First identification of resonant states in the 45V(p,γ)46Cr reaction and their influence on the production of 44Ti in core-collapse supernovae

Chris Cousins[1]
[1]University of Surrey, UK

Core-collapse supernovae (CCSNe) are among the most spectacular astronomical events to occur in our Galaxy, yet modelling their operation has proven to be a formidable challenge. The long half-life of 44Ti (t1/2∼59 yr) makes it one of the few cosmic γ-ray-emitting species observable in the Galaxy, providing unique insight into CCSNe. The nucleus 44Ti is expected to be produced during explosive silicon burning in the deepest regions of CCSNe, with observed ejected abundances providing an ideal indicator for the so-called “mass cut” of the star.

Several state-of-the-art sensitivity studies have been performed to identify key reactions that influence the production of 44Ti in CCSNe, with the 45V(p,γ)46Cr reaction being of particular significance. This reaction is expected to be dominated by resonant capture to excited states located above the proton-emission threshold energy of 4874(11) keV in 46Cr. However, at present, no experimental information exists on the properties of resonances in the 45V(p,γ)46Cr reaction.

We present the first identification of resonant states in the 45V+p system, extending to resonance energies of Er∼2.2 MeV. In coupling the advanced γ-ray tracking array GRETINA with the Argonne Fragment Mass Analyzer, this enabled access to very weakly-populated, low-spin excited states within the 12C(36Ar,2n)46Cr fusion-evaporation reaction, hitherto inaccessible with previous setups. By studying the γ decays of resonant states in 46Cr, we are able to significantly reduce uncertainties in the astrophysical 45V(p,γ)46Cr reaction over the temperature range of CCSNe, and subsequently assess the impact of this new rate on 44Ti abundances from CCSNe.