



IMPRS UFAST Call for PhD applications 2026/2027



AR3 - Foundations of Pauli-Fierz theory and quantum- electro dynamical density-functional theories

Title of PhD Project	Foundations of Pauli-Fierz theory and quantum-electrodynamical density-functional theories
Type	Theory
Supervisor(s)	Dr. Michael Ruggenthaler and Dr. Heiko Appel Prof. Angel Rubio
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-energy 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 theoretical and mathematical structure of the Pauli-Fierz Hamiltonian is to be further investigated and basic results for quantum-electrodynamical density-functional theories and related approaches are to be advanced. A specific focus is on non-perturbative mass renormalization schemes, the connection of QED to thermodynamics, dissipation and decoherence. [1] M. Ruggenthaler, D. Sidler, and A. Rubio Chemical Reviews, 123 (19), 11191-11229 (2023)
Contact person for scientific questions about the project:	Michael Ruggenthaler: michael.ruggenthaler@mpsd.mpg.de Angel Rubio: angel.rubio@mpsd.mpg.de
Research Group Website:	MPSD Theory Department Website