Eighteenth Annual Undergraduate Mini-Symposium

Department of Astronomy and Physics
Saint Mary's University
1:00 pm – 4:30 pm, Friday September 10, 2021
On-line version; to be held on *Zoom* (passcode 476456)

No one submitted an image, so we get our dog, Luna, as a puppy to adorn the front cover!

SAINT MARY'S UNIVERSITY SINCE 1802
One University. One World. Yours.

The Department of Astronomy and Physics

Eighteenth Annual Undergraduate Mini-Symposium

Friday September 10, 2021, 1:00 pm – 4:30 pm

All events happening on *Zoom* (passcode 476456)

Programme

Opening remarks (Clarke)			1:00 – 1:10
1	A. Battson (Henault-Brunet)	*Finding high-velocity stars in globular clusters*	1:10 – 1:30
2	K. Butler (Christian)	*Gamma ray and neutron pulse shape discrimination of the p-Terphenyl scintillator*	1:30 – 1:50
3	G. Desmarais (Christian)	*Understanding nucleosynthesis in novae through indirect measurement of* ^{24}Al	1:50 – 2:10
4	K. Myers (Gallo)	*A look into narrow line Seyfert 1s in the x-ray: motivation and data processing*	2:10 – 2:30
Zoom photo (stay put, cameras on!), then bio break			2:30 – 2:40
5	D. Koranteng (Gallo)	*A look into narrow-line Seyfert 1s in the x-ray: methodology and results*	2:40 – 3:00
6	C. O'Keefe (Kanungo)	*Investigating the excitation spectrum of* ^{8}He *from inelastic scattering with deuterons*	3:00 – 3:20
7	J. Park (Kanungo)	*A search for resonance states of* ^{12}Li	3:20 – 3:40
8	P. Smith (Henault-Brunet)	*Strong constraints on the black hole population of 47 Tuc using pulsar timing*	3:40 – 4:00
Award deliberations/presentations (I. Damjanov and TBA)			4:00 – 4:30

1. *Finding high-velocity stars in globular clusters*

Abigail Battson (Henault-Brunet)

Due to 3-body interactions between stellar binaries and black holes in the core of globular clusters, stars can be shot out at a high velocity uncharacteristic of that of cluster members. By observing and characterising these high-velocity stars, we can probe a cluster's population of black holes, binaries and its central density. In an effort to perform the first systematic search for high-velocity stars from globular clusters, I use proper motions and parallaxes from the Gaia Early Data Release 3 (EDR3) and select a sample of stars around every Milky Way Globular Cluster. This sample is then filtered to include only high-velocity star candidates appearing to originate from the cluster core. The stars which pass these filters still contain non-cluster contaminant stars, so I devised a method to filter out statistically contaminants based on some of the cluster's properties such as its colour-magnitude diagram (CMD), proper motion, and parallax. I present here results for the cluster NGC 5053, which contains a few strong candidate high-velocity stars. One of these stars has a radial velocity measurement associated with it and is confirmed to originate in the core of the cluster NGC 5053 through tracking its motion in three dimensions.

2. *Gamma ray and neutron pulse shape discrimination of the p-Terphenyl scintillator*

Kendrin Butler (Christian)

The objective of this research is to use different data analysis techniques to determine if there is a more effect way to distinguish between emitted gamma rays or neutrons from a source. In this instance, a ^{252}Cf source was used. The scintillator is a combination of six p-Terphenyl cubes ($2\,\text{cm} \times 2\,\text{cm} \times 2\,\text{cm}$) side by side in the shape of a pseudo-bar, and there is a detector on each far end of the bar. This scintillator discriminates between gamma rays and neutrons by emitting light more intensely for a slightly longer period for the neutron relative to the time it takes for the intensity to drop for the gamma ray. The "integration method"—to be described in my talk—is used as a foundation to see what our figure of merit target must be for the other various methods. Methods such as the T-mean function, weighted averages, time over threshold, wave packet transformation method, Fourier transforms, Gatti's linear weighting method, and machine learning were all used and compared to the integration method. Many of these methods perform much worse than the integration method, however with some slight changes to Gatti's linear weighting method, favourable results can be obtained.

3. *Understanding nucleosynthesis in novae through indirect measurement of ^{24}Al*

Gabriel Desmarais (Christian)

This work focuses on the ^{23}Na(d,p)^{24}Na reaction. The focus on this reaction is with the future purpose of indirectly measuring the proton width of the mirror system of ^{24}Na, ^{24}Al,

in the context of a ^{23}Mg(p,γ)^{24}Al reaction. The data used in this work are the same as those used for a previous study by Eames A. Bennett. The data come from a ^{23}Na beam fired on a deuteron target. The data are analysed by scaling the theoretical model generated by the program `TWOFNR20.f` to the cross section of the detected gamma ray counts per the angle of the detector rings. The gamma ray emissions come from the de-excitation of the ^{24}Na nuclei. To analyse these data, the programs `ROOT` and `TWOFNR20.f` were used on top of a custom python scaling program.

