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DEEP NEURAL NETWORKS AND THE PHENOMENOLOGY OF SUPER-HEAVY NUCLEI

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In recent years, several successful applications of the Artificial Neural Networks (ANNs) have emerged in nuclear physics, high-energy physics, and other fields of science. These works have already shown, that modeling of nuclear data with ANNs provides a valuable complementary approach to theory-driven models of the systematics of nuclear data (see e.g. [1] and references therein). A significant effort to exploit these novel methodologies is motivated by aspirations toward experimental and theoretical exploration of nuclei far from stability.

In our work we aimed at predicting the binding energies $\{B/A\}$, as well as the two-proton and two-neutron separation energies (S_{2p}, S_{2n}) of super-heavy nuclides, specifying only their proton and neutron numbers (Z, N) together with the numerical parity of the latter. Given a body of training data [2] the iRPROP (improved resilient backpropagation) and Adam (adaptive moment estimation) learning algorithms have been used to adjust the parameters of the deep ANN, determining (without any further theoretical assumptions) the mapping from the proton and neutron numbers to the properties of the nuclear ground state.

The predictive power of the neural network emerging from simulations done within the Keras+TensorFlow framework is compared with that of traditional phenomenological models. The obtained results show not only excellent learning performance of our network (with the MSE deviation between the ANN output and the 2498 experimentally known binding energies at the level of 70 eV), but are also very promising in predictions of various properties of both super-heavy nuclei as well as nuclei far from stability. It is found that the purely phenomenological models, based on deep ANNs can match or even surpass the predictive performance of conventional models for nuclear systematics (e.g. in grasping the existence of shell structure) and accordingly should provide a valuable additional tool for exploring the expanding nuclear landscape.

1. R. Utama, J. Piekarewicz, arXiv:1709.09502v1 [nucl-th]; G. A. Negoita *et al*, arXiv:1803.03215v1 [physics.comp-ph]
2. Huang *et al*, Chinese Physics C Vol. 41, No. 3 (2017) 030002; Meng Wang *et al*, Chinese Physics C Vol. 41, No. 3 (2017) 030003

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