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

AR3 – Band engineering of solids with intense light

Title of PhD Project	**Band engineering of solids with intense light**
Type	Theoretical (Condensed Matter Physics)
Supervisor(s)	Prof. Angel Rubio Dr. Hannes Hübener Prof. Umberto De Giovannini
Affiliation(s):	Max Planck Institute for the Structure and Dynamics of Matter
Number of positions:	1
Abstract:	Objectives: Development of a first principles based Floquet-technique for the manipulation of materials properties through the design of band structures by multi-colour and multi polarisation light pulses. The method aims at creating pre-determined features of Floquet-bandstructures (bandgaps, effective masses, spin-orbit splitting etc.) by specifically designed light pulses. Based on Floquet theory for light-driven materials [1], this project will develop protocols to design dressed band structures of solids. It aims at characterising and classifying the (classical) light pulses that can create predefined target bandstructures in semiconductor host materials [2], through first principles calculations using TDDFT and simplified band-models. 1. Develop a numerical optimization environment to design lasers for given target Floquet bandstructures. 2. Apply multi-colour Floquet drives within first principles TDDFT code octopus to benchmark the laser design. 3. Define a set of target bandstructures for a semiconductor host material and design the required Floquet drives. 4. Characterize the Floquet drives in terms of symmetries to deduce general rules for bandstructure design. [1] De Giovannini, U., & Hübener, H. (2020). Floquet analysis of excitations in materials. Journal of Physics: Materials, 3(1), 012001. http://doi.org/10.1088/2515-7639/ab387b [2] Castro, A., De Giovannini, U., Sato, S. A., Hübener, H., & Rubio, A. (2022). Floquet engineering the band structure of materials with optimal control theory. Physical Review Research, 4(3), 033213. https://doi.org/10.1103/PhysRevResearch.4.033213
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