Multi-Wavelength Identification of Galactic X-ray Sources

by

Reuben S. Gazer

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

Department of Physics
University of Alberta

Abstract

We explore the production and observation of high energy (X-ray and ultraviolet/UV) radiation in the context of Galactic, compact binary systems. At the end of the stellar lifecycle, a star collapses into one of three *compact objects* (COs) depending on the mass at the time of collapse: a white dwarf (WD), neutron star (NS) or a black hole (BH). These dense, stellar remnants are often found in close orbits ($a \sim R_{\odot}$) with another star whose atmosphere can flow to the CO, releasing massive amounts of gravitational energy in the process. These systems are known as *X-ray binaries* (XRBs) for the complex interaction of the stellar pair and constituent matter manifests in bright X-ray luminosities of $L_X \sim 10^{32} - 10^{42}$ erg/s making them among the brightest X-ray emitters in the sky. The formation and distribution of XRBs is still not fully understood, in part because a homogeneous sample of Galactic XRBs is not yet available due to selection effects biased towards bright and transient sources. The *Galactic Bulge Survey* (GBS) was designed to identify a large, quiescent population and found 1640 unique X-ray sources in 12 square degrees near the Galactic Plane. Most systems are still unclassified, specifically those in dense optical or infrared (IR) fields where the true source of X-ray emission can be visually ambiguous. We avoid this ambiguity for 269 of 1640 systems by using UV

data from *GALEX* to identify the correct optical/IR counterparts, making use of the low *GALEX* surface density (and high correlation with X-ray sources). We then create and model spectral energy distributions for each system. We identify a new group of $15 - 25$ likely compact binary systems by their excess UV fluxes and classify ~ 150 GBS systems as nearby, chromospherically-active stars. Finally, we discuss our results in the context of the GBS and suggest future research directions.

Preface

All research in this thesis is original work by Reuben Samuel Gazer, under the supervision of Dr. Craig O. Heinke between September 2015 and November 2017 at the University of Alberta. All of the data used is publicly available online.

"I began to realize how important it was to be an enthusiast in life. If you are interested in something, no matter what it is, go at it full speed. Embrace it with both arms, hug it, love it and above all become passionate about it. Lukewarm is no good."

Roald Dahl

Acknowledgements

I would like to thank first and foremost Craig O. Heinke for supervising me during this thesis. Craig is a wonderful teacher, and a selfless, kind human being. I would also like to thank the rest of the University of Alberta astrophysics group with specific thank-yous to Eric Koch, Arash Bahramian and Alex & Bailey Tetarenko for programming and general research aid.