Chapter 6

Summary and conclusion

It is clear from the results presented in the thesis that the $\gamma$-decay from the giant dipole resonance can be used to study the different reaction mechanisms. The linearized GDR lineshapes for the systems $^{47}$V and $^{32}$S populated via $^{20}$Ne + $^{27}$Al and $^{20}$Ne + $^{12}$C, respectively, are remarkably different from each other. Interestingly, the two lineshapes are also dissimilar from what is expected for a spherical or a near spherical system pointing towards large deformations. The most striking feature for $^{47}$V is the strong enhancement in the $\gamma$-ray yield at $\sim 10$ MeV. It is the characteristics of Jacobi shape transition, an abrupt change from an oblate to an elongated triaxial shape, and Coriolis effect due to high angular momentum. The experimental results are also consistent with the predictions of a hot rotating liquid drop model.

It is well known that the $\gamma$-ray yield from the decay of the GDR in self-conjugate nuclei ($^{32}$S) populated by T=0 entrance channel are found to be strongly inhibited due to the isovector nature of the electric dipole radiation and increase in the presence of isospin mixing. However, in heavy ion collision at projectile energies above 6 MeV/nucleon, incomplete fusion and pre-equilibrium emission processes also occur. Hence, the high energy $\gamma$-rays may also arise following incomplete fusion and pre-equilibrium nucleon emission.
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Since the statistical model code CASCASE used in the thesis does not include the effect of isospin, the data have been analyzed twice i.e. considering pre-equilibrium emission and without pre-equilibrium emission. For both the cases, the GDR parameters are very similar except for the overall GDR strength function. Thus, it is expected that the isospin included statistical model analysis will not change the spectral shape of the resonance but rather the overall magnitude of the strength function will be modified. Interestingly, no enhancement is seen at $\sim 10$ MeV for $^{20}$Ne + $^{12}$C reactions populating $^{32}$S although it is populated well beyond the Jacobi transition point. The shape looks more like a highly extended prolate and is seen for the first time for this nucleus. In this case, the thermal shape fluctuation model fails to explain the experimental data. The occurrence of such a large deformation without showing the characteristics of Jacobi transition is possible only if some other reaction mechanism is responsible. This unusual deformation has been speculated due to the formation of either the orbiting dinuclear configuration or the molecular structure of $^{16}$O + $^{16}$O forming a super-deformed structure in $^{32}$S at high excitation.

It is interesting to note that the Jacobi shape transition is seen only upto $A = 50$. However, it is predicted to take place in heavier nuclei, atleast upto $A \sim 100$, where the angular momentum corresponding to Jacobi transition is less than that of the fission limit. Thus, it would be an exciting study to look for the Jacobi transition in heavier mass systems in future. Similar to the $^{32}$S nucleus, a strong entrance channel effect is also seen for heavier nuclei in the reactions $^{16}$O + $^{89}$Y and $^{16}$O + $^{93}$Nb pointing towards the formation of orbiting dinuclear configuration. However, in the case of $^{12}$C + $^{93}$Nb no such large back-angle yield is observed [Ray91]. It would be interesting to measure the GDR $\gamma$-decay from these systems to look for the anomaly observed in the corresponding charged particle experiments.
Apart from the heavy-ion reaction, an extensive experiment was carried out to study the emission of high-energy photons from the spontaneous fission of $^{252}$Cf source. Interestingly, high-energy $\gamma$-rays upto 80 MeV have been observed in the experiment. The $\gamma$-rays in the range 8-20 MeV are attributed to the GDR $\gamma$-decay from the excited fission fragments while the spectrum above 20 MeV is attributed to the coherent bremsstrahlung $\gamma$-rays due to acceleration of the fission fragments in their mutual Coulomb field. The result has been substantiated with a theoretical calculation by estimating the emission of $\gamma$-rays considering classical Coulomb acceleration. This approximate calculation describes the experimental data remarkably well when the pre-scission kinetic energies of the emitted fission fragments and the conservation of energy are taken into account.