β^--decay half-lives using the ANN model: Input for the r-process*

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Nucleosynthesis via the r-process continues to be a major challenge for nuclear astrophysics [1]. Besides in astrophysical modeling, significant uncertainties still remain in the nuclear physics input, which involves among others, the β-decay half-lives of very neutron-rich nuclei. Both the element distribution on the r-process path and the time scale of the r-process are highly sensitive to them. Since the vast majority of nuclides which lie on the r-process path will not be experimentally accessible in the foreseeable future, it is important to provide accurate predictions by reliable models.

In this work, we apply our recently developed statistical global model of the β^--decay half-life systematics [2] to calculate the half-lives of relevant to the r-process nuclides. It is a fully-connected, multilayered feed-forward Artificial Neural Network (ANN) model developed using Levenberg-Marquardt optimization algorithm together with Bayesian regularization and cross-validation for the half-lives of nuclear ground states that decay 100% by the β^- mode. Its predictive performance can match or even surpass the one of conventional models for β-decay systematics. We present results for nuclides situated on the r-ladders N=50, 82, 126 where abundances peak, as well as for others that affect abundances between peaks. We also give the values of half-lives for interesting neutron-rich nuclides that have been recently measured or will be measured in the forthcoming rare-isotope experimental facilities. Comparison of our results with those available from conventional models and from experiment is very promising. It suggests that statistical modeling of β^- half-lives is a valuable tool for explorations of nuclei beyond the valley of stability and for the study of r-process abundances. It also indicates that statistical models developed by machine-learning can be useful to study the systematics of other nuclear properties that are used as input in r-process nucleosynthesis. A global statistical model for masses has recently been developed with considerable success [3].

References

[1] Y. Z. Qian and G. J. Wasserburg, Phys. Rept. **442** (2007) 237; K.-L. Kratz , K. Farouqi, and B. Pfeiffer, Prog. Part. Nucl. Phys. **59** (2007) 147; M. Arnould, S. Goriely, K. Takahashi. Phys. Rep. **450** (2007) 97.

[2] N. J. Costiris, E. Mavrommatis, K. A. Gernoth, and J. W. Clark, Phys. Rev. **C80** (2009) 044332.

[3] S. Athanassopoulos, E. Mavrommatis, K. A. Gernoth and J. W. Clark, in Advances in Nuclear Physics, Nuclear Astrophysics, Heavy Ions and Related Areas, edited by G. A. Lalazissis and C. C. Moustakidis (HNPS, Thessaloniki, 2005), p. 65, arXiv:nucl-th/0511088 and to be published.

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