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Machine learning methods in nuclear physics

We investigate the advantages of developing machine learning methods in the context of theoretical nuclear physics and in particular of nuclear fission.

Actually, the description of the fission realized with the HFB+TDGCM is numerically very expensive. Because the method requires a potential energy surface (PES), for each nucleus, made of thousands of HFB states at different nuclear deformations. These latters are obtained by solving the HFB equation under fixed deformation constraints and by varying the oscillator basis parameters with respect to the minimum of energy. In contrast to the standard methods, we propose to optimize the basis parameters thanks to global optimization algorithms with the HFB energy modelized by a Gaussian process. This Bayesian approach offers the estimation of the energy, its associated error and it takes into consideration the numerical noise. We observe ameliorations for a single HFB calculation, by reaching a lower energy faster than classical minimization methods. Furthermore for multiple HFB calculations, such as the PES production, we are able to improve the distribution of the calculations to be performed simultaneously. Quantitatively, one notices a speedup of 5 times for the production of the PESs in contrast to the reference.

Finally, we will present the learning of the nuclear properties (defromations, energy, etc ...) from calculated PESs, in order to construct an approximated HFB state as a starting point of a complete HFB calculation. This method is very helpful in spite of improving the production of new PESs by compiling all the knowledge obtained from calculated nuclei. Also, this is a big step in solving scalability problems, so far limited by a propagation mechanism.

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