

Bachelor/Master Theses

Winter 2021

Astro Quantum Optics (AQO) is about revealing the geometrical secrets of stars and other astronomical objects coded in their photon stream. Astronomical intensity interferometers detect coincident photons (“bunching”) of such thermal light sources at spatially separated telescopes. The coincidence rate depends on the source’s angular size and the baseline distance between the detectors allowing for reconstructing the object’s size and geometry. The advantage in contrast to amplitude interferometers is the insensitivity against atmospheric turbulences which enables kilometer-baselines offering a never before achieved resolution of the cosmic sources. Arrays of Cherenkov telescopes such as **H.E.S.S.** or the future **CTA** provide a suitable environment for astro quantum optics, a test of ECAP’s AQO setup is planned to be operated at H.E.S.S. in the near future.

Characterization and modeling of Photomultiplier Tube signals

The ECAP AQO setup will use Photomultiplier Tubes (PMTs) for photo detection. A decent understanding of the PMT behaviour in terms of quantum efficiency, gain and single-photon response is crucial in order to understand the measured PMT signals and - even more important - the measured correlation between the telescopes quantitatively. Therefore the different PMTs need to be characterized in the lab, the single-photon signal pulse shape and the different pulse height distributions are of special interest here. This can be done using easy-to-operate light sources such as LEDs. Further a fitting model describing the obtained pulse height distributions can be found, which can help to improve the understanding of the measurements and enables ultra-realistic simulations of photon signals.

Physics topics related to this work:

- Intensity interferometry in astronomy (Astro Quantum Optics)
- Photomultiplier Tubes and photo detection electronics

Skills acquired during this work:

- Systematic experimental work
- Statistical analysis of data, programming

Interested? Please get in touch:

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Intensity correlation measurements in preparation for H.E.S.S.

The observable in Astro Quantum Optics is the photon correlation between different telescopes. These correlations will be measured at at least two of the HESS-1 telescopes. In preparation for that the setup needs to be tested in the lab by measuring the photon bunching of thermal light sources such as a Xenon lamp and analyzing it quantitatively. One challenge is the synchronization of two data taking computers with (sub-)nanosecond accuracy using an optical fiber synchronization system (“White Rabbit”). At H.E.S.S. the photo-detectors will be placed on a separate optical setup which remote controls the precise position and alignment of the PMTs in the focal plane. This setup is also developed at ECAP, tests with that need to be executed as well in order to evaluate its functionality.

Physics topics related to this work:

- Intensity interferometry in astronomy (Astro Quantum Optics)
- Optics of Cherenkov telescopes
- Photo-detectors (PMTs)

Skills acquired during this work:

- Learn hardware design, systematic experimental work
- Statistical analysis of data, programming

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