*Star Clusters: From the Milky Way to the Early Universe*
*Proceedings IAU Symposium No. 351, 2019*
*A. Bragaglia, M. Davies, A. Sills & E. Vesperini, eds.*

doi:10.1017/S1743921319007336

# RR Lyrae analysis in the Local Group globular clusters and dwarf galaxies

**Saruta Benkortem**[1], **Nahathai Tanakul**[2] and **Chutipong Suwannajak**[2]

[1]Department of Physics, Faculty of Science, Mahidol University, 272 Rama VI Road, Ratchathewi, Bangkok 10400, Thailand
email: saruta.ben@student.mahidol.ac.th

[2]National Astronomical Research Institute of Thailand (Public Organization), 260 Moo 4, Donkaew, Maerim, Chiangmai 50180, Thailand
emails: nahathai@narit.or.th, chutipong@narit.or.th

**Abstract.** RR Lyrae variables are powerful tools to study their host stellar populations. Globular clusters and dwarf galaxies are old and usually host this type of variables. With a growing number of low luminosity objects discovered in the halo of the Milky Way, classifying stars clusters and galaxies has become more challenging. In this study, we examine the properties of RR Lyrae stars in globular clusters and dwarf galaxies in the Local Group. We construct a catalog of RR Lyrae variables in the Local Group globular clusters and dwarf galaxies from previously published data and compare the properties of RR Lyrae variables between those two types of stellar systems. Our goal is to search for a physical difference in the properties of RR Lyrae variables in those two classes of stellar systems. We also analyze the global trend of RRLs in these systems to understand more about their formation and evolution history.

**Keywords.** galaxies: star clusters; galaxies: dwarf; stars: variables

## 1. Introduction

RR Lyrae variable stars are powerful tools to study their host stellar populations. Information such as distance, metallicity, reddening, and age can be obtained from their pulsation properties. Globular clusters and dwarf galaxies are old and usually host RR Lyrae variables. Studying RRL properties in MW globular clusters, Oosterhoff (1939) found that there are two group of globular clusters. We later called them Oosterhoff I (OoI) and Oosterhoff II (OoII). OoI globular clusters tend to have shorter mean periods (∼0.55 d), with a smaller ratio of c-type to total RRL stars and are more metal-rich $(-1.6\langle[Fe/H]\langle-1.0)$, while OoII globular clusters have longer mean periods (∼0.65 d) with a larger ratio of c-type to total RRL stars and are more metal-poor ([Fe/H] ⟨−1.6). They also occupy different regions of period-amplitude diagram. With a growing number of extended, low luminosity objects discovered in the halo of the Milky Way, classifying stars clusters and low luminosity galaxies has become more challenging. These objects has blurred out the boundary between galaxies and globular clusters on the size-luminosity space. Some recent studies have been using [Fe/H] spread to differentiate galaxies and globular clusters. However, these method require spectroscopy to measure [Fe/H]. In this study, we construct a catalog of RR Lyrae variables in the Local Group dwarf galaxies and globular clusters, using the published RR Lyrae studies (Clement *et al.* (2001) updated version, Martínez-Vázquez *et al.* (2017) and references therein). We also calculate the specific frequency of RRL stars in each type of the systems following the method described by Suntzeff, Kinman & Kraft (1991). This specific frequency ($S_{RR}$) is defined as the number of RRLs per unit absolute visual magnitude normalized to

