Fusion and quasifission studies in reactions of Ca projectiles

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Reactions using 48Ca beams with actinide targets have been extensively used in recent years to produce superheavy elements (SHEs) [1]. SHEs have very low production cross sections partly due to a competing process called quasifission and also due to the very low survival probability of the compound nucleus (CN) formed. For successful production of SHEs, it is important to understand fusion and quasifission in finer details. Calcium being one of the candidates in hot fusion reactions, we studied the fission of a number of reactions using 40,48Ca beams at ANU, using the CUBE detector setup [2]. The results of 40Ca reactions with 186W and 192Os targets will be presented. The mass ratio (MR) and mass-angle distributions (MAD) of the fragments were generated using the two-body kinematics. The angular distributions of the fragments were also obtained from the same data and were compared with the transition state model (TSM) [3]. The MAD, MR width and angular distribution (which deviate from the 1/sinθ behaviour expected for fusion-fission events) indicate strong quasifission in 40Ca + 186W, 192Os reactions.

The experimental MADs were further simulated following a phenomenological approach [4] using the spin distribution generated using the angle-integrated cross section, moment of inertia and sticking time distributions. An average sticking time of $1 \times 10^{-21}$ s for the axial collisions is required to simulate the quasifission events in these reactions. In Fig. 1 (a - e), we show the experimental as well as the theoretical results for the 40Ca + 186W reaction at center-of-mass beam energy (Ecm) 168.2 MeV. The capture excitation function for the 40Ca + 186W reaction is shown in Fig. 1 (f) along with the results of coupled channels calculations (solid red line).

FIG. 1: For the 40Ca+186W reaction at E_{c.m.}=168.2 MeV : (a) Experimental MAD. (b) Simulated MAD. (c) Experimental MR distribution compared with the expected MR distribution (red line) for CN fission using the semi-empirical model GEF [5]. (d) Experimental MR distribution versus simulation within the experimental acceptance shown as a rectangular box in panel (a). (e) Experimental angular distribution versus simulated distribution within the acceptance defined in panel (b). Dashed blue line represents the TSM prediction for fusion-fission events. (f) Capture excitation function for the 40Ca+186W reaction. Solid red line represents the coupled channels calculation.