Calculation of *rp*-process Rates in the *sd* Shell via the Nuclear Shell Model

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We have embarked on a systematic study of important astrophysical rp-process rates for sd shell nuclei. Results for the ^{25}Al(p,γ)^{26}Si [1] and ^{29}P(p,γ)^{30}S reactions have been obtained, and we are currently engaged in calculations for the ^{23}Al(p,γ)^{24}Si reaction. In many of the proton-rich final nuclei the properties of only the few lowest levels are well established. However, the structure of proton unbound states is important for determining the reaction rates, which influence explosive hydrogen burning in classical novae and type I X-ray bursters. We make use of a method based on the IMME (Isobaric Mass Multiplet Equation) to predict the properties of such states. The predicted states use as input known experimental binding energies in the isobaric multiplet partners, and the only theoretical input consists of calculated c or b coefficients of the IMME [2], which can be calculated with good accuracy. Where data on the isobaric analogue states is lacking, the USDA and USDB two-body interactions [3] are employed to calculate levels. The calculated gamma-decay lifetimes and spectroscopic factors for single-nucleon transfer to the final states together with experimental information on the levels of excited states are used to determine the reaction rates based on the use of the USDA and USDB interactions. Some theoretical error estimates based on the use of different interactions are given, and comparisons with other astrophysical rate calculations are made.

References

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