Alpha half-lives calculation of superheavy nuclei with Qα-values predictions based on Bayesian neural network approach

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Abstract

In this work we performed a systematic study of the α-decay process by employing the Bayesian neural network [1] approach. The Qα-value prediction of the ten parameters Duflo-Zuker [2] mass model has been improved from a root-mean-square deviation relative to the experimental data σ=0.43 MeV to σ=0.122 MeV. This correction brought to light some missing physical aspects in the DZ mass model used, so as to identify some magic numbers not present in the original model. By using a phenomenological effective model proposed by Gonçalves and Duarte [3] to deal with alpha decay half-lives, we were able to obtain the half-life values. In the present approach the cluster-like mode is used considering that the alpha particle is preformed inside the parent nucleus and emitted after tunneling an effective potential barrier. A crucial element in the α-decay half-live calculation is the energy released in the process, the Qα-value, in our case this value was obtained by using the machine learning methodology. The major improvements in the predictions were obtained to transactinide elements, also referred to as superheavy elements (SHE). These results pointed to the importance of focusing attention in predictions in this region, where data are very scarce. As main result, we found that the region of greatest stability against the alpha-decay process for super-heavy elements is located between $106 \leq Z \leq 110$ and $180 \leq N \leq 184$.

References

1- R. M. Neal, Bayesian Learning for Neural Networks, Lecture Notes in Statistics, Vol. 118 (Springer New York, New York, NY, 1996) p. 204.

2- Duflo and A. Zuker, Physical Review C52, R23 (1995)

3- M. Gonçalves and S. B. Duarte, Physical Review C48, 2409 (1993)