Contributed Talk

Applying Recurrence Methods to Classify Binary Stars

Anisha Kashyap[1], G. Ambika[2], Ranjeev Misra[1], Sandip George[3] and Devraj Pawar[4]

[1]*Inter-University Centre for Astronomy & Astrophysics, Pune, India*
[2]*Indian Institute of Science Education and Research, Thiruvananthapuram, India*
[3]*University of Aberdeenm, King's College, Aberdeen*
[4]*R. J. College, Ghatkopar, Mumbai, India*

Some of the binary stars are in compact orbits as a result of which they can exchange mass due to stellar wind or Roche lobe overflow. The compact binaries are further classified as Semi-detached, Overcontact and Ellipsoidal systems. In case the stars in the binary system are aligned along the line of sight with the earth, then they eclipse each other eventually leading to variability in the light curve of the system. Analysis of these light curves has indicated that they are nonlinear and chaotic [1]. The interaction between stars in each category of eclipsing binaries results in distinct complex dynamics, which can serve as a valuable tool for classification. To investigate this, we utilized recurrence plots and recurrence networks to visualize the 'recurrences' of the states of these dynamical systems [2]. This approach effectively captures the essential features of their dynamics, allowing us to distinguish between the different types of eclipsing binaries based on their unique recurrence patterns [3]. In this work, we employ recurrence quantification analysis applied to a phase space constructed from the light curves as an efficient tool for classification of the binary systems into their sub-classes like semi-detached, over contact and ellipsoidal binaries. We initially use data from Kepler exoplanet exploratory mission as it has observed the same region of the sky for around four years hence providing a rich data set of long term lightcurves for thousands of stars many of which are binary systems. Moreover this dataset has further increased in volume with similar campaigns where traditional methods of identifying and classifying binary systems can be computationally costly. Hence we aim to develop a classification based on nonlinear analysis of lightcurves. To apply this classification scheme to large data sets we plan to identify parameters which can be inputs to machine learning algorithms.

References

[1] Sandip V George, Ranjeev Misra, and G Ambika. Fractal measures and nonlinear dynamics of overcontact binaries. Communications in Nonlinear Science and Numerical Simulation, 80:104988, 2020.

[2] Jean-Pierre Eckmann, S Oliffson Kamphorst, David Ruelle, et al. Recurrence plots of dynamical systems. World Scientific Series on Nonlinear Science Series A, 16:441–446, 1995.

[3] G Ambika and KP Harikrishnan. Methods of nonlinear time series analysis and applications: A review. Dynamics and Control of Energy Systems, pages 9–27, 2020.