Statistical global modeling of β^--decay halflives systematics using Multilayer Feed-Forward Neural Networks and Support Vector Machines*

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Abstract

Reliable estimates of halflives for β^--decaying nuclei far from the stability line are needed for the experimental exploration of the nuclear landscape at radioactive beam facilities and for studies of nuclear astrophysical processes, notably r-process nucleosynthesis [1]. A constellation of theory-thick, macroscopic or semi-microscopic models has been developed during the last decades for generating β^--decay halflives. However, the predictive power of these models is rather limited for nuclides far from stability (and often inaccessible to experiment). The recent advances in statistical learning theory present, on the other hand, the opportunity to develop statistical models of quantum many-body systems exhibiting remarkable predictive power. Statistical modeling of nuclear data, using Artificial Neural Networks (ANNs) [2, 3, 4] and more recently Support Vector Machines (SVMs) [5, 6], is providing a complementary theory-thin approach to the prediction of nuclear systematics.

In this work, we examine the potential of such theory-thin approaches via a detailed comparison of halflife estimates of neutron-rich β^- unstable nuclei produced by the global models developed using ANNs and SVMs. The former have been developed by following the methodology of reference [4] for each class of nuclei with given even-odd character in Z, N that decay 100% by the β^- mode in their ground states. Corresponding models using the same data sets have been developed by means of SVMs in reference [6]. The halflife estimates generated by both types of machines are discussed and compared with the available experimental data [7], with previous results obtained with neural networks [8], and with estimates coming from traditional global nuclear models. Particular attention is paid to r-process nuclides.

Our results demonstrate that in the framework of the β^--decay problem considered here the statistical models based on machine learning can match or even surpass the predictive performance of the best conventional theory-thick global models based on nuclear phenomenology. Regarding extrapability, the models based on Multilayer Feedforward Neural Networks are slightly better than those based on SVMs. Accordingly, work is in progress to develop global statistical models of other quantities of nuclear systematics using both techniques of machine learning.

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