First measurement in the Gamow window of a reaction for the $\gamma$-process in inverse kinematics: $^{76}$Se($\alpha,\gamma)^{80}$Kr

The $p$-nuclei are the few stable nuclei heavier than iron on the neutron-deficient side of the valley of stability that cannot be produced through astrophysical neutron-capture reactions. The limited experimental data on reactions through which the $p$-nuclei might be produced leaves the origin of their production largely unknown. This work presents the first cross section measurements of the $^{76}$Se($\alpha,\gamma)^{80}$Kr reaction. The rate of the time reversed reaction, $^{80}$Kr($\gamma,\alpha)^{76}$Se, is one of the most uncertain of possible reactions which can occur at the $^{80}$Kr branching point on the $\gamma$-process photo-disintegration pathway. The reaction flow through $^{80}$Kr will directly affect the final abundance of the $p$-nuclide $^{78}$Kr. Experimental cross sections at two astrophysically relevant energies are reported and compared to cross sections calculated using Hauser-Feshbach codes TALYS, NON-SMOKER, and SMARAGD. The success of these first ($\alpha,\gamma$) cross section measurements performed in inverse kinematics in the energy region of the $\gamma$-process opens the door for future studies of reactions on radioactive $\gamma$-process nuclides.