CHRIST
(DEEMED TO BE UNIVERSITY)
BANGALORE · INDIA

Notice for the PhD Viva-Voce Examination

Ms Sneha Prakash M (Registration Number: 1840074), PhD scholar at the School of Sciences, CHRIST (Deemed to be University), Bangalore will defend her PhD thesis at the public viva-voce examination on Thursday, 26 September 2024 at 10.00 am in Room No. 044, Ground Floor, R & D Block, CHRIST (Deemed to be University), Bengaluru - 560029.

Title of the Thesis	:	**Spectral and Timing Properties of Selected Black Hole Binaries**
Discipline	:	**Physics**
External Examiner (Outside Karnataka)	:	**Dr Mariano Méndez** Professor Faculty of Science and Engineering Kapteyn Astronomical Institute University of Groningen P.O. Box 800, 9700 A V Groningen The Netherlands
External Examiner (Within Karnataka)	:	**Dr Sudip Bhattacharyya** Professor Department of Astronomy and Astrophysics Tata Institute of Fundamental Research Homi Bhabha Road Colaba, Mumbai – 400005 Maharashtra
Supervisor	:	**Dr Shivappa B Gudennavar** Professor Department of Physics and Electronics School of Sciences CHRIST (Deemed to be University) Bengaluru - 560029 Karnataka

The members of the Research Advisory Committee of the Scholar, the faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva-voce examination.

Registrar

Place: Bengaluru
Date: 18 September 2024

ABSTRACT

X-ray binaries hosting a black hole (accretor) and a main sequence or a post-main sequence star (companion star) are called black hole X-ray binaries (BHXBs). BHXBs are gravitationally bound systems where the matter from the companion star is accreted onto the accretor either via a Roche lobe overflow (low-mass companion star) or stellar wind (high-mass companion star). The accreted matter spirals towards the accretor, losing its angular momentum in the process. The gravitational potential energy of the in-falling matter is converted to kinetic energy which is eventually released as X-rays X-ray spectrum of BHXB is quite complex by nature, which is contributed by various X-ray production processes. Systematic and comprehensive investigations of the X-ray production mechanisms are essential for understanding the fundamentals of accretion physics and exploring the general relativistic effects in extreme gravity environments. Launch of several dedicated X-ray missions like Uhuru, Ginga, RXTE, Chandra, XMM-Newton, NuSTAR, Swift, etc. for over half a century have led to the discovery, classification and fair understanding of spectro-temporal properties of BHXBs. Despite the continuous and ongoing efforts, the physics of the accretion mechanism in BHXBs, accretion disk geometry, the origin of quasi periodic oscillations (QPOs), energy-dependent time lags and coherence of X-ray photons in different energies, etc. are yet to be completely understood. Hence, there is a need for revisiting these problems using the data from more sensitive instruments, that have broadband energy coverage and have better spectral and timing resolutions than RXTE. Thus, data from the latest missions like AstroSat, Swift, NuSTAR with their broadband energy coverage, especially in the lower energy regime ($\geq$ 3.0 keV), and larger effective area can help fill in the gap in the existing body of knowledge and provide a holistic understanding of these sources.

The present study makes complete use of the unprecedented spectro-temporal capabilities of two of the three X-ray instruments aboard AstroSat, India's first astronomical satellite. The instruments- Soft X-ray telescope (SXT) and Large Area X-ray Proportional Counters (LAXPC) provide broadband and nearly simultaneous spectral coverage from soft X-rays (0.3 – 8.0 keV) to hard X-rays (3.0 – 80.0 keV), respectively. The 10 μs timing capability of LAXPC enables us to examine time lags and energy-dependent root mean square variability in a high energy regime (> 30.0 keV). In addition to this, the availability of simultaneous data of the sources from AstroSat, Swift and NuSTAR is an added advantage as it may provide a better signal-to-noise ratio. This in turn allows one to put a more stringent constraint on accretion disk and black hole parameters. With this in view, in this work, simultaneous broadband spectro-temporal studies on three BHXBs have been carried out predominantly using archival data from AstroSat. One of the three chosen BHXBs is a recently discovered transient source, MAXI J1820+070 whereas, the other others are persistent sources, LMC X-1 and 4U 1957+115. Primarily, the physical properties of the black hole namely the mass accretion rate, black hole spin, and orbital inclination and intrinsic properties of accretion disk such as disk temperature and disk size have been obtained for these chosen BHXBs. The details of the studies are presented in this thesis.

Keywords: High-energy astrophysics, X-ray astronomy, Black hole X-ray binaries, X-ray spectro-timing analysis, AstroSat, NuSTAR, Swift.

Publications:

1. Unveiling the temporal properties of MAXI J1820+070 through AstroSat observations, **S P Mudambi**, B Maqbool, R Misra, Sabhya Hebbar, J S Yadav, S B Gudennavar and S G Bubbly, The Astrophysical Journal Letters, 889(1), L17, 2020.
2. Estimation of the blackhole spin in LMC X-1 using AstroSat, **S P Mudambi**, A Rao, S B Gudennavar, R Misra and S G Bubbly, Monthly Notices of the Royal Astronomical Society, 498(3), 4404, 2020.
3. Spectral characteristics of the black hole binary 4U 1957+115 – A multi-mission perspective, **S P Mudambi**, S B Gudennavar, R Misra and S G Bubbly, Monthly Notices of the Royal Astronomical Society, 517(3), 4489, 2022.