Detection of a New Halo Stream at 90 Kpc

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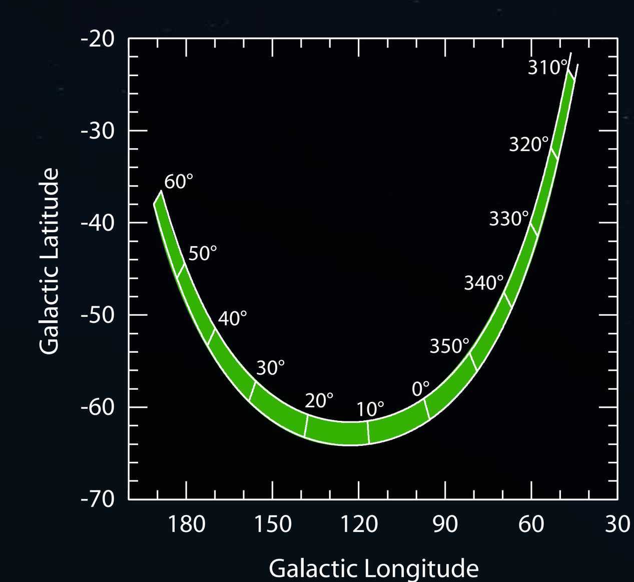
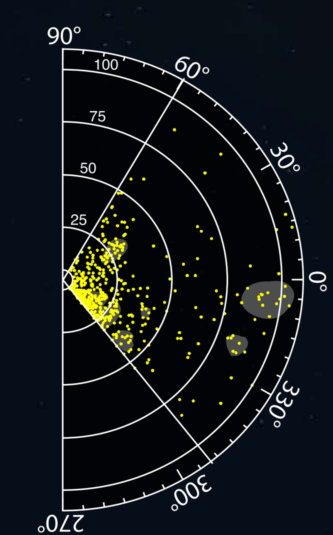
Using 500 RR Lyrae stars discovered in the SDSS stripe 82 region as tracers of stellar density, we map the halo structure to beyond 100 kpc from the Galactic center, and discover two new halo overdensities at ~90 kpc.

Overdensities associated with the Sagittarius dwarf tidal stream and with the Hercules-Aquila cloud are also detected. Using a theoretically motivated correlation between metallicity and the bluest u-g color of RR Lyrae stars, we study the metallicity distributions of detected halo sub-structures. The newly discovered 90 kpc overdensities and the Sagittarius dwarf tidal stream have similar halo-like metallicities, while the Hercules-Aquila cloud is more metal-rich and may have a larger metallicity dispersion. This may indicate that the Hercules-Aquila cloud is a complex structure consisting of several merger remains.

Studies of the Galactic halo can help constrain the formation history of the Milky Way and the galaxy formation process in general. For example, within the framework of the hierachical galaxy formation, the spheroidal component of the luminous matter should reveal substructures such as tidal tails and streams. The amount of these substructures, which are due to mergers and accretion over the galaxy's lifetime, may provide a crucial test for the proposed solutions to the "missing satellite" problem. The halo substructures should be ubiquitous in the outer halo (galactocentric distance > 15-20 kpc), where the dynamical timescales are sufficiently long for them to remain spatially coherent, and indeed, many have been discovered. Various luminous tracers, such as turn-off stars, RR Lyrae variables, or giants (G, K, M) are used to detect halo substructures, and of them, RR Lyrae stars have proven to be especially useful.

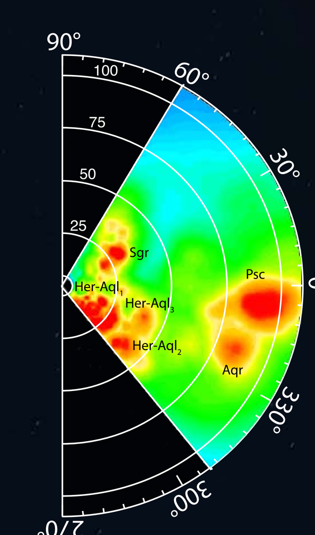
The SDSS equatorial stripe 82 region ($20^h\,32^m < \alpha_{J2000.0} < 04^h\,00^m$, $-1.26° < \delta_{J2000.0} < +1.26°$, ~280 deg^2) is the largest source of multi-epoch data in the SDSS. Its footprint in galactic coordinates is shown in the left plot, where the numbers above the strip indicate the equatorial R.A. angle. Using repeated observations of the region, we select 500 RR Lyrae stars (classified using template-fitting) and plot their positions in a polar projection, shown on the right. In this plot, distances are in kpc and the angle indicates equatorial R.A. Closed curves mark halo substructures defined using the density map shown below.



