Relativistic Fluid Dynamics in Heavy-Ion Collisions and Particle & Nuclear Astrophysics

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Relativistic fluid dynamics (or relativistic hydrodynamics) is the study of flows in the arena of special or general relativity. In special relativity, the velocities attained by certain portions of the fluid or by the fluid as a whole approach the speed of light. The relativistic fluid is a highly successful model used to describe the dynamics of many-particle, relativistic systems. Relativistic astrophysical processes and relativistic heavy-ion collision dynamics could be understood by using relativistic hydrodynamics.

Many-particle astrophysical and cosmological systems can be described using relativistic fluid dynamics. Two examples, the expansion of the Universe and oscillations of neutron stars, indicate the vast range of scales on which relativistic fluid models are relevant. A particularly exciting context for relativistic fluids today is their use in the modelling of sources of gravitational waves. This includes the compact binary inspiral problem (either of two neutron stars or a neutron star and a black hole) or the collapse of stellar cores during supernovae. In nuclear and particle physics, the use of relativistic fluids in modelling collisions of heavy nuclei and astrophysical jets should be kept in mind. Furthermore, studies such as magnetohydrodynamics can be applied on a conducting medium for astrophysics and heavy-ion collisions.

In this topic, we will theoretically and computationally study heavy-ion collisions such as those at the Relativistic Heavy-Ion Collider (RHIC) and the Large Hadron Collider (LHC) experiments and astrophysical systems such as those produced during the stellar core collapse and neutron stars mergers.

Under this topic, projects will involve:

(i) Deriving equations to describe hydrodynamics for heavy-ion collisions and astrophysics.

(ii) Applying fluid dynamics for relevant stages of the heavy-ion collisions and astrophysics systems.