MEXANE – Open modeling pipelines to Make Extreme Astrophysical Events NICER

OSCARS
Open Science Clusters' Action for Research & Society

The MEXANE project will develop an Open Science service for modeling X-ray data from compact astrophysical objects, leveraging AI to enhance scientific inference. MEXANE will create a FAIR-compliant pipeline – to be released on Zenodo – that integrates Physics-Informed Neural Networks (PINNs), MCMC methods and genetic algorithms to solve physical equations in real time while simultaneously fitting observational data.

ESCAPE
Astronomy, Nuclear and Particle Physics

Challenge

Main RI-concerned X-ray missions, such as NICER, generate rich datasets critical to understanding the physics of neutron stars and black holes. But current modeling tools are fragmented, computationally demanding and often inaccessible to researchers without HPC resources. Also, the integration of real-time data fitting with physically consistent modeling remains unexplored.

Solution

MEXANE will develop a next-generation modeling framework that combines machine learning with physical simulation. By using PINNs to solve nonlinear equations describing compact object environments and coupling them with inference tools such as MCMC and genetic algorithms, the pipeline will enable dynamic modeling of NICER observations.

Scientific Impact

The MEXANE pipeline will reduce the computational barriers to modeling high-energy astrophysical data, democratising access to sophisticated analysis tools. Its methodology is directly applicable to multi-messenger astrophysics, while the AI framework has cross-domain relevance in fields, such as hydrodynamics and aerospace engineering.

Partners

Research Center for Astronomy and Applied Mathematics of the Academy of Athens - RCAAM Academy of Athens

https://oscars-project.eu/projects/mexane-open-modeling-pipelines-make-extreme-astrophysical-events-nicer