"Twinkle, Twinkle Little Stars"
The Importance of Finding RR Lyrae Stars in Ultra-Faint Dwarf Galaxies

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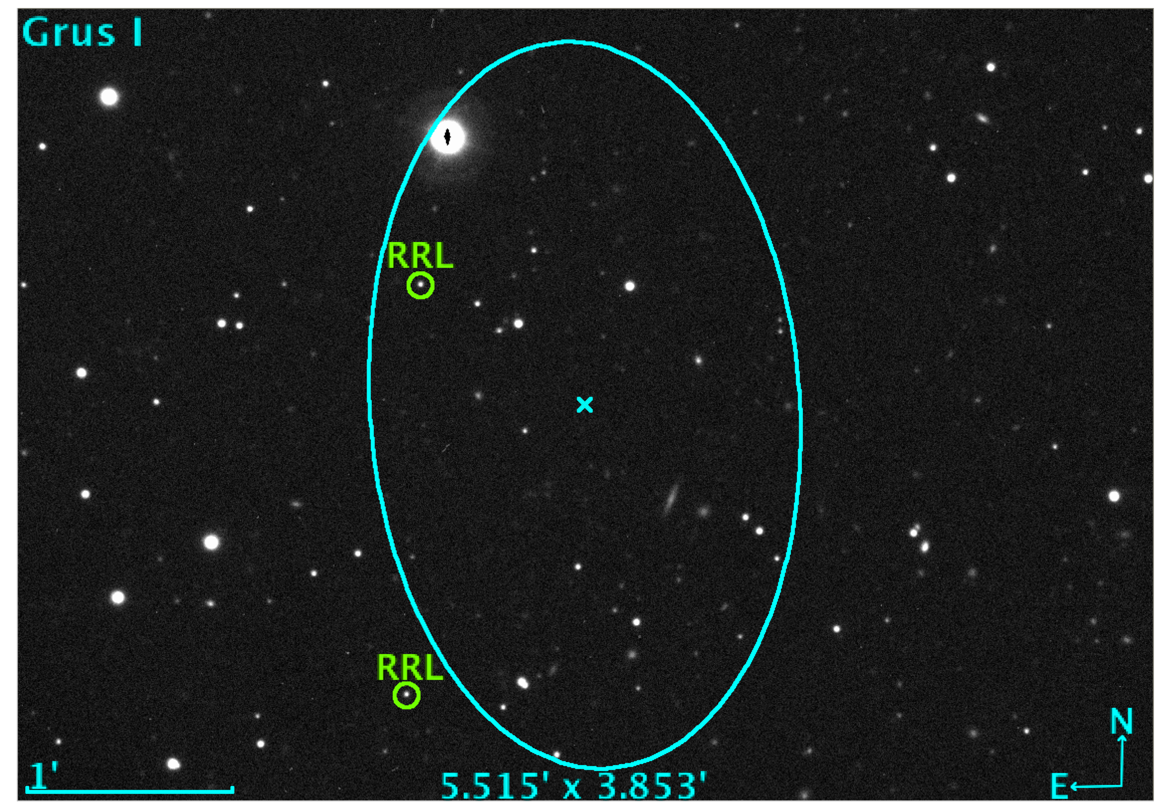
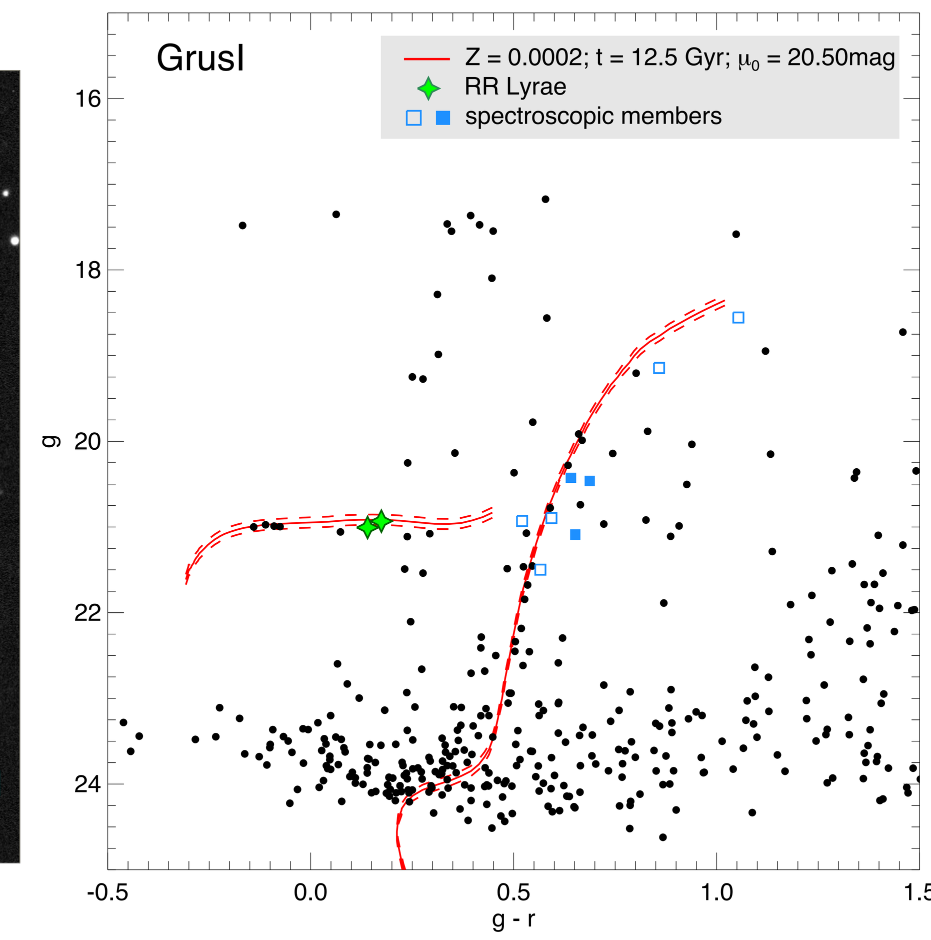
In the last decade, wide-area multi-band optical imaging surveys such as SDSS, DES, SMASH, MagLiteS, DELVE, ATLAS, Pans-STARRS1, and Gaia have contributed to the discovery of more than 50 ultra-faint dwarf galaxies (UFDs, $M_V > -8$ mag), satellites of the Milky Way, which were undetectable in the past. The low mass, the scarcity of stars and the large contamination by field stars make the determination of morphological parameters and distances for these galaxies a challenging task. An attractive method to improve the distance determination to these UFDs, and thus to clarify their nature, is to find RR Lyrae (RRL) star members.





