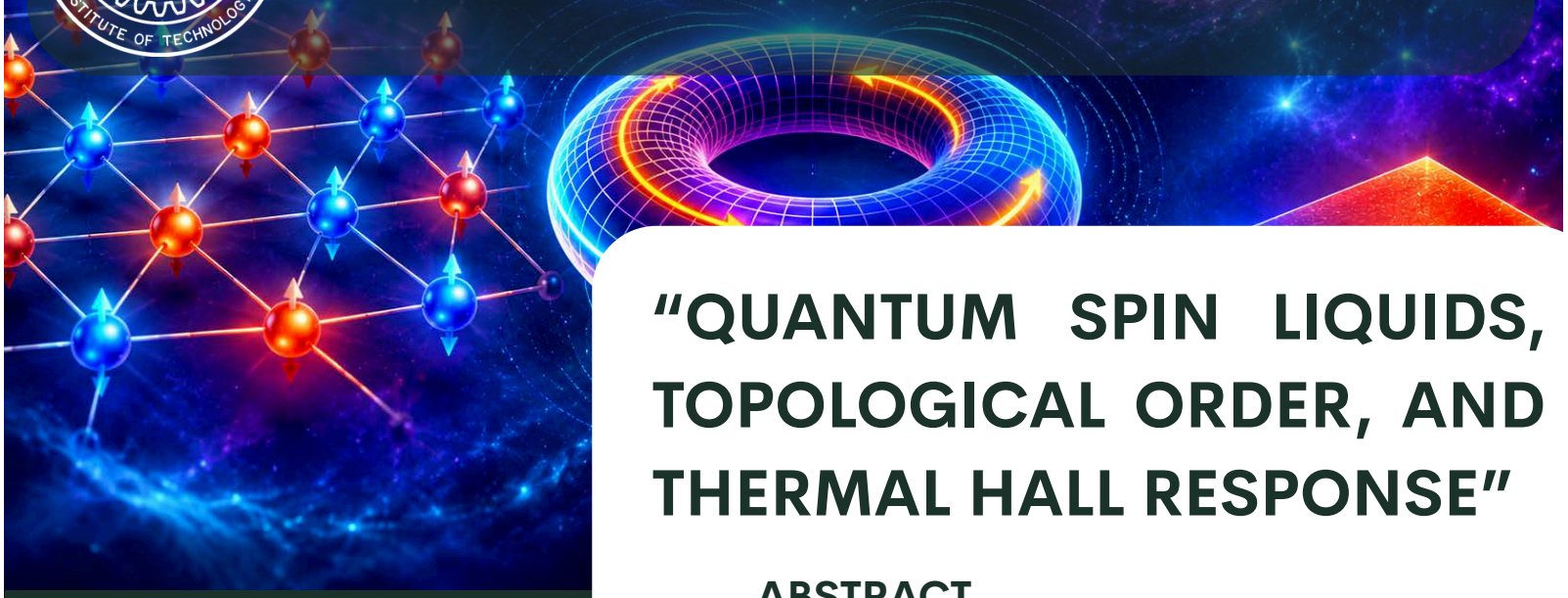
DEPARTMENT OF PHYSICS
INDIAN INSTITUTE OF TECHNOLOGY KANPUR



PHYSICS COLLOQUIUM

"QUANTUM SPIN LIQUIDS, TOPOLOGICAL ORDER, AND THERMAL HALL RESPONSE"

SPEAKER



Prof. Vikram Tripathi
Department of Theoretical Physics
TIFR, Mumbai

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ABSTRACT

Over the past century, Landau's paradigm taught us that states of matter can be classified through spontaneous global symmetry breaking characterized by a local order parameter. However, this framework fails to capture topologically ordered phases, which are instead defined by patterns of long-range quantum entanglement rather than symmetry breaking. Fractional quantum Hall states and quantum spin liquids (QSLs) represent prominent examples of topological order in vastly different physical systems — high-mobility 2D electron gases and spin-1/2 Mott insulators, respectively. In two dimensions, QSLs feature fractionalized excitations and non-trivial ground-state degeneracy on closed manifolds. I will illustrate these ideas using the resonating valence bond (RVB) state on a triangular lattice.

Experimentally, while QSLs have recently been engineered in small quantum processors, they are difficult to establish in real materials due to imperfect Hamiltonians and competing interactions, and smoking-gun tests for fractionalized excitations remain challenging to implement. The thermal Hall effect has emerged as a crucial probe in this context. Theoretically, the thermal Hall response cannot be calculated through the Kubo formula like other linear response properties, and indeed, it is not even a very well-defined quantity unless additional physical assumptions are made. It therefore becomes important to have a physically meaningful definition of the thermal Hall response that actually corresponds to experiment. I will describe how this is done.

For two-dimensional chiral quantum spin liquids (QSLs) — magnetic analogues of fractional quantum Hall states — the low-temperature thermal Hall conductance is quantized and directly proportional to the chiral central charge of the one-dimensional edge modes, providing a hallmark of the underlying two-dimensional fractionalized phase through bulk-boundary correspondence. However, experimentally extracting the chiral central charge from low-temperature thermal Hall measurements has proven challenging and, in many cases, controversial. I demonstrate that, despite the breakdown of bulk-boundary correspondence at finite temperatures, the thermal Hall response retains distinct and diagnostic signatures of the underlying QSL. These findings establish an alternative route to probing chiral QSLs through finite-temperature thermal Hall measurements.

All are Cordially Invited