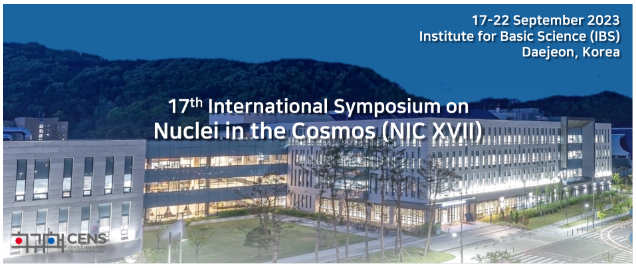

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Impact of the excited- and bound-state β-decays of ^{63}Ni on weak s-process nucleosynthesis [1]

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Although about 90% and 50% of the solar-system Cu and Zn abundances are presumed to originate from the slow neutron-capture process (weak *s*-process) during core He and shell C burning in massive stars, their stellar conditions are still poor known. This is because ^{63}Ni ($t_{1/2}$=101.2±1.5yr) takes the key as a bottleneck for the synthesis of these nuclei in the *s*-process branching: At high temperature, the β-decays from the excited states make a remarkable contribution. On the other hand, at low temperature and high density, the bound-state β-decays are important for highly ionized atoms when the transition energy is small. For these reasons many shell model calculations using different Hamiltonians were devoted to calculate excited-state β-decays, and both excited- and bound-state β-decay effects were studied in gross theory [2]. The calculated half-lives are unfortunately different from one another. In order to assess the significance of these effects, we carry out, for the first time, the *s*-process nucleosynthesis calculations using all nuclear models of β-decays in a $25M_\odot$ star with solar metallicity [1].
Firstly, we study the competition between ^{63}Ni($\beta^-\bar{\upsilon}$)^{63}Cu vs. ^{63}Ni(n,γ)^{64}Ni by taking account of the both effects to clarify the main nuclear flow paths [1]. We find that ^{63}Cu and ^{64}Ni change by 7% in abundance, ^{64}Zn changes by more than 20%, ^{65}Cu and $^{66-68}$Zn change by 6%, and all the other stable nuclei A = 69 − 90 change systematically by 5% at the mass coordinate $M_r = 2M_\odot$ before the onset of the core Si burning, which depends strongly on the nuclear models [2]. We, secondly, confirm that although the β-decay half-life of ^{63}Ni^{28+} changes by more than 35% at T = 0.3 GK due to the effect of bound-state β-decay, abundance change of stable nuclei proves to be less than 3% [1]. These new quantitative results show the significance of future experimental measurement of the excited-state β-decays, in particular of ^{63}Ni, and the microscopic nuclear model calculations of both excited-state and bound-state β-decays.

[1] Xinxu Wang, B. Sun, D. Fang, Z. He, M. Kusakabe, T. Kajino, Z. Niu, et al. (2023), to be submitted.
[2] K. Takahashi, K. Yokoi, At. Data Nucl. Data Tables 36, 375 (1987).

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