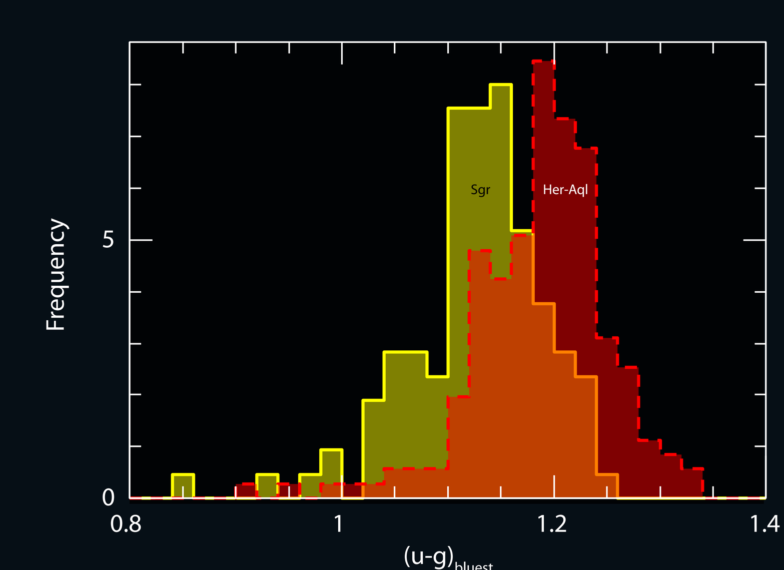


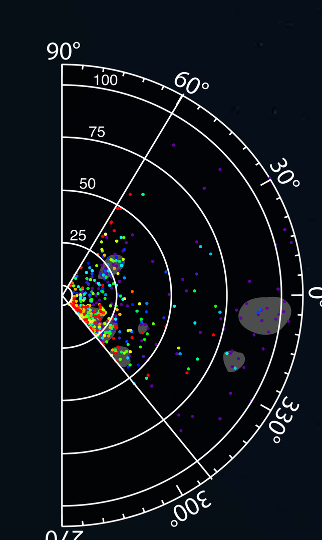
The plot on the left shows the number density distribution of RR Lyrae stars, computed using an adaptive Bayesian density estimator developed by Ivezic et al. (2005). The color scheme represents the number density multiplied by the cube of the galactocentric radius, and displayed on a logarithmic scale with a dynamic range of 300 (from light blue to red). The green color corresponds to the mean density—the wedge with the data would have this color if the halo number density distribution followed a perfectly smooth r^{-3} power-law. The yellow/orange regions are formally about 3σ significant overdensities, and red regions have an even higher significance (using only the counts variance).

