Time-domain studies of compact binaries

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Background

Cataclysmic variables (CVs) are semi-detached compact binaries consisting of a white dwarf (WD) and a low-mass main-sequence star – usually a red-dwarf (Warner, 1995). The close proximity of the two stars allows matter (gas) to be transferred from the red dwarf to the WD via a Roche lobe overflow. CVs offer astronomers a laboratory to study a wide range of phenomenon including the physics of accretion onto compact objects such as WDs, the formation and evolution of close binaries. Their rapid variability on a variety of time scales (e.g. from a few seconds to decades) allow us to study and understand their long and short time scales variabilities which are directly linked to the variation in mass transfer from the companion star to the WD. CVs are classified according to a wide range of properties including outbursts, photometric and spectroscopic properties, and sometimes CVs are divided into two groups, magnetic CVs and non-magnetic CVs. The non-magnetic CVs group includes dwarf novae (DNe) and nova-likes and these are generally disc-dominated systems which shows a wide range of behaviour such as dwarf nova outbursts, superoutbursts, standstills and super-humps. The magnetic CVs (mCVs) are divided into polars (Tapia, 1977) and the intermediate polars (IPs; Patterson 1994). The classification into polars and IPs is based on the magnetic field strength of the WD amongst others properties. For example, the WD in polars have strong magnetic fields ranging $7-230$ MG (see e.g. Wickramasinghe & Ferrario, 2000) – which prevent the formation of an accretion disc, and the WD and the companion star in polars are locked together in synchronous rotation (Frank et al., 1992). The field strength of the WD in IPs range from 1 to 10 MG (e.g. BG CMi, Chanmugam et al. 1990) – and is strong enough to disrupt and/or truncate the inner part of the accretion disc which is formed around the WD. One of the defining characteristics of IPs is that their WDs rotate rapidly and their spin period is always less than or a fraction of the binary's orbital period. For CVs which contain an accretion disc, e.g. dwarf novae and nova-likes, understanding the physics of accretion disc in these systems on short time scales directly gives us clues to understanding other astronomical objects with accretion discs such as active galactic nuclei and tidal disruption events. On the other hand, CVs with strong magnetic fields, such as polars and IPs, allow us to study the effects of magnetic fields on accreting WDs and also the physics of accretion onto these systems.

Project outline

In this project, student(s) will engage in the comprehensive reduction and analysis of spectroscopic, photometric, and polarimetric observations of selected magnetic CVs, utilizing data collected from the South African Large Telescope (SALT) and the 1.9-m and 1.0-m telescopes at the South African Astronomical Observatory (SAAO). This project involves the analysis of phase-resolved spectra, facilitating the creation of Doppler tomography maps. This process is crucial for delineating the diverse emission regions within the magnetic CVs, offering insights into their complex astrophysical processes. In addition, the student(s) will conduct an in-depth time-series analysis of a sample of mCVs to scrutinize the dynamic nature of these systems.

Requirements

Python coding and a good knowledge of the Linux environment. Attended the ACB MSc course.

References

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