

## CSC-RUB PhD Project Proposal

**Title:** Monitoring the polarized sky with the Large Array Survey Telescope (LAST)

**Sector of research:** Dr.rer.nat.

**Degree awarded:** Physics

**Keywords:** photometry, polarization, blazars, multi-messenger astronomy

### Supervisors of PhD project:

Prof. Dr. Anna Franckowiak, Chair for Multimessenger Astrophysics, Faculty of Physics and Astronomy, leader of Helmholtz Young Investigator Group at DESY Zeuthen

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Prof. Dr. Hendrik Hildebrandt, Astronomical Institute, Faculty of Physics and Astronomy, Ruhr University Bochum (RUB); co-director of the German Centre for Cosmological Lensing (GCCL)

**Research focus of supervisor:** Prof. Franckowiak's research focuses on multi-messenger astronomy. She is a member of the IceCube collaboration operating the largest neutrino telescope in the world at the South Pole, where she currently serves as the deputy analysis coordinator. Furthermore, she works with gamma-ray and optical data and is a member of the gamma-ray space telescope Fermi-LAT and the optical survey instrument ZTF. Her group collaborates with astronomers at the Weizmann Institute in Israel to build the Large Array Survey Telescope (LAST), where her group is especially interested to add the capability to measure polarization and the synergies with the next generation gamma-ray instrument, the Cherenkov Telescope Array. Her group was significantly involved in the detection of the first compelling neutrino source candidates: the blazar TXS 0506+056 and the tidal disruption event AT2019dsg. Her group has strong ties to Germany's leading center of astroparticle physics, DESY Zeuthen.

**Publications:** more than 100 publications in the last 5 years., h-index 42

- R. Stein, S. van Velzen, M. Kowalski, **A. Franckowiak**, ... et al., "A high-energy neutrino coincident with a tidal disruption event", *Nature Astronomy*, 5, 510 (2021)
- X. Rodrigues, S. Garrappa, S. Gao, V. Paliya, **A. Franckowiak**, W. Winter, "Multi-wavelength and neutrino emission from blazar PKS 1502+106", *Astrophys.J.* 912 (2021)
- **Franckowiak**, S. Garrappa, V. Paliya, ... et al., "Patterns in the multi-wavelength behavior of candidate neutrino blazars", *ApJ*, 893, 162 (2020)
- M. G. Aartsen, M. Ackermann, J. Adams, ... **A. Franckowiak**, ... et al., "Multi-messenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A" *Science* 361, eaat1378 (2018)
- **Franckowiak**, P. Jean, M. Wood, C. C. Cheung, S. Buson "Search for Gamma-ray Emission from Galactic Novae with the Fermi-LAT", *A&A* 609, A120 (2018)

### Summary of research plan

**Background:** Relativistic jets from active galactic nuclei (AGNs) are powered by strong accretion onto central supermassive black holes. These plasma jets are the most powerful astrophysical

systems in our universe, showing bright emission from radio up to TeV gamma rays. The jet emission is mainly of non-thermal origin and highly variable. Polarimetry is a crucial tool to probe the magnetic field in those jets. Especially monitoring of the time variability gives important insights into the jet dynamics and emission mechanisms. For example, optical polarization angle swings observed in multi-wavelength flares demonstrate that the magnetic field in jets plays a crucial role in particle acceleration. Furthermore, predictions on multi-wavelength polarimetry have suggested that future X-ray and gamma-ray polarimetry alongside optical polarimetry can provide powerful diagnostics of proton acceleration and neutrino emission in AGN jets. Because current optical polarimeters have a small field of view, only a small number of sources can be monitored on a daily basis. To improve this situation the RUB group in collaboration with astronomers at the Weizmann Institute develop a cost-effective, wide-field-of-view instrument, consisting of an array of small off-the-shelf optical telescopes.

**Study objective:** The goal is to demonstrate polarization measurements with a prototype instrument consisting of 4 small telescopes. First verification data using bright sources will be collected in Bochum. The prototype will then be moved to a site with excellent observing conditions in Israel and become part of the first 30-telescope node. The candidate will participate in the installation in Israel and have the unique opportunity to evaluate the first science data.

**Expected Results:** This PhD project will demonstrate that polarization measurements with 1%-level precision are possible with the LAST telescope and perform first measurements with a 4-telescope prototype. The work will result in a technical publication on the verification of the prototype and several papers presenting the scientific results using the first year of science data collected with the prototype in Israel.

**Methods:** The candidate will be trained to perform observations and analyze photometric data. They will contribute to the development of a data analysis pipeline. The work will be performed in collaboration with the LAST team, which entails regular presentations in the weekly teleconferences. An extended stay at the Weizmann institute is foreseen.

**Candidate Requirements:** MSc degree in physics or astronomy is mandatory. Expertise in data analysis and a programming language such as python and matlab is strongly desired. Experience with optical data processing is a plus. Good English language skills are essential. Soft skills and good communication is required to work successfully in the international team that this project is embedded in.

**Motivation for CSC application:** The candidate will become part of one of the world-leading multi-messenger astronomy groups (split between RUB and DESY Zeuthen), which is involved and connected to a large number of multi-wavelength facilities. A broad scientific skill set will be taught that covers all aspects of optical data taking and statistical data analysis. The candidate will build up a large international network and naturally train their communication and presentation skills by working in an international team. Furthermore, the project will be embedded in the Ruhr-University Research School and the candidate can become a fellow of the Weizmann-Helmholtz Research School, which offer additional soft-skill seminars, tutoring, and career development.