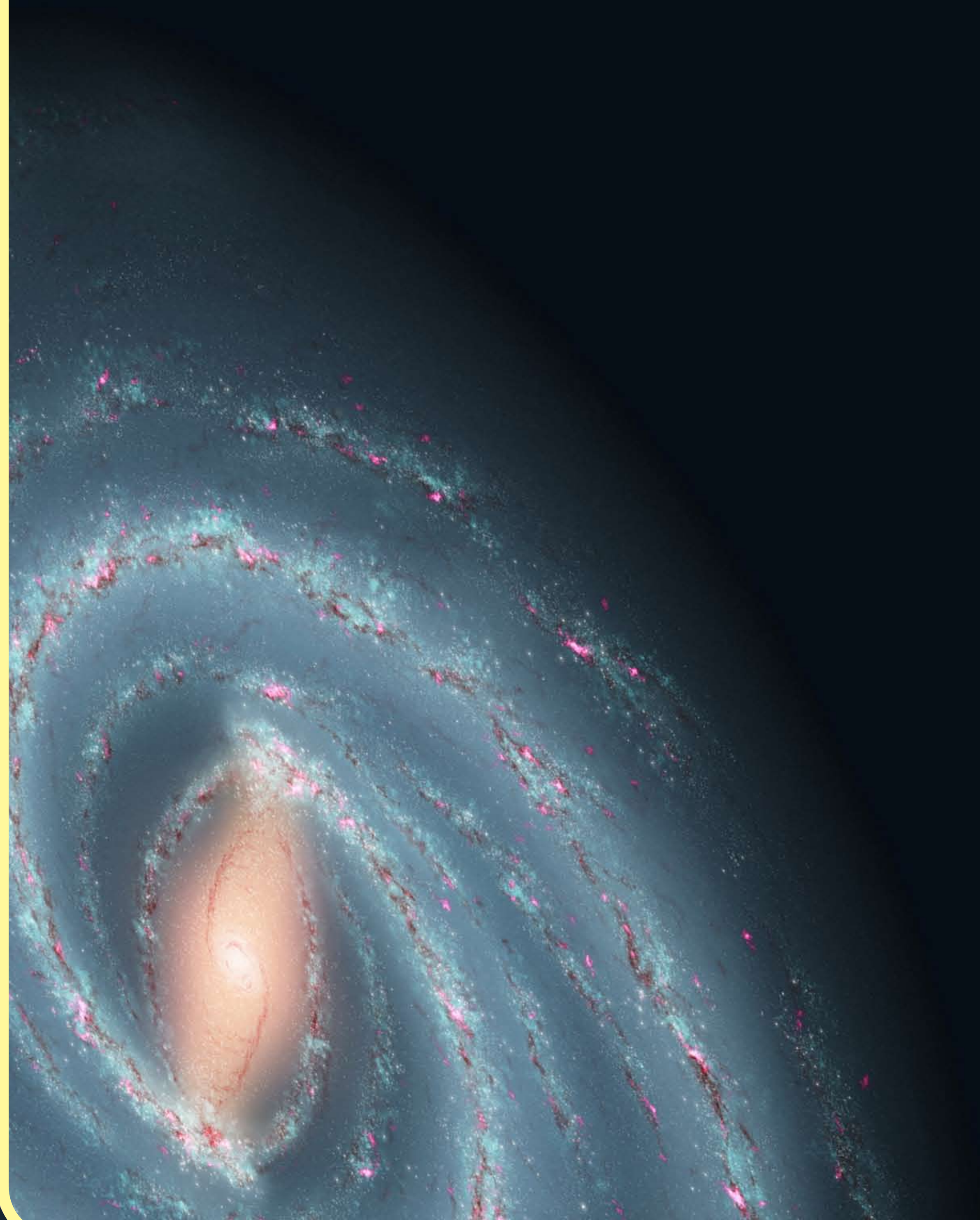
The number density distribution of RR Lyrae stars indicates several overdensities. The clumps marked as Her-Aql may be associated with the Hercules-Aquila cloud (Belokurov et al. 2006), while the clump marked as Sgr belongs to the Sagittarius dwarf tidal tail (trailing arm). The underdensity of RR Lyrae stars in the 35°< R.A. < 60°, 60 < d < 110 kpc range is real and is not due to selection effects. The clumps marked as Psc and Aqr, located at ~90 kpc between R.A. of 325° and 0° (approximately l=85°, b=-55°), are new detections and may be associated with a previously unknown tidal stream or streams. Note that this is a different structure than the 90 kpc clump at l=190°, b=30° discussed by Newberg et al. (2003).



Pulsation models of RR Lyrae stars predict a correlation between the bluest u-g color of an RR Lyrae and its metallicity (Marconi et al. 2006). In the right plot, we color code RR Lyrae stars with $(u\text{-}g)_{bluest}$, where the blue color corresponds to 1.1 or lesser, green to 1.18, and red to 1.25 or greater. Note that the distribution of $(u\text{-}g)_{bluest}$ is inhomogeneous in the halo, with Sgr and the Aqr-Psc clumps being bluer (more metal-poor) than the Her-Aql clumps. This is even more evident in the histogram shown on the left, where we compare the $(u\text{-}g)_{bluest}$ distributions of RR Lyrae stars from the Sagittarius dwarf tidal tail (yellow solid line) and Hercules-Aquila cloud (red dashed line).







Milky Way rendering by NASA