2022 MSc Project

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Student may register at any South African university

Exploring the properties of the known CV sample using astrometric, variability, and multi-wavelength all-sky surveys

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Cataclysmic variable stars (CVs) are amongst the most dramatically variable objects in the sky. This variability fueled early interest in CVs, starting with observers in ancient times. Today CVs are known to be close binary stars in which a white dwarf accretes material from a main sequence star. They remain of interest as accretion laboratories, and because they make up important Galactic transient and X-ray source populations.

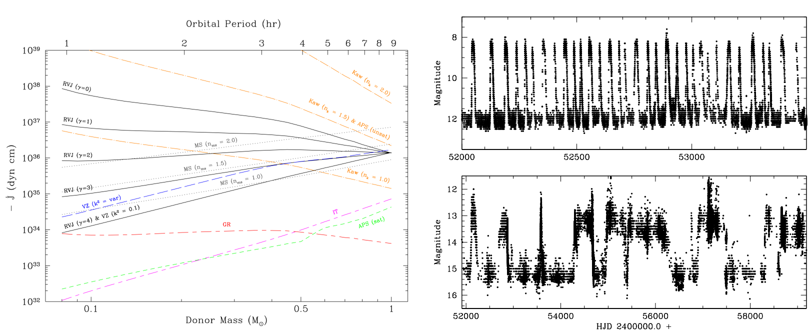
It has historically been impossible to estimate accurate and precise distances for more than a handful of CVs. The *Gaia* mission has completely changed this situation, solving one of the toughest problems we have faced in studies of the CV population. At the same time, decades-long light curves are now available from several variability surveys, including ATLAS and ASAS-SN. A wealth of multi-wavelength all-sky surveys have also provided single-epoch flux measurements across the electromagnetic spectrum. Putting together these data for the thousands of reasonably well-studied CVs will produce an extremely rich dataset, that can be used for several interesting investigations, an obvious example being to find mass transfer rates.

The evolution of CVs have wide consequences in astrophysics, being relevant e.g. to the origin of type Ia SNe, the chemical evolution of galaxies, and the dynamics of globular clusters. The most important ingredient of CV evolution models is the angular momentum loss rate at different times — rates spanning many orders of magnitude have been used in different models, as shown in the figure below. This is not directly measurable, but can be approximated via the mass transfer rate ($\dot{M}$), which in turn can be derived from an average absolute magnitude. Distances from *Gaia* together with light curves from wide-field variability surveys mean that we can obtain long-term average absolute magnitudes of thousands of CVs. Using this information, we can derive $\dot{M}$ as a function of orbital period (P_{orb}). This should provide a key observational constraint on CV evolution theory. In addition, scatter in $\dot{M}$ vs P_{orb} may alert us to variations on time scales that are too long to be covered by the observational baseline, or to individually interesting outlier systems.

Project goals This project will use existing data. You will start with a catalogue of known CVs, correlate this with *Gaia* to find distances, and obtain light curves from variability surveys. Average apparent magnitudes from these light curves, together with the distances, will allow you to estimate $\dot{M}$ and hence the angular momentum loss rate. The huge range of angular momentum prescriptions that have been proposed (as shown on the left in the figure) can then be confronted with reality.

Depending on your interests, you may also use single-epoch flux measurements at different wavelengths, together with machine learning techniques, to hunt for multivariate correlations in the extremely rich dataset you will have constructed.

Skills Basic programming skills and good knowledge of undergraduate physics or astrophysics are required.



Left hand panel: Angular momentum loss rates used by different evolution models. Note the huge range spanned by the vertical scale.
Right hand panels: Optical light curves of a dwarf nova covering 1500 days (top) and a NL covering 20 years (bottom).