Contribution ID: **114** Type: **Talk (15min + 5min)**

Fast GPU-powered and auto-differentiable forward modeling for cosmological hydrodynamical simulations

Wednesday 26 February 2025 14:00 (20 minutes)

In the field of extragalactic astronomy we have typical two groups: The observers and the theorists. The nature of the data these two groups work with is very different: Observers count photons with the instrument detectors and theorists work with particles that have specific physical properties. This results in a rather small scientific exchange between both groups.
Generally, there are two ways to bring observational data and simulation data closer together to allow a direct comparison between them: Forward modeling and inverse modeling.
Forward modeling calculates what should be observed for a particular model. The forward model takes certain parameters and produces data that are comparable to actual observations. Here, we present RUBIX, a novel python framework that aims at bridging the gap between observation and modeling. RUBIX leverages modern GPU computing via the JAX ecosystem to implement forward modeling of the observation process in a telescope. It is a fully-tested, well documented, and modular Open Source tool developed in JAX, designed to forward model IFU cubes of galaxies from cosmological hydrodynamical simulations. We aim to establish RUBIX as a widely used community tool in astronomy. Because of modular and flexible software design, RUBIX also has potential applications outside of astronomy and thus can become a valuable research tool for a wide community. The software is designed in a linear pipeline structure that takes pure jax functions. The code automatically parallelizes computations across multiple GPUs, reducing computation time from many hours in common for state-of-the-art CPU computing frameworks to seconds.
Inverse modeling is the process of starting with the result - the observational data - and calculating the causal factors that produce these data, which means constructing a model that accounts for the given set of observations. In the future, RUBIX will also allow for inverse modeling of observational data of galaxies. To this end, it leverages the sophisticated features of the JAX ecosystem and implements a pipeline structure that naturally supports differentiability of the computations.
In this way, RUBIX aims at supporting the entire modeling spectrum that contemporary extragalactic astronomy demands. Our proposed contribution consists of a talk with a twofold focus: First, we will present the RUBIX project, its inherent challenges and the techniques we employ to overcome them on a technical level. Second and of equal importance, we will discuss the experiences and lessons learned in the journey from being a PhD student with no prior experience in research software engineering to developing an innovative open-source scientific software project that uses cutting edge technologies.

I want to participate in the youngRSE prize

yes

Primary author: SCHAIBLE, Anna Lena (Heidelberg University)

Co-author: MACK, Harald (Interdisciplinary Center of scientific computing, Heidelberg University)

Presenter: SCHAIBLE, Anna Lena (Heidelberg University)

Session Classification: Research Software Engineering in HPC

Track Classification: Research Software: high-performance computing (HPC)