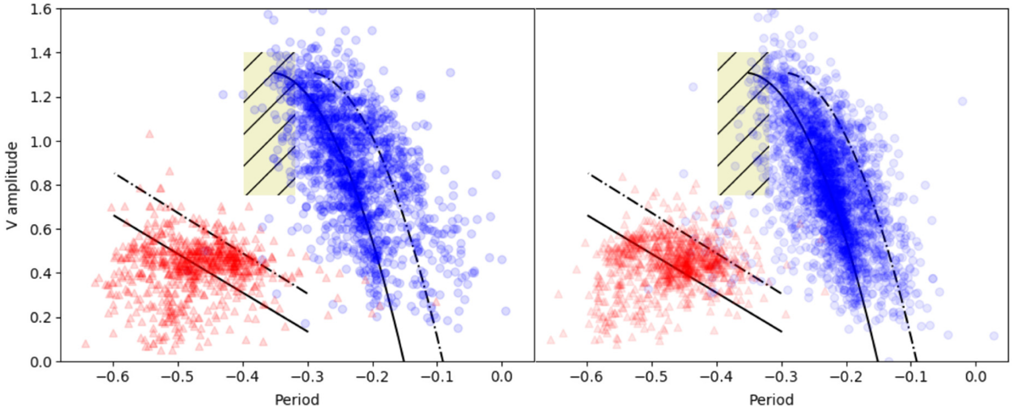


**Figure 1.** Left: Bailey diagram of RR Lyrae variables in all globular clusters in our sample. RRab are shown as blue circles and RRc are shown as red triangles. The solid lines represent Oosterhoff type I (OoI) and the dash-dotted lines represents Oosterhoff type II (OoII). The yellow area show the location of High Amplitude Short Period (HASP) RR Lyrae variables on the diagram. In general, RR Lyrae in globular clusters are mainly OoI or OoII. Right: Bailey diagram of RR Lyrae variables in all dwarf galaxies in our sample. Unlike in globular clusters, RR Lyrae in dwarf galaxies tend to be OoI and Oosterhoff intermediate.

$M_V = -7.5$ to remove the effect of the host's luminosity. We also compare our results with previous studies by Vivas & Zinn (2006) and found that they follow the same trend. Then, we examine the global properties of RR Lyrae variables including mean metallicities, specific frequencies, and fraction of high-amplitude-short-period variables. Our goal is to compare those properties of the Local group dwarf galaxies to those of the globular clusters and search for a physical difference in the characteristics of RR Lyrae variables in the two classes of objects.

## 2. Discussion

We have constructed a catalog of RRL in the Local Group globular clusters and dwarf galaxies and examined their properties. We found that the two types of systems show different Oosterhoff properties as in Figure 1. With our extensive sample, we found that RRL in globular clusters follow the same trend as dwarf galaxies on $S_{RR}$ vs $M_V$ diagram. As shown in Figure 2 - Figure 3, globular clusters tend to have higher $S_{RR}$ than dwarf galaxies. RRL in globular clusters and dwarf galaxies can be separated into different populations of high and low $S_{RR}$ when their host are relatively metal-rich. RRL variables with HASP can also be found in only the metal-rich systems. Recent study (Fiorentino *et al.* (2015)) suggested that ab type RRL in some MW dSphs were lacking in HASP variables. These HASP stars are defined as those with $P \lesssim 0.48$ days and $A_V \geqslant 0.75$ mag. They are common in the MW halo and globular clusters. The main parameter affecting this seems to be metallicities. In this study, we plot the fraction of RRLs in HASP region against the mean metallicity as shown in Figure 4. We can see that the more metal-rich galaxies do have a higher fraction of stars in the HASP region. Finally, dwarf galaxies and globular clusters seem to follow different sequences on a $S_{RR}$ vs. $f_{HASP}$ diagram as shown in Figure 5. For systems with HASP variables, most dwarf galaxies have $S_{RR}$ below 10, while SRR of globular clusters are higher and show larger dispersion. This might be another way to determine whether a system is a globular cluster or dwarf galaxies. However, more studies of HASP RRL and RRL in high metallicity systems are necessary.

https://doi.org/10.1017/S1743921319007336 Published online by Cambridge University Press

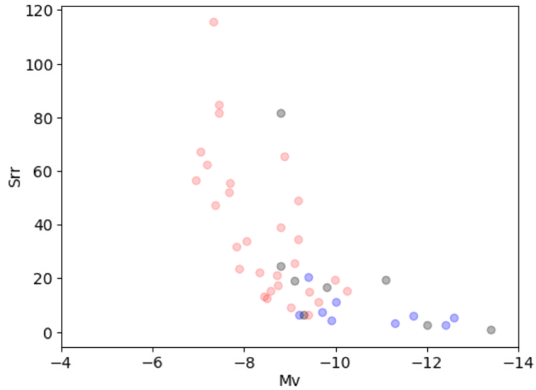


**Figure 2.** Specific frequency of RR Lyrae ($S_{RR}$) vs. absolute visual magnitude ($M_V$) of their host. Globular clusters are shown in red, the Milky Way's dwarf galaxies are shown in black, and M31's dwarf galaxies are shown in blue. RR Lyrae variables in both globular clusters and dwarf galaxies follow a similar trend that $S_{RR}$ decreases as $M_V$ increases.

