Bachelor / Master theses

2024

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. While standard amplitude interferometry measures the first order correlation - each photon interferes with itself - 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 inteferometry 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 and has already performed measurements of star diameters. We are now looking to improve this experimental setup, our data analysis and modelling of II targets.

Master's theses

- Simulation of binary star systems for Intensity Interferometry measurements
- Off-axis response of Fresnel lens telescopes and suitability for air shower observations

Possible supervisors for projects in this group:

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- Alison Mitchell, alison.mw.mitchell@fau.de, office 02.038
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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:

- Alison Mitchell, alison.mw.mitchell@fau.de, office 02.038
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Master Thesis

Off-axis response of Fresnel lens telescopes and suitability for air shower observations

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

Interested? Please get in touch:

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