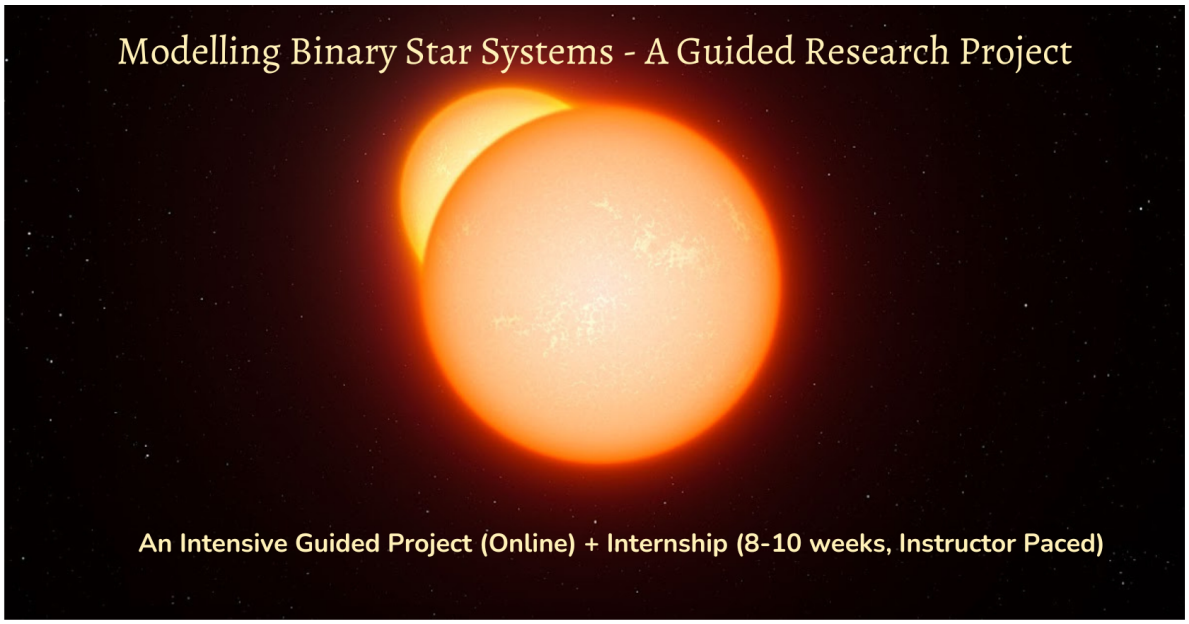
NAXXATRA
A CONSTELLATION OF CURIOUS MINDS

Modelling Binary Star Systems

An Intensive Guided Project (Online) + Internship (8-10 weeks, Instructor Paced)



What is a Naxxatra Guided Project?

1. Connects you with an active community of researchers and a panel of experts who guide you through a s**tructured project with weekly goals and a highly engaging curriculum.**
2. Undergraduate students and above are welcome to register. This is an intermediate-level program, meaning that the p**articipants need to put in 10-15 hours a week** to complete the intended curriculum. The content assumes a few basic prerequisites that most first year undergraduates will have the knowledge of. However, the project is **suitable even for masters-level students** to get hands-on experience and start a career in Observational or Data Driven Astrophysics.
3. A majority of the program will **consist of hands-on activities and tasks, which the students are expected to complete on time.** Students will be provided with mentoring sessions, continuous support and access to resources.
4. The program is a combination of **technical lectures, discussions and activity sessions, presentations by the participants, and an introduction to research writing** with LaTeX.

Why take the “Modeling Binary System” binary project?

1. The program is designed to introduce the core concepts essential to pursue advanced subjects in Astrophysics. An ideal starting point for a career in Astrophysics!
2. The program focuses on the field of Observational and Data-Driven Astrophysics, providing an in-depth understanding of the commonly used techniques and tools in research.
3. A complete toolkit for a student to kick off an active journey in exploring the subject while being able to experience basic research methodologies through a practical approach. Figure out your strengths and weaknesses, and analyze if research is something you truly enjoy. Get mentorship to make future decisions about your career in science.
4. A dynamic ecosystem of people to work with, and the opportunity to connect with peers from across the country from diverse backgrounds and institutions.
5. The program offers lifetime access to our bundle of resources, lectures, and slides.

Project Overview

- Estimation of the orbital period using Period04
- Radial velocity estimation using Gaussian Fitting (python)
- Modeling a Binary System using Phoebe (real-world data: modeling, to estimate stellar and orbital parameters)

- Binary evolution using MESA (simulation: theoretical evolution software)

WEEKLY BREAKDOWN

Week 1 - A quick tour of Python - Students are expected to revise the fundamental concepts in Python and solve problems that cover important libraries

- Matplotlib (Making graphs and visualization)
- Numpy (For numerical analysis and statistical functions)
- Pandas (Analyzing data)
- Scipy (for curve fitting)

Week 2 - Estimation of the orbital period using period04

- What is Period 04? - Period04 is a computer program especially dedicated to the statistical analysis of large astronomical time series containing gaps. The program offers tools to extract the individual frequencies from the multi periodic content of time series and provides a flexible interface to perform multiple-frequency fits.
- Installation of period 04
- Understanding the UI and playing with sample data.
- Estimating the orbital period of a binary star system using the data given.

Week 3 - Radial velocity estimation using Gaussian Fitting

- Implementing radial velocity method using Python
- Hands-on exercises to understand the radial velocity method in-depth.

Week 4 - Modeling a Binary System using PHOEBE

- What is PHOEBE? PHOEBE is an eclipsing binary modeling code - reproducing and fitting light curves, radial velocity curves, and spectral line profiles of eclipsing systems.
- Installation of Phoebe software and understanding its UI.
- Getting the real world data and making it usable.
- Estimate the stellar and orbital parameters.
- Model the binary star using the parameters.

Week 5 - Binary evolution using MESA (simulation: theoretical evolution software)

We will explore the MESA software and model Binary evolution in particular. Stellar evolution calculations (i.e., stellar evolution tracks and detailed information about the evolution of internal

and global properties) are a basic tool that enable a broad range of research in astrophysics. Areas that critically depend on high-fidelity and modern stellar evolution include asteroseismology, nuclear astrophysics, stellar populations, chemical evolution and population synthesis, astrobiology, binary stars, variable stars, supernovae, novae, compact objects, tidal disruption events, stellar hydrodynamics, and stellar activity.

Learning Outcomes

a. Concise Introduction to all the important concepts in Binary stars. Understanding how to use important softwares like Period 04, Phoebe, MESA.
b. Mathematical Rigor as seen in actual astrophysical research problems.
c. Concise Introduction to Coding in Python.
d. Hands-On experience in handling data and performing analysis techniques.
e. Get trained in accessing datasets, regression, curve-fitting, and visualization.

Submit your own report

- Join a team of like-minded peers or work independently
- Get continued mentorship and guidance throughout the guided-project.
- Get access to our “research- writing with LaTeX” course for free. Write a report using LaTeX software.
- Submit your report as well as get a chance to present your work in front of a panel of scientists and researchers.