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Alpha-capture reactions and the alpha-Nucleus Optical Potential for p-process nucleosynthesis

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The p process is the production mechanism for a certain number of proton-rich, stable nuclei, that cannot be produced by neutron captures. These 35 nuclei, lying between Se and Hg, are referred to as p nuclei. The most favoured scenarios for the p process involve the photodisintegration of intermediate and heavy elements at high temperatures (2-3 billion degrees Kelvin) that can be achieved only during the explosive burning phases of massive stars. One of the persistent puzzles of the current abundance calculations, is the underproduction of the Mo-Ru region. These discrepancies could be due to uncertainties in the astrophysical models or in the nuclear physics data used.

During the photodisintegration process, neutron, proton and alpha emission compete with one another and with beta decays. A p-process network calculation involves almost 20000 reactions. However, only very few of these reactions can or have been measured in the laboratory, so the network calculations rely largely on theoretical estimates of the relevant reaction rates. Considerable effort has been devoted in the recent years to determine the nuclear properties entering the theoretical calculations of reaction rates. One such property is the alpha-nucleus optical model potential (OMP) which is poorly known at low energies close to the Coulomb barrier. The uncertainties in the alpha OMP, lead to large uncertainties in the alpha-induced reaction cross sections and inverse processes (up to a factor 10), and can therefore affect the p-process network calculations. This has motivated us to carry out a systematic investigation of low-energy alpha-induced reactions on nuclei of relevance to the p process. Experiments have been carried out at the Dynamitron accelerator of the University of Bochum. At the same time, we have updated a recent global, alpha-nucleus OMP based on the double-folding method, on all existing data on alpha-nucleus reactions.

In this paper, we shall report on our new measurements and present detailed comparisons with calculations using the improved alpha-nucleus OMP. The impact on p-nuclei abundances and perspectives will also be discussed.

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