# Abstract

Compact objects -- white dwarfs, neutron stars and black holes -- are the brightest lighthouses in the cosmos serving as a navigational aid for astronomers on their journey to understand the depths of the Universe. In this thesis, we investigate the origins of the various variability features observed in accretion discs and shells present around the compact objects. For this, we adapt analytic, semi-analytical and general relativistic magnetohydrodynamical (GRMHD) simulations approaches, based on what best suits the problem.

In Paper I, we explore the disc-instability outbursts in two Symbiotic star (SS) systems, RS Oph and Z And, which have white dwarfs as the accreting object. Using a one dimensional (1D) semi-analytic code, we study the thermal and viscous evolution of large size, standard thin discs present in these systems. Our findings suggest that (i) The disc-instability outbursts could trigger the recurrent novae observed in these systems, thereby causing the short recurrence time scales observed in these systems (ii) The 'combination nova' mechanism proposed for the observed outbursts in Z And can be ruled out and instead the mass-transfer enhancement from the secondary could be the key.

In Paper II and Paper III, we perform a purely analytical study of the radial oscillations of levitating atmospheres around near-Eddington luminous neutron stars, with possible relevance to the burst oscillations observed during the Type-I X-ray bursts. In these two papers, we found that (i) the eigenfrequencies of these oscillations typically lie within 300--600 Hz, i.e., the observed range of burst oscillation frequencies; (ii) radiation drag introduces a characteristic frequency maximum through damping of oscillations, which plays a vital role in determining the stellar parameters; (iii) given the luminosity and the flux observations, we can estimate the mass and radius of the neutron star to within a few percent accuracy and determine the distance to the source to less than one percent error. The errors are remarkably small, compared to the estimates from any other currently available methods and therefore can potentially put better constraints on the equation of state.

In Paper IV, we use GRMHD simulations to investigate the aperiodic variability observed in the black hole binaries over a wide range of time scales -- a few milliseconds to seconds. Theoretical models explain this variability as the inward propagating fluctuations of mass accretion rate on viscous timescales, although confirmations from the numerical simulations of magnetized accretion flows are required for a better understanding of the underlying variability process. Using a set of five exceptionally long GRMHD simulations of geometrically thick, optically thin, black hole accretion flows as test-beds, we show evidence for the inward propagating fluctuations in these simulations by establishing strong radial coherence and reproducing the other observed variability features -- linear rms-flux relation, lognormal distribution of flux, and frequency-dependent time lags between different energy bands.