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What do RR Lyrae tell us about the formation of the Milky Way and M31 haloes?

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RR Lyrae variables are old (>10 Gyr) stars and, as such, they are useful probes of the earliest events of star formation in galaxies (Bernard *et al.* 2008, Martínez-Vázquez *et al.* 2016) as well as of the galaxy assembly process predicted by ΛCDM simulations of structure formation. In fact, the nature of the building-blocks of galaxies such as the Milky Way, and in particular, those of their stellar haloes, has been a matter of a substantial debate (Venn *et al.* 2004). Unlike other stellar tracers, RR Lyrae offer a snapshot of the stellar content present at the epoch when most of the merging action is predicted to have taken place, and thus they are ideal witnesses of this process.

Stetson *et al.* (2014) and Fiorentino *et al.* (2015) first showed that the period distribution and period-amplitude relation (Bailey diagram) of RR Lyrae stars have distinctive features in stellar systems of different mass and metallicity. In particular, the Galactic halo, the Magellanic Clouds, the Sagittarius dSph and Galactic globular clusters with metallicity [Fe/H]>-1.5 host High Amplitude Short Period (HASP) RR Lyrae, defined as those having P<0.48 days and $A_V \geqslant 0.75$ mag. HASP are instead missing in low mass dSph satellites and low metallicity globular clusters. They concluded that the metallicity of the RR Lyrae progenitors is the main parameter ruling the presence of HASP variables in a given stellar system, and that low mass dSph similar to the ones still orbiting the Milky Way are unlikely to be main contributors to the build-up of the Galactic halo. Fiorentino *et al.* (2017) additionally showed that in dwarf galaxies of intermediate luminosity ($-11 < M_V < -13.5$) such as Fornax, the occurrence of HASPs appears to be correlated with the early star formation and chemical enrichment of the host galaxy, with *fast* and *slow* dwarfs (following the nomenclature introduced by Gallart *et al.* 2015) hosting and not hosting HASP, respectively.

Monelli *et al.* (2017) analysed the pulsational properties of the RR Lyrae population in a sample of M31 satellites, and compared them with those in the M31 inner halo. The bright dSph in their sample (namely M32, NGC 185, NGC 147 and AndVII) host HASP RR Lyrae, while the faint ones do not. This confirms the picture emerging from the Milky Way. The results are summarised in Figure 1: taken together, these findings suggest that the M31 and Milky Way inner halo components, if accreted, mainly originate in massive dwarf galaxy building blocks, as low-mass dwarfs do not seem to be able to chemically enrich fast enough to produce a HASP RR Lyrae population.

Gaia will increase substantially the census of RR Lyrae variable stars in the Milky Way, and we plan to follow up on these findings using forthcoming Gaia RR Lyrae datasets. In the mean time, we are completing the census of RR Lyrae variable stars in dSph satellites of the Milky Way by using extensive compilations of archival data, together with proprietary data when needed.

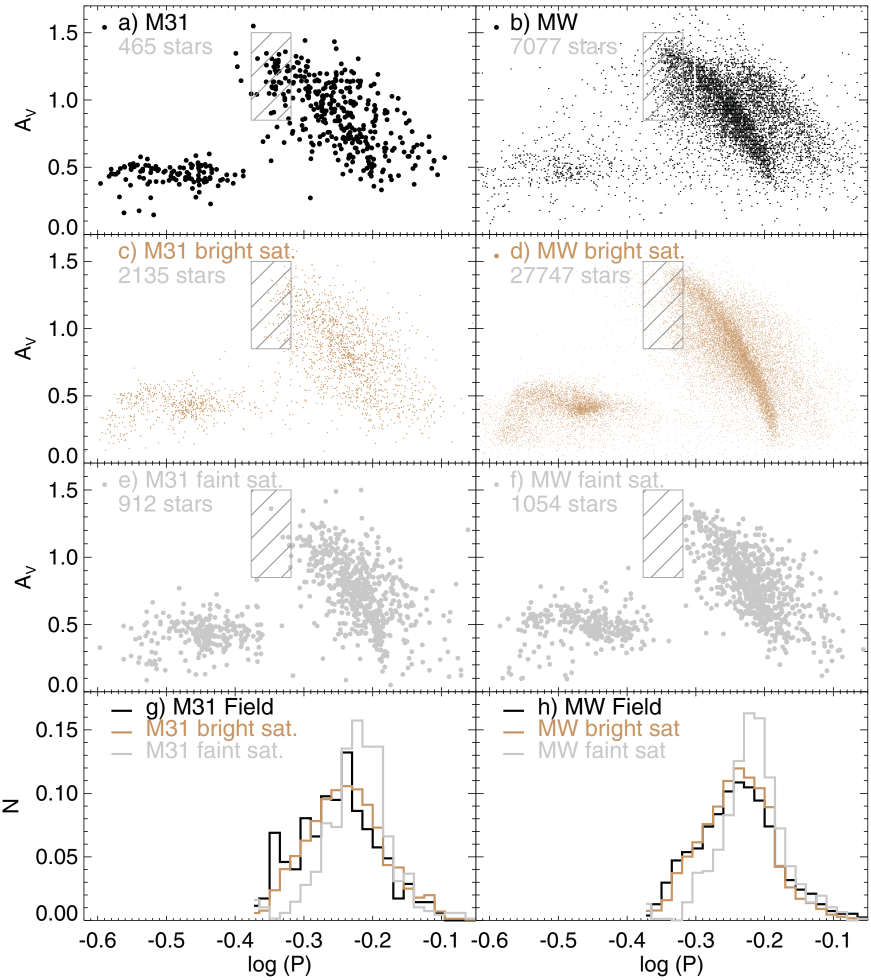

Figure 1. Comparison of the Bailey diagram of samples of RR Lyrae stars belonging to the inner halos of M31 (left) and the Milky Way (right), and to a number of satellite dwarf galaxies. From top to bottom: panels (a) and (b) show the case of the available RR Lyrae stars in the halo of both spirals; panels (c) and (d) refer to the system of bright satellites; and panels (e) and (f) present the faint satellites of both systems. The number indicates the total number of RR Lyrae in each panel. Panels (g) and (h) illustrate the period histogram of the samples shown above. Reproduced by permission: Figure 10 from paper "Variable Stars in Local Group Galaxies. III. And VII, NGC 147, and NGC 185: Insight into the Building Blocks of the M31 Halo", Monelli *et al.*, (2017) ApJ, 842, 60. See references for the data shown in this plot in the original paper.

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