Statistical and Thermal Physics in Heavy-Ion Collision and Particle & Nuclear Astrophysics

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Thermal and statistical physics established the principles and procedures needed to understand and explain the properties of systems consisting of macroscopically large numbers of particles. By developing microscopic statistical physics (application of classical and quantum mechanics) and macroscopic classical thermodynamic descriptions in tandem, *Statistical and Thermal Physics* topic provides insight into basic concepts and relationships: interrelating the microscopic statistical properties of a system containing a very large number of particles, via a statistical treatment of the laws of particle motion and the macroscopic thermodynamic properties of the system.

Since astrophysics deals with very large systems, only through statistical mechanics and its offshoot thermodynamics can we understand stellar interiors, planetary atmospheres, interstellar gas, and a slew of other astrophysical environments. At the same time, astrophysical observations of objects such as white dwarfs and neutron stars feed back into our understanding of fundamental physics. In burnt-out suns (white dwarfs) one finds the electron gas and nuclear matter (in the center of neutron stars and in supernova explosions), which consists of many neutrons and protons.

Our universe was created in the "big bang" from a many-particle system of leptons, quarks, and gluons. Theoretical study of matter under extreme temperature and densities covers a large area of contemporary research. Such matter is produced during heavy ion collisions at particle accelerators and astrophysical processes. This study entails a detailed use of statistical and thermal model description of the matter. Computational and data science tools, mathematical and analytical methods are to be employed in conducting the investigation.

The matter under study is produced in particle accelerators such as RHIC-BNL, LHC-CERN, CBM-FAIR and NICA-JINR. At the other end, such exotic matter is believed to be formed in astrophysical processes such as neutron star collisions, supernovae explosions, black hole mergers etc. and the subsequent detection of astrophysical signals (messengers) from these events by the ground-based and space-based telescopes and detectors such as SKA, SALT, MeerKAT, LIGO, Hubble telescope etc.

The expected activities include, but not limited to:

I. The description of the matter produced in the final stage of the evolution of heavy ion collisions
II. The study of particle production, Particle ratios, Transverse momentum distributions
III. Extracting information on temperature, chemical potential, and net charge density of matter.
IV. Investigating the Equation of State (EoS) of the matter which will serve as input into fluid dynamic models.