NEUTRON MULTIPLICITY MEASUREMENTS AS A PROBE OF NUCLEAR VISCOSITY AND FUSION-FISSION DYNAMICS

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Summary and Future Outlook

In the present thesis, a detailed study of fission dynamics of excited nuclei formed in heavy-ion collisions is presented with a view to extract knowledge about the dissipative properties of hot fissioning nuclei. An attempt has been made to study the dynamics of heavy ion induced fusion-fission reactions and to determine the dissipation strength using pre-scission neutrons, fission cross sections and evaporation residue (ER) cross sections as the probes. All the experiments required for this research work have been performed using 15UD pelletron accelerator and the LINAC facility at Inter University Accelerator Centre, New Delhi.
New combinations of proton and neutron numbers, i.e. the isospin degree of freedom, are expected to provide new information on nuclear forces. These results open up new possibilities for experimental studies of neutron-rich nuclei employing different reaction mechanisms. Such reactions not only provide invaluable nuclear structure information but they also allow to reach nuclei even further away from the stability line. The total number of nucleons (A) and the ratio of neutrons to protons (N/Z) are the most critical ingredients in determining the properties of a nucleus. So, beams of neutron rich nuclei offer better chance to synthesize heavy elements because the fused system will be less neutron deficient. The survival probability of the compound nucleus depends on the fission probability. Moreover the fission probability is critically depends on the fission time scales which in turn is proportional to the dissipation effects. Thus a proper understanding of nuclear friction is very crucial for the stability of super heavy elements (SHEs) against fission. So keeping these aspects in mind we have carried out experiments using ^{16,18}O beams on ^{194,198}Pt targets forming compound nuclei ^{210,212,214,216}Rn which have same Z values but different N values.

In the first experiment pre-scission neutron multiplicities have been measured for the ^{16,18}O + ^{194,198}Pt reactions forming the compound nuclei at excitation energies of 50, 61, 71.7, and 79 MeV. The measured multiplicities have been analyzed with the statistical model of nuclear decay where fission hindrance due to nuclear dissipation is considered. The dissipation strength is treated as an adjustable parameter in order to fit the experimental data. The N/Z dependence of the dissipation strength at the lowest excitation energy of the compound nuclei suggests shell closure effects. However, such effects have not been observed at higher excitations where the variation of the dissipation strength with N/Z does not show any specific trend.

In the second experiment fission cross section for ^{16,18}O+^{194,198}Pt reactions have been measured. PACE calculations were performed to fit the experimentally extracted fission cross sections. In the calculations the Sierk fission barrier, B_f, level density ratio, a_f/a_n, and level density parameter "a" were varied to fit the fission and ER cross sections for ^{16}O+^{194}Pt reaction for which the ER cross sections were already exist. Fission cross sections for the other three reactions ^{16,18}O+^{198}Pt and ^{18}O+^{194}Pt were not fitting well with the same parameters those used to fit ^{16}O+^{194}Pt. So, to constrain the statistical model (PACE) parameters and to study the dissipation effects we have measured the ER cross sections for ^{16,18}O+^{198}Pt reactions.

Third experiment was performed at HYRA (Hybrid Recoil Mass Analyzer) with ^{16,18}O beams on ^{198}Pt target to measure the evaporation residue (ER) cross sections. Simultaneous fitting was done by HIVAP and PACE codes to fit ER, fission and fusion cross sections in order to constrain the parameters in the respective codes. Also the statistical model calculations have been performed by taking the dissipation coefficient as an adjustable parameter in order to obtain the dissipation strength that matches the experimental data for both the reactions. These results show that the value of dissipation coefficient (β) which match the experimental data (ER and fusion cross section) for ^{18}O+^{198}Pt ranges from 0 to 2.6 MeV/$\hbar$ and for ^{16}O+^{198}Pt, it is 0 to 1.9 MeV/$\hbar$. Similar Statistical Model calculations were also done by Prasad et. al. for $^{16}O+^{194}Pt$ to observe the effect of dissipation where, a value of β= 1.5 was needed to fit the ER cross sections at about similar excitation energies. So, it can be observed that pre-saddle dissipation increases with the N/Z ratio of compound nuclei. Also the values for the dissipation coefficient those fit the ER cross sections are less than those calculated from the neutron data ($\sim$0.2 to 3 MeV/$\hbar$). Because, the ER cross sections give the knowledge about the dissipation only upto the saddle point (i.e pre-saddle dissipation) but, the prescission neutron multiplicities give the information about the dissipation for the whole path upto scission, as the neutrons are evaporated during the whole process and contribute from saddle to scission region.

Further, dynamical effects such as inclusion of Langevin equation can influence the time scale of the post-saddle dynamics and hence the number of emitted neutrons. Such possibilities should be examined in future for a better understanding of dynamics of nuclear fission for the same compound nuclei.