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Possible evidences for Giant Quadrupole Resonances within neutron-induced alpha-particle emission

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The first measurement of 91Zr(n,a)88Sr reaction cross sections [1], performed in the 3.9–5.3 MeV incident–energy range, followed the need of reliable nuclear data for the isotopes of zirconium used in the blanked and first wall of fusion reactors while the related evaluated data changed by up to 6.4 times were found in widely used libraries. The alpha-particle optical model potential (OMP) was thought to be the reason behind this variance, other parameters of the corresponding statistical model (SM) and pre-equilibrium emission (PE) predictions having only a marginal influence at these incident energies. However, the TALYS default alpha-particle OMP [2] has recently been proved to describe well the neutron–induced alpha emission in the mass range A˜90 including all Zr stable isotopes [3]. Thus, a further discussion should concern the analysis of the new (n,a) reaction data, while several issues could be of interest also for the related nuclear processes understanding.
First, the alpha-nucleus OMP [2] was finally obtained by analysis of alpha-particle elastic scattering at energies ≤50 MeV, and induced reactions below and around the Coulomb barrier, on A˜45–209 nuclei. More recently, also alpha-emission description by the same potential [2] has become possible by additional consideration of (i) the pickup direct reaction, and (ii) eventual isoscalar giant quadrupole resonance alpha-decay [3,4].
Second, the following key demands supported these results. (i) Consistent SM parameter sets were formerly validated by analysis of independent data, other than the concerned reaction cross sections. (ii) Hence, no further empirical rescaling factors of the gamma and nucleon widths were needed. (iii) Thus, compensation effects of less accurate model parameters were prevented. (iv) Due consideration was given to the correlation between the accuracy of the above–mentioned independent data, the input parameters determined by their fit, and the corresponding final uncertainties of the calculated reaction cross sections. (v) Suitable description of all competitive reaction channels was also concerned, for parameter sets validation. (vi) The analysis included the available data for whole isotopic chains as well as neighboring elements.
Third, there are singular conditions [1] supporting a significant reaction modeling challenge on far better terms than usual. The feeding, basically, of the only one final state reduces essentially the model parameters which could affect the results correctness. Moreover, following the suitable account of the other reaction channels of neutrons incident on 91Zr and the use of a consistent SM+PE parameter set already fixed [3,5], the alpha-particle OMP remains the only constraint on the calculated (n,alpha) reaction cross sections. Therefore, comparison of the new measured and calculated (n,alpha) cross sections is aimed to either check this OMP or reveal the weight of the non–statistical processes that have to be additionally considered.

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