UNIVERSITY OF HAWAII • INSTITUTE FOR ASTRONOMY
RESEARCH PROPOSAL – OBSERVING TIME REQUEST

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Abstract

TELESCOPE TIME REQUESTED

COLLABORATORS

Name	Institution	E-mail	Program(s)
Jeff	UH		
Marielle	UH		
Connor	IfA		
JT	IfA		

1 SCIENTIFIC JUSTIFICATION

1.1 Immediate Objective

Using various data reduction techniques, we will measure the size, shape, and age of the spiral arms located on the Milky Way galaxy. To determine the size and shape of particular spiral arms, variable star distributions must be spatially mapped. The number distribution of variable stars will give insight into the age of our galaxy.

- Distance Equation with reference
- Determine deviation of variable stars from model
- Variations arise from non-gravitational effects
- Figure out dark matter distribution
- include - Plot of known var star distributions in spiral arms
- possibly make figures below, side by side

Subtraction of gri data will cause transient objects to emerge. Distinct light curves will lead to the identification of variable stars. Variable stars comprise under 1% of the total number of observable stars Allen et al. (2016), making it possible to analyze all of the data collected by the gri project.

A H-R Diagram of pulsating variable stars is shown by Figure 2 Turner et al. (2012).

1.2 Scientific Rationale

Of the different types of variable stars, we will focus on RR Lyrae, Type 1 Cephedis, and Type 2 Cephedis. These pulsating variables have well established absolute magnitudes B. et al. (2012). From this the luminosity is known, permitting the distance to each star to be calculated using Period-Luminosity (PL) relationship.

RR Lyrae have short periods, $1.5 - 24$ hours, and are generally classified as stars with spectral type A. On average, absolute magnitudes of RR Lyrae stars fall between 0.6-0.7 Tsujimoto et al. (1998). Using the distance modulus assuming no ISM extinction yields the upper limit on RR Lyrae distance measurements of 7.9 kpc with $m = 15$ (photometric accuracy of 4%). Figure 1 shows the PL relationship for variable stars classified as RR Lyrae Ngeow et al. (1998) (*how do we calibrate different band passes?*). Since the typical age of RR Lyrae is 10 Gyr, it can be used as the lower limit of the age of spiral arms.

[DISCUSS Type 1 Cephedis, and Type 2 Cephedis] [DISCUSS DIFFERENCE IN ALL 3 VAR TYPE'S LIGHT CURVES - POSSIBLY SHOW EXAMPLES]

Near the galactic center, ISM is dense, and the number density of stars is high, which makes optical investigations quite difficult. Figure 3 shows the distribution of gasses in the Milky Way (Nakanishi and Sofue 2015). In order to determine the spiral arm structure of the Milky Way galaxy, we will avoid the galactic center. To take into account for the ISM extinction, we will use the ratio of total to selective extinction $R = \frac{1}{(\tau_1/\tau_2)-1} = \frac{1}{(\lambda_{eff,1}/\lambda_{eff,2})^{-1}-1}$ assuming the optical depth $\tau \propto \lambda^{-1}$ according to the Mie scattering.

References

Allen, S. et al., 2016. (n.d.). The Classification of Stellar Spectra. Retrieved February 15, 2016, from $http://www.star.ucl.ac.uk/\ pac/sp$

B. et al., 2012. Types of Variables — AAVSO. Retrieved February 16, 2016, from https://www.aavso.org/types-variables

Ngeow, C. et al., 2013. "Distance Determination From The Cepheid And RR Lyrae Period-Luminosity Relations". *Proc. IAU* 9.S301: 123-128. Web. 18 Feb. 2016.

Tsujimoto et al., 1998. The Absolute Magnitude of RR Lyrae Stars Derived from the [ITAL]Hipparcos[/ITAL] Catalogue. *The Astrophysical Journal, 492*(1). Retrieved February 15, 2016.