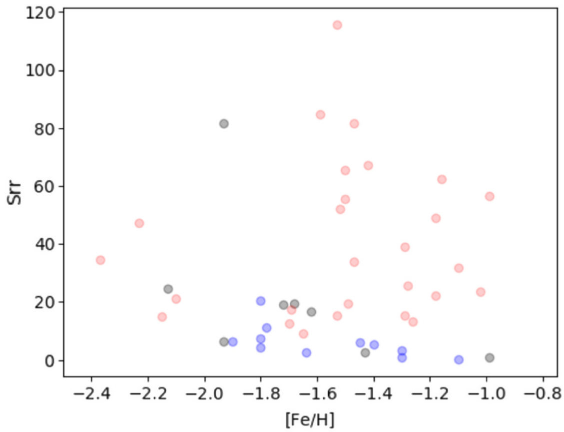


**Figure 3.** Specific frequency of RR Lyrae vs. metallicity. For systems with [Fe/H] $> -1.6$, globular clusters have higher $S_{RR}$ than dwarf galaxies.

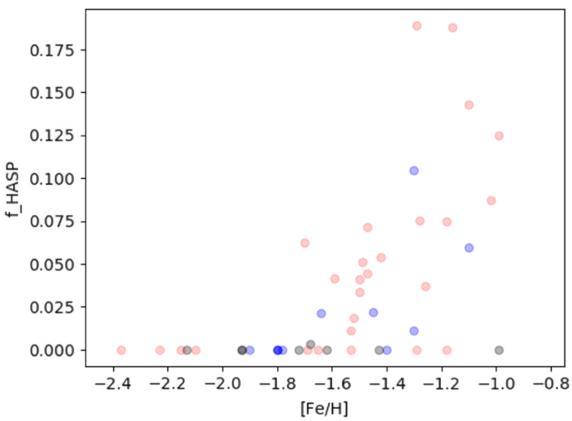


**Figure 4.** Fraction of HASP RR Lyrae ($f_{HASP}$) vs. metallicity. Only relatively metal-rich systems ([Fe/H] $> -1.6$) host RRL stars in the HASP region.

https://doi.org/10.1017/S1743921319007336 Published online by Cambridge University Press

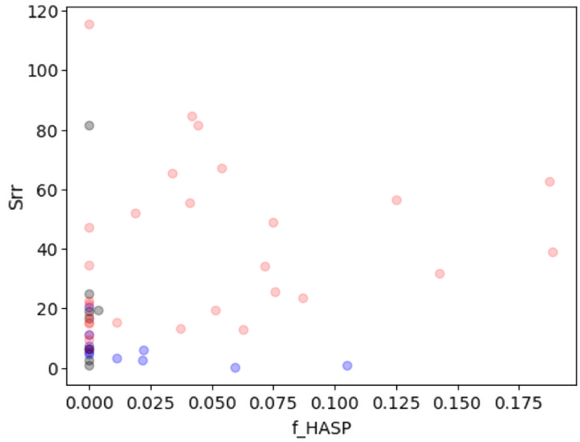


**Figure 5.** Specific frequency vs. fraction HASP RRL. For $f_{HASP} > 0$, dwarf galaxies and globular clusters seem to follow different sequences. While $S_{RR}$ of most dwarf galaxies stays below 10, $S_{RR}$ of globular clusters are higher and show larger dispersion.

## References


Clement, C. M., Muzzin, A., Dufton, Q., *et al.* 2001, *AJ*, 122, 2587

Fiorentino, G., Bono, G., Monelli, M., *et al.* 2015, *ApJ*, 798, 12

Martínez-Vázquez, C. E., Monelli, M., Bernard, E. J., *et al.* 2017, *ApJ*, 850, 137

Oosterhoff, P. T. 1939, *The Observatory*, 62, 104

Suntzeff, N. B., Kinman, T. D., & Kraft, R. P. 1991, *ApJ*, 367, 528

Vivas, A. K. & Zinn, R. 2006, *AJ*, 132, 714


https://doi.org/10.1017/S1743921319007336 Published online by Cambridge University Press