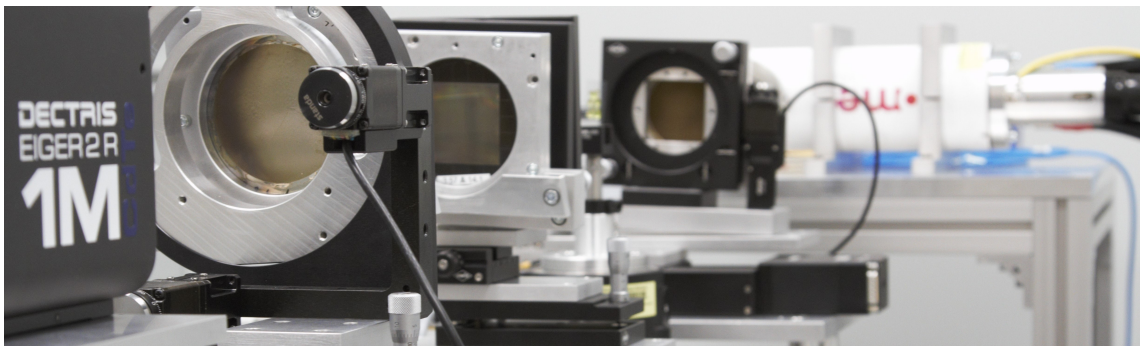
Master's Thesis

Spring 202

LA+PCI
Laboratory astrophysics
& Phase contrast imaging

Grating-based phase-contrast X-ray imaging enhances conventional X-ray imaging by providing two additional image modalities: the differential phase contrast (DPC) image and the dark-field (DF) image. Using a Talbot-Lau interferometer, the DPC image captures the phase shift of X-rays as they pass through a material, offering high sensitivity to small density variations. The DF image, generated by small-angle scattering at microscopic fibers or granular structures, highlights inhomogeneities, air pockets, providing a more comprehensive view of the sample's internal structure.



Enhancement of a Dark-Field Breast-CT imaging setup: Comparative Analysis and Design of an Advanced Version

This thesis aims to tackle a pressing health challenge in modern hospitals: the high reoperation rate for Ductal Carcinoma in Situ (DCIS), the most prevalent form of breast cancer. The project focuses on enhancing grating-based phase contrast computed tomography as a diagnostic tool to complement mammography.

In this work, you will utilize an existing dark-field CT system to acquire and analyze data from various samples, benchmarking the performance of the current setup. Additionally, with our guidance, you will design a novel imaging setup aimed at reducing radiation dose and improving image quality.

What you can expect:

- A mix of lab work, Simulation and Data analysis
- Conceptualization and implementation of simulated setups and samples
- Data evaluation with Python & Digital image processing
- X-ray physics

Interested? Please get in Touch:

- Constantin Rauch, constantin.rauch@fau.de
  Markus Schneider, markus.ms.schneider@fau.de
  Stephan Schreiner, ste.schreiner@fau.de
  Büro 02.035, Nikolaus-Fiebiger Str. 2
- Prof. Dr. Stefan Funk, s.funk@fau.de
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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Bachelorarbeit

Frühjahr 2025

LA+PCI
Laboratory astrophysics
& Phase contrast imaging

Durch die gitterbasierte Phasenkontrast-Röntgenbildgebung können neben dem herkömmlichen Absorptionsbild zwei weitere Bildmodalitäten rekonstruiert werden: Das differentielle Phasenbild und das Dunkelfeldbild. Dafür wird ein Talbot-Lau-Interferometer verwendet. Das differentialle Phasenbild basiert auf den Phasenschub, den Röntgenstrahlung beim Durchdringen von Material erfährt. Somit können kleine Dichteunterschiede, im Verleich zum herkömmlichen Absorptionsbild, besser detektiert werden. Das Dunkelfeldbild entsteht durch Kleinwinkelstreuungen an mikrometergroßen Fasern oder granularen Strukturen. Durch das Dunkelfeldbild können beispielsweise Inhomogenitäten, Lufteinschlüsse oder Defekte im Material festgestellt werden.

Untersuchung von Proben mittels eines Zwei-Zeilen-Scanners

In unserer Arbeitsgruppe wird zur Zeit ein Zwei-Zeilen-Röntgenscanner entwickelt, welcher eine quantitative Strukturgrößenanalyse ermöglicht. Dieser Scanner kann für die zerstörungsfreie Materialprüfung verwendet werden, um Inhomogenitäten und Defekte in Materialien feststellen zu können. In dieser Arbeit sollen verschiedene Proben mittels des Zwei-Zeilen-Scanners untersucht werden, um Unregelmäßigkeiten in diesen zu detektieren.

Was dich erwartet:

- Laborarbeit
- Datenauswertung mit Python
- Röntgenphysik und Detektoren
- Digitale Bildverarbeitung (Python/Matlab)

Interesse? Bitte eine kurze Mail an:

- Markus Schneider, markus.ms.schneider@fau.de
  Constantin Rauch, constantin.rauch@fau.de
  Stephan Schreiner, ste.schreiner@fau.de
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ECAP
ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

