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 2025/2026

AR7 – Pauli-Fierz quantum field theory and quantum-electrodynamical density-functional theory: Dissipation and decoherence processes

Title of PhD Project	**Pauli-Fierz quantum field theory and quantum-electrodynamical density-functional theory: Dissipation and decoherence processes**
Type	Theory
Supervisor(s)	Prof. Angel Rubio Dr. Michael Ruggenthaler
Affiliation(s):	Max Planck Institute for the Structure and Dynamics of Matter
Number of positions:	1
Abstract:	Recent groundbreaking experiments have demonstrated that the quantized electromagnetic field can have a substantial impact on the dynamics and properties of molecules and solids even at ambient conditions. A detailed description of such situations necessitates the use of quantum electrodynamics (QED) in the non-perturbative low-momentum regime. It has been established that the resulting Pauli-Fierz quantum-field theory is mathematically similar to quantum mechanics and can be based on a self-adjoint and bounded-below Hamiltonian [1]. In this project the mathematical structure of the Pauli-Fierz Hamiltonian will be considered and the corresponding quantum-electrodynamical density-functional theory will be further developed. A specific focus is on the dissipative and decoherence properties of the quantum-field description. These properties arise because the matter subsystem is coupled to an infinite amount of photonic degrees of freedom. Moreover, the interplay of these properties with ultra-violet and infra-red regularizations will be investigated. [1] M. Ruggenthaler, D. Sidler, and A. Rubio Chemical Reviews, 123 (19), 11191-11229 (2023) https://doi.org/10.1021/acs.chemrev.2c00788
Contact person for scientific questions about the project:	Prof. Angel Rubio: angel.rubio@mpsd.mpg.de Dr. Michael Ruggenthaler: michael.ruggenthaler@mpsd.mpg.de
Research Group Website:	https://theory.mpsd.mpg.de/