(Right) Sky montage image for Grus I dwarf galaxy. Cyan cross mark the center of each galaxy, and the cyan ellipses mark the half-light radius of each galaxy, accounting for the ellipticity and position angle. The green circles indicate the position of the RRLs.
(Left) Color-magnitude diagram of Grus I dwarf galaxy from SOAR/Goodman photometry. Isochrones (red lines) were fitted using the distance modulus obtained from the RRLs that belong to the system.

RRLs are pulsating variable stars with periods ranging from 0.2 to 1.2 days and readily identifiable with suitable time-series photometry. Since RRLs obey well-calibrated period-luminosity relations, they are an excellent distance indicator, and are observable throughout the Local Group. Moreover, since RRLs are older than 10 Gyr, they can also provide insight on the properties of the old stellar population in any systems in which they are found. Our team has concentrated on increasing the census of RRLs in UFDs. We detected RRL members for the first time in several UFDs from time-domain studies made from ground-based telescopes (Martínez-Vázquez et al. 2019, 2021b,c) and using the Gaia DR2 RRL catalog (Vivas, Martínez-Vázquez & Walker, 2021). We also identify possible candidate extra-tidal RRLs in some of the UFDs.

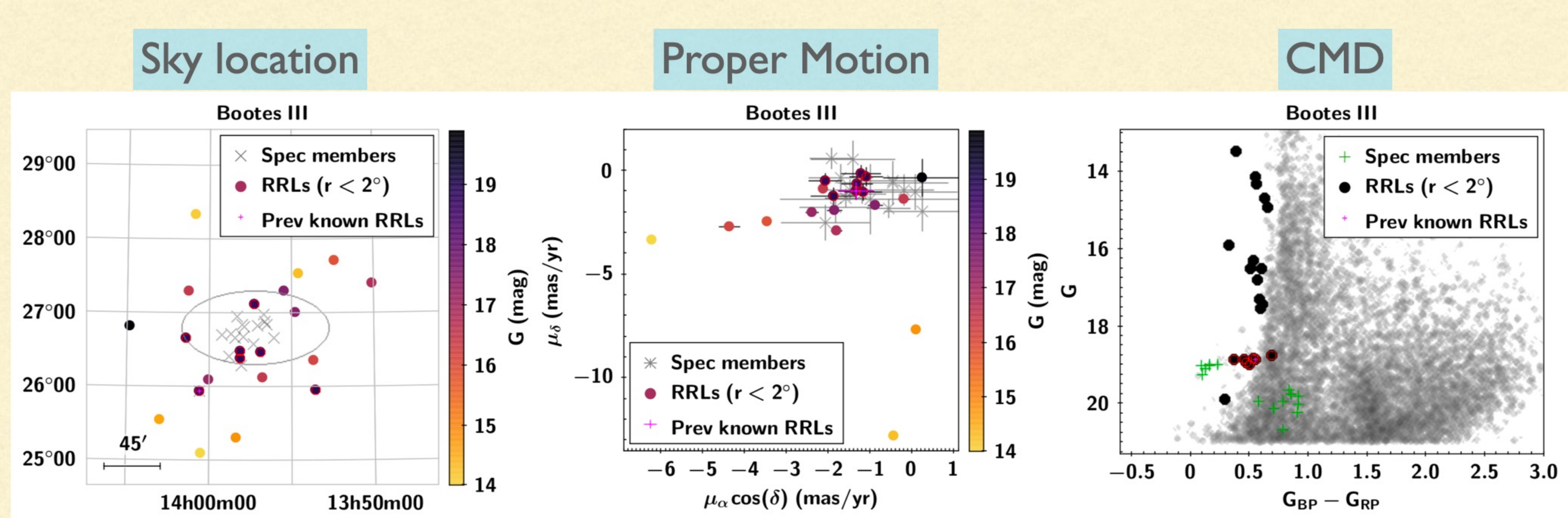
Galaxy	Distance modulus (mag)	Reference
Grus I	20.51 ± 0.10	Martínez-Vázquez et al. (2019)
Phoenix II	20.01 ± 0.10	
Grus II	18.71 ± 0.10	
Cen I	20.35 ± 0.03	Martínez-Vázquez et al. (2021c)
Eridanus II	22.84 ± 0.05	Martínez-Vázquez et al. (2021b)

Only a few RR Lyrae stars, but...

Constraint better their physical sizes	
r_h = 65 pc	> 5 %
r_h = 44 pc	> 33 %
r_h = 96 pc	> 3 %

Changes from previous measurements

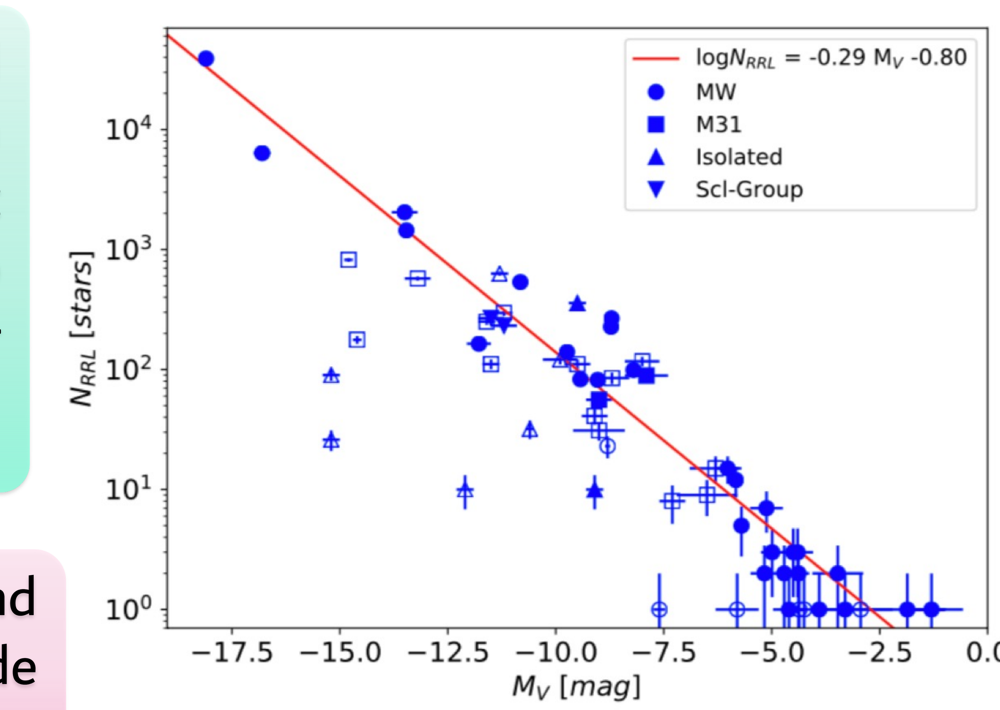
- Using Gaia DR2 RRL catalog, we search for RRLs in 27 UFD galaxies within < 100 kpc (more distant galaxies would have RRLs beyond the Gaia DR2 limits, G ~ 21 mag)
- 47 Gaia RRLs associated to 14 UFDs.
  - First RRL detection in Tuc II
  - Additional RRL members: UMa II, Com Ber, Hyd I, Boo I, Boo III
  - Extra-tidal RRLs: Boo I, Boo III, Sgr II, Tuc III, Eri III, Ret III (radial velocities are needed to confirm these stars)

