Theoretical Physics at VECC

Theoretical physics research at VECC is mainly centred around nuclear properties and nuclear reaction mechanisms at low, intermediate and relativistic energies. The current research initiatives can be summarised as follows.

A. Properties of nuclear matter and nuclear processes in finite nuclei:

Mean field calculations are made for the properties of nuclear matter. Microscopic calculations of nuclear potentials are also made to extract the particle and cluster radioactivity lifetimes of finite nuclei.

The liquid drop mass formula is extended to estimate the binding energies of hyperons and also to predict the existence of bound hypernuclei near the drip lines.

B. Dynamical and statistical models of nuclear fission:

Langevin equations are employed to study the dissipative dynamics of highly excited compound nuclei undergoing fission. A microscopic model of nuclear dissipation is developed.

The statistical model is used to study systematic features of fission including photo-fission cross-section.

C. Dissipative fluid dynamics in relativistic heavy ion collisions:

Space-time evolution of a dissipative fluid modeling a strongly coupled quark-gluon plasma and undergoing boost-invariant longitudinal and arbitrary transverse expansion is formulated from Israel-Stewart's formal theory of 2nd order dissipative fluid dynamics. A computer code AZHYDRO-KOLKATA is developed to solve these equations to study the fluid properties.

D. Mach shock wave in Jet-plasma interaction in relativistic heavy ion collision:

Mach shock waves produced in relativistic heavy ion collisions due to jet-plasma interactions are studied. The distortion of the shock wave front is investigated.

E. Quark Gluon Plasma diagnostic: J/psi suppression in nuclear medium:

J/psi suppression in nuclear collisions at SPS (E_{cm}~18 AGeV) and RHIC (E_{cm}~200 AGeV) energies is studied and its role as a quark gluon plasma diagnostic evaluated.

F. Thermal Radiations from Relativistic Heavy Ion Collisions:

Radiation of thermal single photons and dileptons from relativistic heavy ion collisions at SPS (E_{cm} ~18 AGeV), RHIC (E_{cm}~200 AGeV), and LHC (E_{cm}~5500 AGeV) energies and their role as a signature of quark-hadron phase transition is studied.

The intensity interferometry of thermal photons is studied with a view to get information about the evolution of the system formed in such collisions.

G. Electromagnetic Radiations from Quark Gluon Plasma due to Passage of Jets:

Suppression of particles having large transverse momenta due to the energy loss suffered partons during their passage through quark gluon plasma, known as jet-quenching is one of the most spectacular observations at RHIC energies. First studies of radiation of high energy photons and large mass dileptons due to the passage of high energy partons through quark gluon partons are performed.

H. Elliptic Flow of Thermal Photons and Thermal Dileptons in Relativistic Heavy Ion Collisions:

Elliptic flow of hadrons radiated from relativistic heavy ion collisions are considered to be a most reliable confirmation of the formation of a hot and dense system very early in the collision. However, the hadrons themselves leave the system at the time of freeze-out. First studies of the elliptic flow of thermal photons and dileptons are performed with a view to get direct information about the evolution of the elliptic flow and the flow of the quark gluon plasma stage of the system.

I. Parton Cascade Model for Relativistic Heavy Ion Collisions:

A description of the relativistic heavy ion collision is attempted in terms of scattering, radiating, and fusing partonic cascades, based on perturbative quantum chromodynamics. Energy densities, Debye screening lengths, and radiation of pre-equilibrium photons from such studies is performed.

J. Stochastic Processes:

The perturbed angular correlation between the two gamma rays is investigated in terms of the transport properties of the environment.

The role of stochastic resonance in information transmission through noisy channel is being studied.

Application of the coherent stochastic resonance phenomenon to separate different sizes of large DNA molecules is under investigation.