Simultaneous Neutron and Charged Particles Spectroscopy for the Study of Fusion-fission Reaction Dynamics

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Introduction

It is now well known that, the light particles emitted during the de-excitation process of hot compound nucleus (CN) contains valuable information about the dissipative nature of CN. These light particles includes neutrons, protons, alphas and GDR γ-rays. Neutrons evaporation is the most dominant cooling process in heavy-ion fusion-fission reactions and their emission is insensitive of the nuclear shape. Charged particles emission is more than two orders weaker in magnitude than neutrons evaporation. However, charged particles emission depends upon the coulomb barrier of the exit channel which is sensitive to the deformation of the emitter. The α-particles emitted near the scission point are focussed at 90^o due to the equal coulomb repulsive forces of the two equal mass fragments. This emission process is known as Near-scission-emission(NSE) and the emission energy spectra of NSE is gaussian and contains characteristics of the scission point. By comparing the particle multiplicities with theoretical model calculations, one can derive the fission time scale and the dissipation or friction coefficient [1]. These model calculations rely on the fact that fission process is hindered due to the viscous nature of compound nucleus. There are very few studies in which both neutrons and charged particles multiplicities were measured simultaneously [1–3]. In the present work, we have simultaneously measured the neutron and charged particles energy spectra and used them to derive the particles multiplicities.

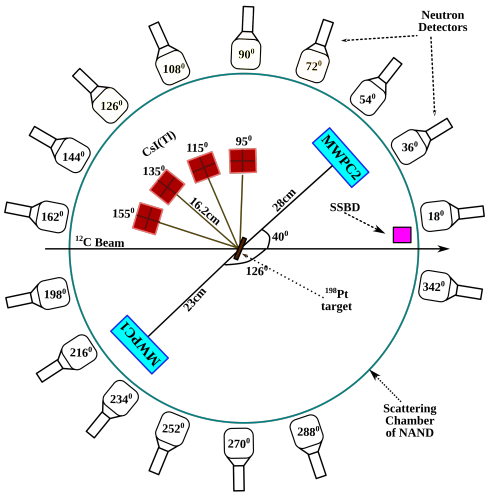

FIG. 1: Experimental setup in NAND detector array.

Experimental Setup

The experiment to measure neutron and charged particles multiplicities was performed in the scattering chamber of National Array of Neutron Detectors (NAND) at IUAC, New Delhi. ^{12}C pulsed beam accelerated to 81MeV energy using pelletron accelerator was bombarded on a self-supporting foil of ^{198}Pt. The thickness of the foil was 2.1mg/cm^2. This reaction yields the compound nucleus ^{210}Po with excitation energy of 61MeV. The whole experimental setup is shown in fig.1. To de-

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tect the fission fragments, two position sensitive MWPCs were placed at angles of 40^o and 126^o. These detectors were having an active area of 20cm × 10cm and were operated with isobute gas at pressure of 4 mbar. The fast timing signals from anode of MWPCs were used to get time-of-flight (TOF) information of the fission fragments. This information enables us to sepatate the fission events from other competing channels. Neutrons were detected using 16 BC501A liquid scintillators placed in the reaction plane of NAND scattering chamber. 16 CsI(Tl) inorganic scintillators directly coupled to Si-photodiode were used to detect the charged particles emitted in coincidence with fission fragments. The discrimination between various charged particles (alphas, protons, deutrons etc) was done using ballistic deficit pulse shaping technique [4]. Data acquisition was done using the indigenous VME controller ROSE and the NiasMARS software.

Data Analysis and Discussion

Data analysis was done using the ROOT software. During the offline data analysis, fission gated neutron and α-particles energy spectra were obtained by normalizing with total fission events after correcting for random coincidences. In order to have a better angle definations, four equal slices were considered in MWPC and then angles between these slices and neutron detectors were calculated. These angles were used during moving source fitting to obtain neutron multiplicities. Fig. 2 shows double differential neutron energy spectra for four neutron detectors placed at $\theta_n = 18^o$, $\theta_n = 36^o$, $\theta_n = 90^o$ and $\theta_n = 108^o$ fitted with moving source code considering three sources of neutron emission viz. compound nucleus, one fragment and complimentary fragment. During the fit, ν_{pre}, ν_{post}, T_{pre} and T_{post} were taken as free parameters. The fitted values obtained were $\nu_{pre} = 2.00 \pm 0.053$, $\nu_{post} = 1.22 \pm 0.01$, $T_{pre} = 1.25 \pm 0.02$ and $T_{post} = 0.91 \pm 0.01$. These values are consistent with the values already published in the literature [5] and also with the energy balance cobdition. Charged particles analysis is in progress and will be presented during the conference.

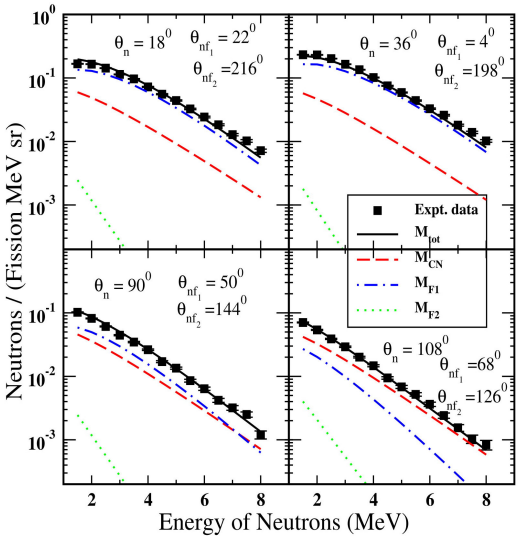

FIG. 2: Double differential neutron multiplicity spectra for $^{12}C + ^{198}Pt$ reaction. The fits for the pre-scission (red dashed line) and post-scission contribution from one fragment (blue dashed-dotted line) and that from the complimentary fragment (green dotted line) are shown. The solid black line represents the sum of all the contributions.

Acknowledgments

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References

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