Bachelor / Master theses

2026

Stars are light sources that appear point-like and it is very hard to resolve their spatial extent. The world's largest telescopes are employed to reach the required angular resolution and many technical challenges have to be overcome in the design and operation of such systems. An alternative approach for high angular resolution astronomy is offered by intensity interferometry (II).
Intensity Interferometry is a method based on the quantum optical correlation of photons. Intensity interferometry measures a second order correlation where two photons correlate such that enhanced intensity is observed as a function of time difference and position distance at which these photons are detected. The resulting coincidence rate between two telescopes as function of the distance between the telescopes is proportional to the diffraction pattern of the light source. The spatial extent of a star is then given by the Fourier transform of this pattern.
Intensity interferometry enables angular resolution down to the sub-milliarcsecond scale. It may even be able to reach better resolution than the largest telescopes. Arrays of Imaging Atmospheric Cherenkov Telescopes (IACTs), such as H.E.S.S. or the future CTA, are suitable for the application of the method. The ECAP team designed and built an intensity interferometer for the H.E.S.S. telescopes as well as a mobile Fresnel lens telescope intensity interferometer for use in Erlangen and has already performed measurements of star diameters with both. We are now looking to improve these experimental setups, our data analysis and modelling of II targets.

Master's theses

- Simulation of binary star systems for Intensity Interferometry measurements
- Characterization of Fresnel lenses and suitability study for air shower observations
- Analysis of intensity interferometry data taken with H.E.S.S.
- SST-II feasibility study
- Upgrades to and potential stellar diameter measurements with the ECAP Intensity Interferometer

Bachelor's theses

- Upgrades to and potential stellar diameter measurements with the ECAP Intensity Interferometer
- Online correlation system

Possible supervisors for projects in this group:

- Stefan Funk, s.funk@fau.de, office 02.036
- Alison Mitchell, alison.mw.mitchell@fau.de, office 02.038

Erlangen Centre for Astroparticle Physics

Master Thesis

Simulation of binary star systems for Intensity Interferometry measurements

The spatial coherence curve of a singular thermal light source of finite size - a single star - is very well understood and explained by intensity interferometry. However, if additional structure (or additional objects in the direct vicinity) is introduced, the picture becomes unclear quite quickly. What is the shape of a binary star system's spatial coherence curve? Which part of it does an intensity interferometer measure? What about n $>$ 2 multiple star systems, occultations or stellar surface inhomogeneities? This masters project will develop simulations to interpret intensity interferometry data of multiple star systems and address challenges related to binaries arising from intensity interferometer design. In particular, this will include theoretical predictions for the performance capabilities of different telescope systems, investigating the necessary properties to address more complex stellar structures.

Physics topics related to this work:

- Intensity Interferometry in astronomy
- Multiple star system dynamics

Skills acquired during this work:

- Programming in Python
- Star system modeling
- Telescope system response simulations

Interested? Please get in touch:

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Erlangen Centre for Astroparticle Physics

Master Thesis

Characterization of Fresnel lenses for II and gamma-ray astronomy

While IACT arrays are suitable for Intensity Interferometry (II), their primary application is gamma-ray astronomy, taking up the time with the best observation conditions. Dedicated instruments for II are very scarce and due to the nature of being a niche field, often are implemented in other telescopes/telescope arrays without impairing their primary function. The ECAP team has assembled two Fresnel lens telescopes for use in II measurements.
While the larger optical aberrations of a Fresnel lens have little impact on II measurements, are they still of good enough quality to be used in air shower observations? What is the off-axis response of Fresnel lenses?
This project will characterize two different types in two different sizes of Fresnel lenses with respect to their point spread function and off-axis response to evaluate them for use in II and gamma-ray astronomy.

Physics topics related to this work:

- Fresnel lenses, lens aberrations
- Gamma-ray astronomy

Skills acquired during this work:

- Statistical analysis of data
- Test bench setup for large optical elements, hardware design
- Systematic experimental work
- Python programming

Interested? Please get in touch:

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Erlangen Centre for Astroparticle Physics

Master Thesis

Analysis of intensity interferometry data taken with H.E.S.S.

