Sonderforschungsbereich 1277

Emergent Relativistic Effects in Condensed Matter -
From Fundamental Aspects to Electronic Functionality

SFB – Seminar

Speaker: **Prof. Dr. Mandar M. Deshmukh**
Tata Institute of Fundamental Research, Mumbai
India

Date: Friday, 02/10/2026, 13:00, PHY 5.1.01

Topic: 2D van der Waals Josephson devices

Abstract:
Over the last decade, the development of Josephson devices based on van der Waals (vdW) materials have advanced rapidly, representing a paradigm shift driven by the advent of 2D materials. The diverse vdW materials library, combined with advanced fabrication techniques, enables the integration of materials with vastly disparate properties for scientific exploration. vdW Josephson junctions (JJs) offer a unique route to explore novel functionalities and associated physics that remain inaccessible in conventional JJs [1].
I will discuss two classes of Josephson devices. First, proximitized graphene-based Josephson junctions that are gate tunable. The graphene Josephson FET enables a quantum-noise-limited parametric amplifier with performance comparable to the best discrete amplifiers in this class [2]. One can realize extremely sensitive and fast bolometers [3] – useful for dark matter search, among other applications. Second, twisted van der Waals heterostructures based on the high-temperature superconductor Bi2Sr2CaCu2O8+δ enable the realization of a high-temperature Josephson diode [4] for the first time. Such Josephson diodes offer an opportunity to realize new devices at liquid nitrogen temperatures. While opportunities abound with vdW JJs, the challenge of scalability must be overcome to translate them into real-world devices.

[1] “New frontiers in quantum science and technology using van der Waals Josephson junctions” Sarkar et al., arXiv:2604.15276. [2] "Quantum-noise-limited microwave amplification using a graphene Josephson junction" Sarkar et al. , Nature Nanotechnology 17, 1147 (2022). [3] “ Kerr non-linearity enhances the response of a graphene Josephson bolometer,” Sarkar et al. , Nature Communications volume 16, 7043 (2025). [4] "High-temperature Josephson diode," Ghosh et al. Nature Materials 23, 612 (2024).

Host: Prof. Dr. Christoph Strunk