4. *A look into narrow line Seyfert 1's in the x-ray: motivation and data processing*

Katherine Myers (Gallo)

X-ray emission from an active galactic nucleus (AGN) can come from two potential sources near the black hole at the centre, namely the hot corona or the base of a jet. An objective of this project is to determine the source of x-ray emission in particular AGNs known as narrow-line Seyfert 1s (NLS1s). This is useful for understanding the geometry and the relationship between AGN components such as the jet, accretion disk, and corona. This project uses a sample of 24 NLS1s, which all had x-ray data from the telescope XMM-Newton, and radio observations. Some objects had jetted emission in the radio band (called radio loud NLS1s), and some did not (radio quiet NLS1s). We focused on comparing the x-ray spectra between them to determine the origin of the x-ray emission. Results are described in the following presentation by Koranteng.

5. *A look into narrow-line Seyfert 1s in the x-ray: methodology and results*

David Koranteng (Gallo)

In the class of active galactic nuclei (AGN) known as Narrow-line Seyfert 1s (NLS1s), x-ray emission can originate from the AGN's diffuse corona or the base of a jet, if present. Determining spectral differences between these two processes provides insight into how the jet is connected to the accretion disc. A sample of 24 NLS1s that have been previously observed in both radio and x-ray spectra is examined. The radio data demonstrate whether an object is jetted (radio loud) or non-jetted (radio quiet). Data reduction and properties of the sample are described in the presentation by Myers preceding. The objective is to model the x-ray spectra of each object and compare the x-ray properties of radio loud and radio quiet NLS1s. The spectra were fitted with toy models, measuring the emission from the corona/jet and accretion disc, while accounting for potential absorption of the object. Radio loud sources are harder in the x-ray, while also exhibiting higher absorption. This potentially indicates a contribution from the jet of radio loud sources in the x-ray, hardening the spectra.

6. *Investigating the excitation spectrum of ^{8}He from inelastic scattering with deuterons*

Colby O'Keefe (Kanungo)

Rare isotopes are nuclei with very short half-lives and can have a large asymmetry of neutrons to protons. These isotopes can have unusual structures such as halos that can exhibit a phenomenon known as a soft dipole mode (SDM). One rare isotope of interest is 8-Helium (^{8}He) which has a four-neutron halo. In previous investigations of ^{8}He two excited states (2^{+} and 1^{+}) and a possible third have been observed with conflicting reports on their locations. The inconsistent reports on the 2^{+} state in particular have been postulated to be due to a low-lying SDM. The goal of this study is to determine if a SDM is present around the 2^{+} excited state. The IRIS facility, which focuses on studying rare isotopes, was used to study the inelastic scattering of ^{8}He with a solid deuteron (d) target.

During this talk I will discuss the experimental setup at IRIS and how it was used to study the ^{8}He(d,d$'$)^{8}He* inelastic scattering. I will also describe how the different radiation detectors are being calibrated and how from this the thickness of the solid deuteron target has been determined. Finally, an outlook on ongoing and future work will be presented.

7. *A search for resonance states of ^{12}Li*

Jared Park (Kanungo)

Since the discovery of a neutron halo in ^{11}Li nuclei, investigations of exotic nuclei have gained increase focus because of large, unexpected deviations from the conventional nuclear model. In this study, we look at the ^{12}Li isotope, an unbound nucleus which means it will exist at an excited state above the neutron emission threshold before decaying by neutron emission. The structure of ^{12}Li is still not fully understood as existing literature contain conflicting information about ^{12}Li resonance states. In this study we examine the excitation spectrum of the neutron transfer reaction ^{11}Li(d,p)^{12}Li to seek out any resonance energies. This experiment was performed using the IRIS facility at the TRIUMF research centre in Vancouver, BC. In this study, a ^{11}Li beam with energy of 80.3 MeV was shot at a solid deuteron target with two different thicknesses of 50 – 100 μm inducing a neutron transfer reaction. The presentation will describe the analysis of the energy spectra of the scattered protons in the detectors from which the excitation spectrum was determined.

8. *Strong constraints on the black hole population of 47 Tuc using pulsar timing*

Peter Smith (Henault-Brunet)

We present a new multimass dynamical model of the globular cluster 47 Tuc, previously suggested to host an intermediate-mass black hole (IMBH) or a population of stellar-mass black holes. We use updated black hole prescriptions, new mass function data, and a detailed analysis of pulsar timing data combined with many other observables to improve the constraints on the black hole content of the cluster. We infer a population of 45^{+22}_{-19} black holes (for a total mass of $260^{+191}_{-133} M_{\odot}$) based on our best-fitting models which accurately reproduce

all the observables, including the pulsar timing data. In particular, we highlight the role of the pulsar timing data in constraining the mass distribution of the cluster. These new constraints represent a significant improvement over previous studies and effectively argue against the need for a central IMBH in 47 Tuc.

$\sim$