Spallation nucleosynthesis by accelerated charged-particles

S. Goriely[1]
[1] Institut d'Astronomie et d'Astrophysics, Université Libre de Bruxelles, Campus de la Plaine, CP-226, 1050 Brussels, Belgium

Recent observations have suggested the presence of radioactive elements, such as Pm [1] and $84 \leq Z \leq 99$ elements [2]) at the surface of the chemically-peculiar magnetic star HD101065, also known as Przybylski's star. This star is know to be a chemically peculiar star and its anomalous $35 < Z < 82$ abundance pattern has been so far explained by diffusion processes in the stellar envelope. However, such processes cannot be called for to explain the origin of short-lived radioelements. The large magnetic field observed in Ap stars can be at the origin of a significant acceleration of charged-particles, mainly protons and α-particles, that in turn can by interaction with the stellar material modify the surface content.

The present contribution explores to what extent the spallation processes resulting from the interaction of the stellar material with stellar energetic particle can by themselves only explain the abundances determined by observation at the surface of the chemically peculiar star HD101065. Due to the unknown characteristics of the accelerated particles that could be held responsible for the spallation process, a purely parametric approach is followed, taken as free parameters the proton and α-particle flux amplitude and energy distribution as well as the time of irradiation. Specific simulations can explain many different observational aspects. In particular, it is shown that a significant production of $Z > 30$ heavy elements can be achieved and in this nucleosynthesis process, the emitted-neutron capture plays a crucial role. The most attractive feature of the spallation process is the systematic production of Pm and the possible production of actinides and sub-actinides.

Based on such a parametric model, it will be shown how intense fluxes of accelerated α-particles with energies up to some 10 MeV/nucleon interacting with surrounding material can efficiently produce elements heavier than iron. Different regimes are considered and shown to leas to the production of s-, p- or even r-elements. The nuclear mechanisms as well as the nuclear physics and astrophysics aspects of these new non-thermal high-eneergy nucleosynthesis processes will be discussed.

[1] C. Cowley, *et al.*, Astron. Astrophys. **419**, 1087 (2004)
[2] V.F. Gopka, *et al.*, in Proc. IAU symposium Nr 224, (eds. Zverko J. et al.), 734 (2004)