In 2022 and 2023 the ECAP team took intensity interferometry data using up to three of the H.E.S.S. telescopes simultaneously. These data, in particular, the squared visibility vs. the projected baseline between the telescopes, can be used to determine geometric parameters of the observed stars, such as their angular diameters. Although a straightforward one-dimensional analysis has already been performed and stellar diameters have been extracted, there are a lot of missing analyses that might yield a better understanding of the observations. One particularly interesting question is: do we see indications of non-spherical stars when we analyze interferometric data of fast rotators? This requires an extension of the data analysis into two dimensions, replacing one-dimensional telescope baselines by the uv-plane.

Physics topics related to this work:

- Intensity Interferometry in astronomy
- Stellar physics

Skills acquired during this work:

- Statistical analysis of data
- Programming in python
- Modeling and simulating

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Erlangen Centre for Astroparticle Physics

Master Thesis

SST-II feasibility study

The construction of the next generation gamma-ray observatory CTAO has already begun at both sites. Intensity interferometry has been implemented at all predecessors of this observatory and there are already implementations for testing II underway (in different stages) for the large- and medium-sized telescopes. Both sites of CTAO will have several small-sized telescopes (SSTs) at varying baselines, making them an interesting opportunity for high density coverage of the uv-plane of a target, specifically allowing high resolution power for asymmetrical aspects.
This project will investigate the feasibility of creating a minimally invasive modification to SSTs that allows them to operate in II mode and create projections of the scientific potential if implemented.

Physics topics related to this work:

- Intensity Interferometry in astronomy
- Stellar physics
- Gamma-ray astronomy

Skills acquired during this work:

- Instrument design
- Modeling and simulating

Interested? Please get in touch:

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Erlangen Centre for Astroparticle Physics

Bachelor/Master Thesis

Upgrades to and potential stellar diameter measurements with the ECAP Intensity Interferometer

Since 2024, ECAP has successfully performed intensity interferometry observations on the roof. The two self-made telescopes each consist of a light-weight 1m diameter plastic Fresnel lens, which enables interferometric measurements of the brightest targets in the northern sky. Due to the small size of the telescopes as well as other qualities, the list of potential targets is fairly short. Developing and implementing improvements to the optical filter behaviour, data acquisition electronics or analysis pipeline could open up fainter targets for observation and solidify the instrument as a testbed for detectors. Another upgrade avenue lies in increasing the amount of telescopes by designing and constructing them for additional Fresnel lenses.
Stellar angular diameter measurements are weather-dependent. A suitable target for a Bachelor student would be a bright single star (such as Vega), while a Master student could focus on a binary system (e.g. Capella), requiring more measurement time and advanced data analysis.

Physics topics related to this work:

- Intensity Interferometry in astronomy
- Stellar physics
- Fresnel lenses

Skills acquired during this work:

- Hands-on work with Photo-multipliers, telescopes and their operation
- Statistical analysis of data
- Python programming

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Erlangen Centre for Astroparticle Physics

Bachelor Thesis

Online correlation system

Intensity Interferometry at good time resolution always runs into a storage problem: if the digitizer cards used sample the detectors' photocurrent at GHz rates, multiple GBs of data are produced per second of observation time. While this is still manageable at current rates used at H.E.S.S. or the ECAP Intensity Interferometer, storing the raw data should not be necessary and is not done at several other intensity interferometers. Storing only the correlation data on the other hand is trivial in both writing speed as well as storage capacity.
Developing a reliable online correlation system could relax the requirements to storage hardware and with it the cost of operation and expansion of already established intensity interferometers as well as construction of or implementation at future instruments.

Physics topics related to this work:

- Intensity Interferometry in astronomy
- Data acquisition and analysis

Skills acquired during this work:

- Statistical analysis of data
- Efficient data reduction
- Programming

Interested? Please get in touch:

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