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Fast-neutron induced alpha-particle emission and the dark side of the alpha-particle optical potential

The interaction of alpha particles with nuclei as well as the related optical model potential (OMP) were of special interest from the earliest days of nuclear physics,. The widely-used phenomenological OMP parameters have been derived from the analysis of either elastic-scattering or alpha-induced reaction cross sections below the Coulomb barrier, and then used to describe also the alpha-particle emission from hot nuclei excited in nuclear reactions. However the later studies are subject of also other various assumptions and quantities. Thus, the alpha-particle OMP for the incident channel seems similar to the familiar side of the Moon which only is facing always the Earth, but for the alpha-emission it is like the dark side of the Moon. Moreover, there is a so-called alpha-potential mystery [1] of the account at once of both absorption and emission of low-energy alpha particles, of interest for nuclear astrophysics as well as nuclear technology.

Former search for new physics in potentials to describe nuclear de-excitation made use of the assumption that particle evaporation occurs from a transient nuclear stratosphere of the emitter nucleus, with a density being not yet relaxed to the density profile expected for complete equilibration. It may be reassessed within a microscopic double-folded OMP (e.g. [2] and Refs. therein), following suitable results obtained similarly for the incident. However, the question of a real difference between the OMPs which describe either alpha-particle elastic scattering and induced reactions [3] or emission from excited compound nuclei [4] could be answered only following definite conclusions concerning the incident channel. Actually, the better results provided by this potential [3] within a large-scale nuclear-data evaluation [5] led to its use as the default alpha-particle OMP within the latest version of the code TALYS [6].

On the other hand, the need to use or not use the same potential also for emitted alpha particles, as pointed out recently for several nuclei within Refs. [7,8], respectively, should make the object of further discussions. The (n,alpha) reactions are particularly considered in this respect due to their interest for nuclear technology. On the other hand, the related statistical model (SM) analysis depends critically on the accuracy of the rest of SM parameters. They could be provided only by independent data analysis as an additional challenge to this work.

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