Max-Planck-Institut für
Struktur und Dynamik der Materie

Max Planck Institute for the Structure and Dynamics of Matter

IMPRS UFAST Call for PhD applications 2026/2027

AR1 - Cavity Engineering of Non-Hermitian Quantum Materials

Title of PhD Project	**Cavity Engineering of Non-Hermitian Quantum Materials**
Type	Theory (Condensed Matter Physics / Cavity QED)
Supervisor(s)	Prof. Dr. Dante M. Kennes Prof. Dr. Angel Rubio
Affiliation(s):	Max Planck Institute for the Structure and Dynamics of Matter
Number of positions:	1
Abstract:	Electromagnetic cavities can reshape quantum materials through vacuum fluctuations and, when photon leakage is deliberately structured, provide a tunable reservoir for effective non-Hermitian many-body dynamics. A central open challenge is to connect realistic cavity geometry and dissipation to microscopic changes of correlated phases and to experimentally distinguish genuine non-Hermitian phenomena from ordinary broadening. This project will develop gauge-consistent, multimode open-system theories for correlated and topological materials coupled to lossy nanophotonic and surface-polaritonic cavities. Combining Keldysh and nonequilibrium Green-function approaches with tensor-network and renormalization-group methods and first-principles light-matter parameters, the candidate will determine when engineered loss and mode structure generate effective complex interactions, nonreciprocal couplings, exceptional points and non-Hermitian topology. Target platforms will include two-dimensional magnets, moire systems and unconventional superconductors. The project will map phase diagrams and dynamical protocols, quantify robustness against disorder, heating and quantum noise, and propose observable signatures in time-resolved spectroscopy, ARPES, Raman scattering and transport. The outcome will be experimentally actionable design principles for cavity-controlled quantum matter.
Contact person for scientific questions about the project:	Prof. Dr. Dante M. Kennes: dante.kennes@rwth-aachen.de Prof. Dr. Angel Rubio: angel.rubio@mpsd.mpg.de
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