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Generative machine learning improves microscopic description of dissociation reactions

Over the last five years, generative machine learning has proven to be incredibly powerful in various domains: communications, image processing, graph analysis⋯The question now is: how can it help improve the microscopic description of complex physical phenomena, such as nuclear fission? In fact, there is currently no theoretical model capable of predicting fission half-lives, yields and de-excitation of the fragments over the entire the nuclear chart. Nevertheless, thanks to the increasing power of supercomputers, the energy density functional is now able to describe dissociation reactions from alpha-emission to actinide fission. In particular, the Time Dependent Generator Coordinate Method is a successful method to obtain fission yields and half-lives.
This approach relies on the computation of potential energy surfaces, which are currently determined by minimizing the energy of the system given some constraints on its shape [1].
In theory, these constraints should be representative of the deformations that the nucleus undergoes during fission. However, the minimization procedure often leads to the presence of "discontinuities" in the potential energy surfaces [2]. A discontinuity is the fact that two states that should occur immediately after each other are very different. In such cases, some information is missing, preventing sound studies of the fission dynamics, especially after and close to the point of scission.
In this talk I will present a method to get rid of discontinuities in potential energy surfaces. This method builds new coordinates based on a generative machine learning algorithm. These new coordinates are more representative of the evolution of the nucleus and allows to describe states that were not accessible within the previous description. This leads, for example, to new potential energy wells and barriers that affect the calculation of half-lives. I will emphasize the first applications of this method to superfluid systems: a study of the 20Ne quadrupole deformation and the alpha emission of 104Te. Eventually, I will discuss its perspectives in the context of fission.

[1] M. Verriere, D. Regnier, Front. In Phys. 8 (2020)
[2] N. Dubray, D. Regnier, CPC 183 (2012)

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