Seminar, Department of Physical Sciences, Bose Institute, Kolkata

Neutron Stars: A Window to Probe High-Density Matter Through Multiple Fronts

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Abstract: Neutron stars (NSs) are among the most fascinating and extreme astrophysical objects in the Universe, providing a unique natural laboratory to study matter under conditions unattainable on Earth. Over the last decade, rapid advances in multi-messenger astronomy have transformed our understanding of dense matter physics, connecting astrophysics, nuclear physics, particle physics, and general relativity in unprecedented ways. Recent observations from the Neutron Star Interior Composition Explorer (NICER), which measures neutron star masses and radii with high precision, together with gravitational-wave detections from binary neutron star mergers such as GW170817, have placed stringent constraints on the equation of state (EoS) of matter at supranuclear densities. These observations have opened a new era in the study of compact stars, where electromagnetic and gravitational-wave signals jointly provide insights into the microscopic properties of ultra-dense matter. In this presentation, I will discuss how future detections of post-merger gravitational-wave signals from binary neutron star mergers may help uncover one of the long-standing questions in nuclear and particle physics: the existence of phase transitions in matter at extreme densities, including the possible emergence of exotic phases such as deconfined quark matter. I will also discuss how modern machine learning techniques can be utilised to solve the inverse problem of neutron stars — namely, constraining the underlying microphysics and dense-matter equation of state directly from astrophysical observations. Particular emphasis will be placed on combining NICER and gravitational-wave observations to infer neutron star properties in a model-informed yet data-driven framework.

- **Date/time: June 12, 2026 (Friday) at 02:30 PM**
- **Venue: Room 204, Physics Seminar Room, (Second floor, UAC, BI)**