Turner, R. et al., 2012. H-R Diagram Education Materials — AAVSO. Retrieved February 14, 2016, from https://www.aavso.org/hr-diagram-education-materials

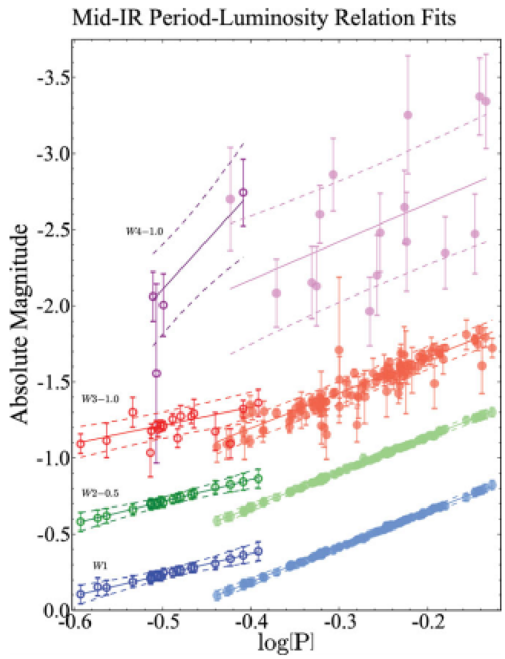

Figure 1: *Period-Luminosity relationship of RR Lyrae variable stars.*

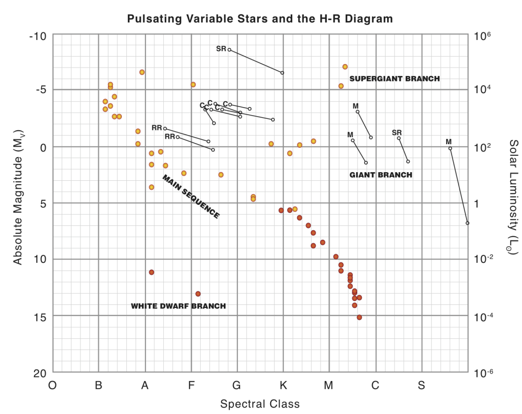

Figure 2: *HR-Diagram: Pulsating Variable Stars.*

Nakanishi, H. and Sofue, Y., 2015. Three-Dimensional Distribution of the ISM in the Milky Way Galaxy: III. The Total Neutral Gas Disk. *Publ. Astron. Soc. Japan (2014) 00(0), 114*. Retrieved February 15, 2016.

TECHNICAL JUSTIFICATION

We request 10.3 hours using Pathfinder to obtain g, r, and i imaging for variable stars in the galactic plane.

The typical pulsation period of RR Lyrae is in a range of 1.5 hours to 24 hours. To sample a 1.5 hours period, we need to image a RR Lyrae at least twice in one period according to the sampling theorem (*sampling rate vs error?*).

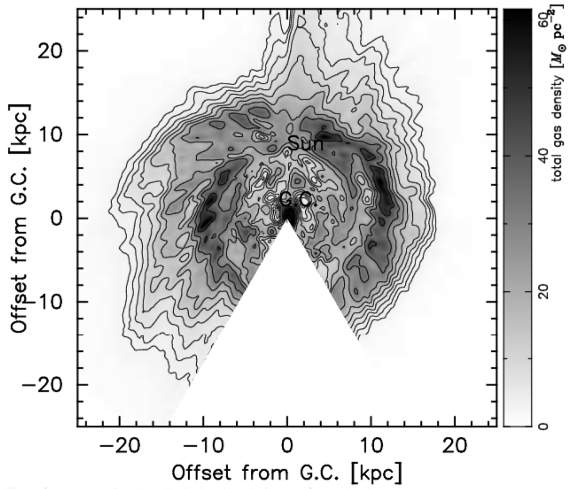

Figure 3: *Column density distribution of the sum of HI and H_2 gases.*

With the exposure time of 30 seconds and readout time of 8 seconds, the sky coverage rate is 948 deg^2/hour. To cover the galactic plane and avoid the galactic center, we choose a region with galactic latitude of $\pm 2^\circ$ and galactic longitude of 70° to 290° (*from the gri project, we should be able to choose smaller patches with variable stars on the galactic plane; more points in one period*). The coverage rate and angular size of the field yield the one observation time of 1.14 hours. We want 3 band passes with 3 pulsation periods each to take into account the ISM extinction (*number of periods vs error?*), so we request the total observational time of 10.3 hours. Since Cepheid stars have longer pulsation periods, we should be able to sample data points well.

The SNRs of g, r, and i bands with $m_g = m_r = m_i = 15$ are 26.11, 26.31, and 20.67, respectively. We use relative intensity to measure pulsation periods, so this photometric accuracy of 4% should be enough (*photometric accuracy vs error?*).