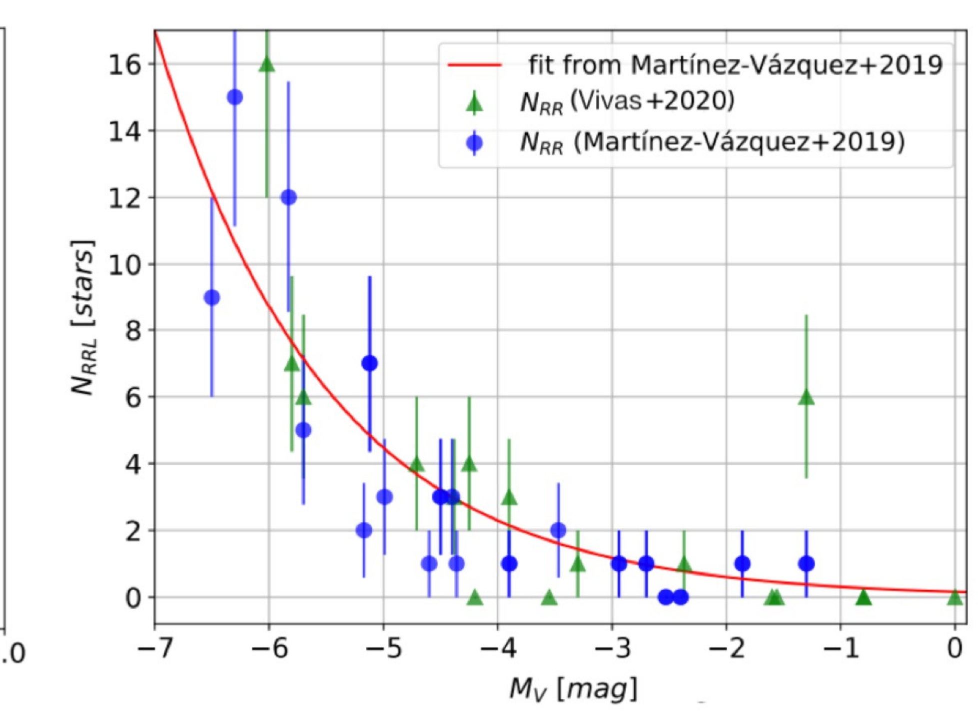


Furthermore, we made comprehensive and updated analysis of the number of RRLs in dwarf galaxies. This allows us to predict that the method of finding new UFDs by using two or more clumped RRLs will work only for systems brighter than $M_V \sim -5$ mag.

These works not only offer independent and accurate distances to the host but also provide clues about the contribution of UFDs in the formation of the halo of the Milky Way to ascertain how much of the long-period tail of field halo RRL stars can be attributed to disrupted UFDs.

All these results are presented in
- Martínez-Vázquez et al. (2019),
- Vivas, Martínez-Vázquez & Walker, (2020),
- Martínez-Vázquez et al. (2021b), and
- Martínez-Vázquez et al. (2021c)





(Right) Current literature number of RRLs versus the absolute magnitude of the galaxy, M_V. Filled symbols represent those dwarf galaxies for which the RRL search was carried out further than $2{\times}r_h$, and for which we expect a ~100% of completeness in the number of RRLs. Open symbols correspond to those galaxies where either the search for RRLs did not reach $2{\times}r_h$ or the study was not complete in terms of RRL detection. The line shows the linear fit between log N_{RRL} versus M_V for the filled symbols. (Left) Zoom-in of the faint part ($M_V > -7$ mag) of the left-hand panel (without the logarithmic scale in the ordinate axis).

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