DFG Deutsche Forschungsgemeinschaft

NARODOWE CENTRUM NAUKI

# PhD OFFER in OPUS LAP grant
# (Polish – German collaboration)

**Position in the project:** PhD student

**Scientific disciplines:** quantum optics, plasmonics, solid state physics

**Remuneration type:** salary (Germany) / stipend (Poland)

**Number of job offers:** 2

**Remuneration:** 75% TVL-E13 (Germany)

3800 PLN - 6200 PLN /month (Poland)

**Maximum period of hiring:** 36 months

**Position starts latest on:** 01.10.2022.

**Institutions:**

Karlsruhe Institute of Technology, Karlsruhe, Germany
Institute of Theoretical Solid State Physics

and

Nicolaus Copernicus University in Toruń, Poland
Faculty of Physics, Astronomy and Informatics
Institute of Physics

**Project leaders:** prof. Carsten Rockstuhl (Germany), dr. Karolina Słowik (Poland)

**Project title:** FLAT: Functionalizing LAyered 2D nanoflakes for Tailored optoelectronics

**Project description:** Twenty years after the first developments towards creation of graphene layers, a plethora of two-dimensional (2D) materials have been synthesized. The development of techniques to tune their compositions and arrangements provided unprecedented opportunities from an electrical, thermal, mechanical, or optical perspective.

2D materials provide a versatile playground for nanoscale optoelectronics: different materials with a thickness of a single atom layer offer a great variety of optical properties. From material to material, these properties differ across a broad range of electromagnetic frequencies. A whole new potential unfolds when monolayered materials are stacked, forming artificial, man-engineered heterostructures of properties controllable by design, but also electrically or optically tunable. Effects of interest are the broadband optical absorption, transduction or light emission from microwave to ultraviolet frequencies. Applications in optoelectronics include fast, broadband, atomically-thin electro-optical modulators, tunnel transistors, photovoltaic devices and many more.

The project is tailored to provide insights into the physics of heterostructures made from flakes or ribbons of different 2D materials using theoretical and computational means. The scope of the

study covers exploration of the energy characteristics and electron dynamics in such nanoflakes or ribbons depending on external electric gating and illumination. The aim is to exploit that information to contribute further towards miniaturized optoelectronic devices such as nanoscaled tunable tunnel transistors, electro-optic modulators, etc.

**Methods**: 2D materials flakes will be described with the quantum tight-binding Hamiltonian. Light-matter interactions in the time domain will be modelled using the master equation.

Python codes developed and available within the group cover the properties of graphene flakes. Extensions to include other materials or stacking will need to be implemented by the students with the guidance of the advisors.

### Key responsibilities include:

1. preparation of numerical tools and simulations of electro-optical properties of nanoflakes of selected materials (e.g. graphene, hexagonal boron nitride, molybdenum disulfide),
2. active collaboration with partners,
3. preparation of scientific articles,
4. presentation of research results at seminars and conferences.

### Profile of candidates / requirements:

1. Master's degree in Physics or related,
2. documented scientific expertise in one of the following disciplines
    - quantum optics,
    - quantum solid state theory,
    - atomic / molecular physics,
    - classical electrodynamics,
3. experience in numerical simulations or programming,
4. strong oral and written communication skills in English,
5. willingness to include the research results in the PhD thesis.

### Required documents:

1. CV,
2. motivation letter (optional),
3. contact details to at least one academic referee.

Please submit the documents to: carsten.rockstuhl@kit.edu or karolina@fizyka.umk.pl
(scanned or pdf versions will be accepted).
For more details please contact us by email: carsten.rockstuhl@kit.edu or karolina@fizyka.umk.pl

### Application deadline:

The call is open until suitable candidates are identified with the final closing date of 31.08.2022. We reserve the right not to select any candidates.