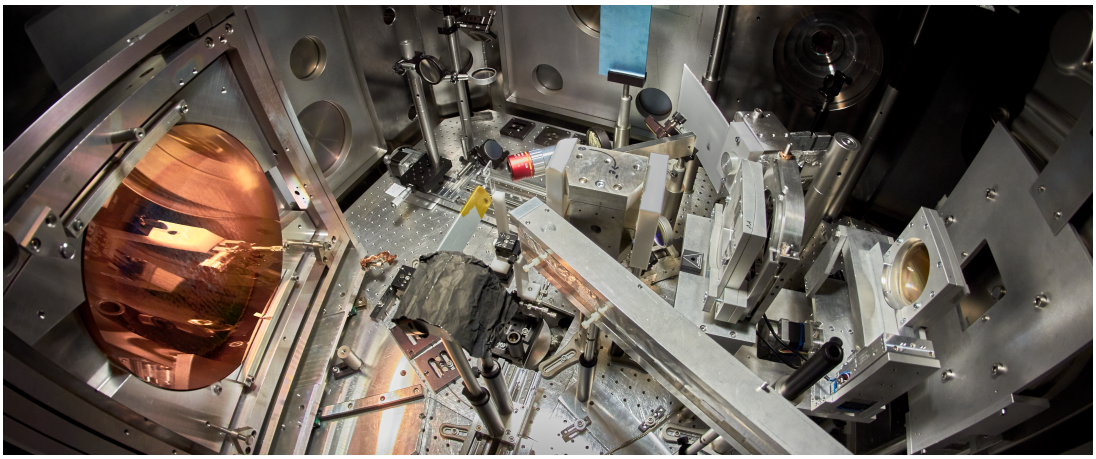
Master's Thesis

Spring 2025

LA+PCI

Laboratory astrophysics
& Phase contrast imaging

The aim of **laboratory astrophysics** is to prepare, control and investigate systems which behave similar to those of astrophysical origin. One example of such laboratory experiments is the production of laser-induced shock fronts and the **imaging and reconstruction** of the resulting **density distribution** with **X-ray phase-contrast imaging**.



Data analysis of High-energy-density pump-probe experiments

We are working on the devolepment of **experimental imaging setups** and image reconstruction. The developed tools are emlployed at large-scale research facilities, see image above. One crucial part is the evaluation of taken data and comparison with simulated data to retrieve new high-energy-density physics.

What you can expect:

- A mix of Simulation and Data analysis
- Conceptualization and implementation of simulated setups and samples
- Data evaluation with Python
- X-ray physics
- Digital image processing

Interested? Please get in Touch:

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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Bachelor's Thesis

Spring 2025

LA+PCI

Laboratory astrophysics
& Phase contrast imaging

The aim of **laboratory astrophysics** is to prepare, control and investigate systems which behave similar to those of astrophysical origin. One example of such laboratory experiments is the production of laser-induced shock fronts and the **imaging and reconstruction** of the resulting **density distribution** with **X-ray phase-contrast imaging**.

Data analysis of EMP measurements from High-energy-density Experiments

We are working on the development of **experimental imaging setups** and image reconstruction at large laser facilities, see image above (PHELIX @ Darmstadt). One crucial part is the usage of digital detectors. However, due to strong EMPS, this is not straight forward. To evaluate the strength and effectiveness of our setup, a good and reliable EMP-probe is necessary. One task will be the characterization of these probes and evaluate already acquired data.

What you can expect:

- Data evaluation with Python
- Digital image processing

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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Master's Thesis

Winter 2025

LA+PCI
Laboratory astrophysics
& Phase contrast imaging

Grating-based X-ray imaging, also called X-ray Talbot-(Lau) imaging, adds two further images to the conventional attenuation image: The differential phase-contrast and the dark-field image. For that purpose a Talbot-Lau interferometer is used. The contrast in the differential phase image is based on the diffraction of X-rays by an object. Small density variations are better detectable, in particular for light materials (C, H, O). The dark-field image covers signals generated by small angle scattering off micrometer sized fibers or granular structures. Therefore, it is sensitive to material transitions, as they occur for cracks, air inclusions or structural defects for example.

Dark-field simulations for a novel dual energy interferometer

We are currently designing and implementing a novel dual interferometer setup for nondestructive testing. As a part of this project, this thesis aims to implement and optionally verify simulations close to reality using a wave field simulation framework developed in house.

A variety of objects are first modelled and then the resulting images for both interferomters are simulated. In this way, the final parameters of the interferometers are verified and tested for their suitability before the actual setup is assembled.

What you can expect:

- Mainly Simulation work, some Laboratory work and Data analysis
- Conceptualisation and implementation of simulated setups and samples
- Simulation framework implemented in Python and C++ (C++ knowledge not necessary)
- Conceptualisation and implementation of experimental setups for simulation verification
- X-ray physics
- Digital image processing (Python/Matlab)

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ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

Bachelor & Master theses

Summer/Autumn 2024

LA+PCI
Laboratory astrophysics
& Phase contrast imaging

The aim of **laboratory astrophysics** is to prepare, control and investigate systems which behave similar to those of astrophysical origin. One example of such laboratory experiments is the production of laser-induced shock fronts and the **imaging and reconstruction** of the resulting **density distribution** with **X-ray phase-contrast imaging**.

We are working on the devolepment of **experimental imaging setups** and image reconstruction. The developed tools are emlployed at large-scale research facilities.

We offer the following **Bachelor** theses:

- Untersuchung von Proben mittels eines Zwei-Zeilen-Scanners
- Evaluating EMP measurements from High-energy-density Experiments

Master theses:

- Enhancement of a Dark-Field Breast-CT imaging setup:
  Comparative Analysis and Design of an Advanced Version
- Data evaluation of High-energy-density pump-probe experiments
- Dark-field simulations for a novel dual energy interferometer

Interested? For more details on the topics feel free to simply drop in the office or get in touch via mail that we can arrange a personal (Zoom) Meeting.

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