Fusion and quasifission studies in reactions of Ca projectiles

E. Prasad,[1] D. J. Hinde,[1] E. Williams,[1] M. Dasgupta,[1] I. P. Carter,[1] K. J. Cook,[1] D. Y. Jeung,[1] D. H. Luong,[1] C. S. Palshetkar,[1] D. C. Rafferty,[1] K. Ramachandran,[1] C. Simenel,[1] and A. Wakhle[1]

[1]*Department of Nuclear Physics, RSPE, The Australian National University, ACT 2601, Australia*

Reactions using ^{48}Ca 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 ^{40,48}Ca beams at ANU, using the CUBE detector setup [2]. The results of ^{40}Ca reactions with ^{186}W and ^{192}Os targets will be presented. The mass ratio (M_R) 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, M_R width and angular distribution (which deviate from the 1/sinθ behaviour expected for fusion-fission events) indicate strong quasifission in ^{40}Ca +^{186}W, ^{192}Os 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 11 $\times$ 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 ^{40}Ca+^{186}W reaction at center-of-mass beam energy ($E_{c.m.}$) 168.2 MeV. The capture excitation function for the ^{40}Ca+^{186}W reaction is shown in Fig. 1 (f) along with the results of coupled channels calculations (solid red line).

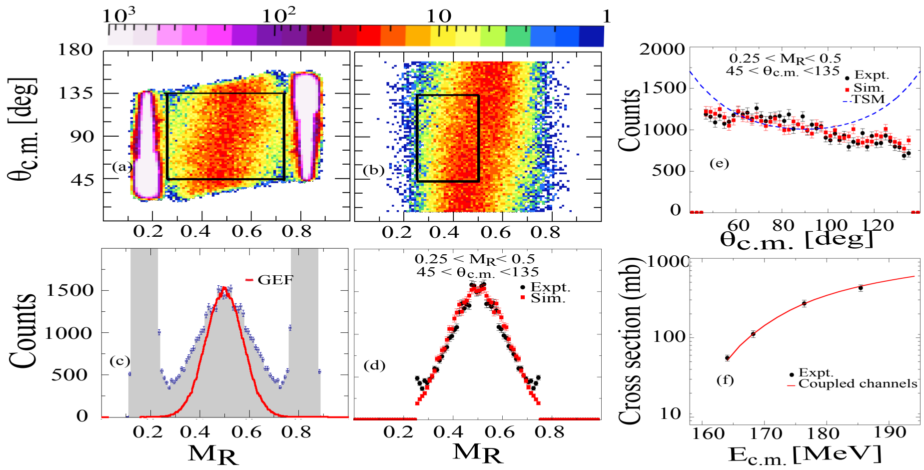

FIG. 1: For the ^{40}Ca+^{186}W reaction at $E_{c.m.}$=168.2 MeV : (a) Experimental MAD. (b) Simulated MAD. (c) Experimental M_R distribition compared with the expected M_R distribution (red line) for CN fission using the semi-empirical model GEF [5]. (d) Experimental M_R distribution versus simulation 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 ^{40}Ca+^{186}W reaction. Solid red line represents the coupled channels calculation.

[1] Y. T. Oganessian and V. K. Utyonkov, Nucl. Phys. **A 944**, 62 (2015).
[2] D. J. Hinde et al., Phys. Rev. **C 54**, 1290 (1996).
[3] B. B. Back et al., Phys. Rev. **C 32**, 195 (1985).
[4] E. Prasad et al., Phys. Rev. **C 93** , 024607 (2016).
[5] K. -H. Schmidt *et al.,* Nuclear Data Sheets **131**, 107 (2016).