Leibniz-Institut für Astrophysik Potsdam (AIP)

The Bulge RR Lyrae star Radial Velocity Assay (BRAVA-RR)

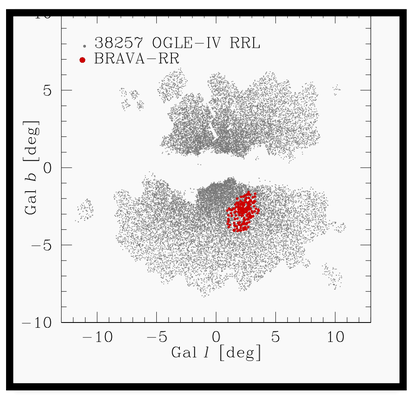
Andrea Kunder,[1] R.M. Rich,[2] J. Storm,[1] A.R Walker,[3] A. Koch,[4] C.I. Johnson,[5] D.M. Nataf,[6] G. Bono,[7,8] J. Shen,[9] Z.-Y. Li,[9] M.J. Cordero[10]

1 Leibniz-Institut für Astrophysik Potsdam (AIP) — 2 University of California Los Angeles (UCLA) — 3 Cerro Tololo Inter-American Observatory (CTIO), NOAO — 4 Landessternwarte, Universität Heidelberg — 5 Harvard-Smithsonian Center for Astrophysics — 6 The Australian National University — 7 Rome Astronomical Observatory — 8 Universita di Roma Tor Vergata — 9 Shanghai Astronomical Observatory — 10 Astronomisches Rechen-Institut Heidelberg

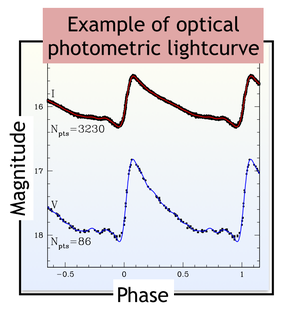
ABSTRACT:

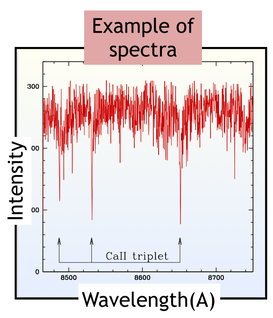
Using mainly bulge red clump giants (RCGs) and giants as tracers, a picture has emerged of the Galactic bulge consisting of a rotating peanut-shaped structure made up largely of old and metal-rich stars (~10 Gyr, [Fe/H] falling between -0.5 and +0.5~dex). However, there is a more metal-poor population of stars present in the bulge, the bulge RR Lyrae stars, and the dynamics of this population has largely gone unexplored. We are carrying out a spectroscopic survey of bulge RR Lyrae variables, tracers of possibly the oldest and most metal-poor stars in the bulge ([Fe/H] peaking at -1.0 dex). To date, we have obtained radial velocities of 180 OGLE bulge RR Lyrae stars in two 2 degree windows centred at (l,b) = (3,-2.5) for which NIR-photometry from the VVV surveys exists. Therefore, our RR Lyrae stars have accurate (3%) distances based on near infrared light curves. A subsample of our RR Lyrae stars have OGLE proper motions, so orbits of this population have been obtained. Our results indicate that the kinematic properties of RR Lyrae stars at (l,b) = (3,-2.5) are similar to that of the metal-poor components of the Galactic bulge, and suffer from larger halo contamination than the more metal-rich populations. In particular, we have identified a likely halo RR Lyrae star ~1 kpc from the Galactic center and travelling at -375 km/s. It's metal-poor nature and large apocenter points to an inside-out formation of the Galaxy.

OBSERVATIONS

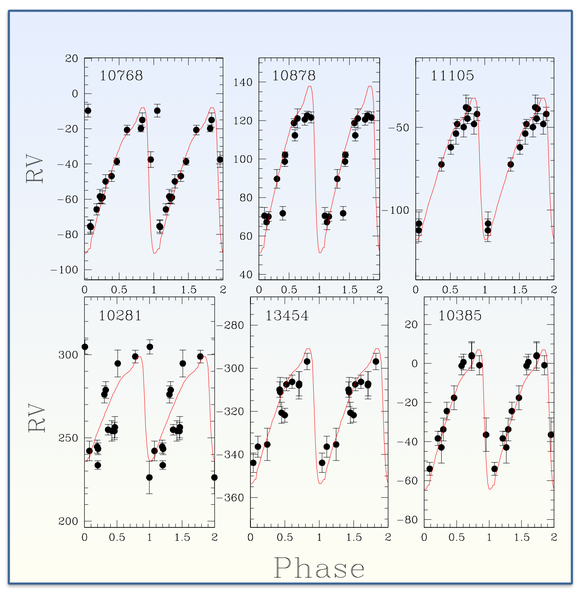


The OGLE RR Lyrae stars in the Galactic bulge with the BRAVA-RR Lyrae stars shown in red. They span a range in Galactic latitude and longitude from +2 < l < +4 and -2 < b < -5.





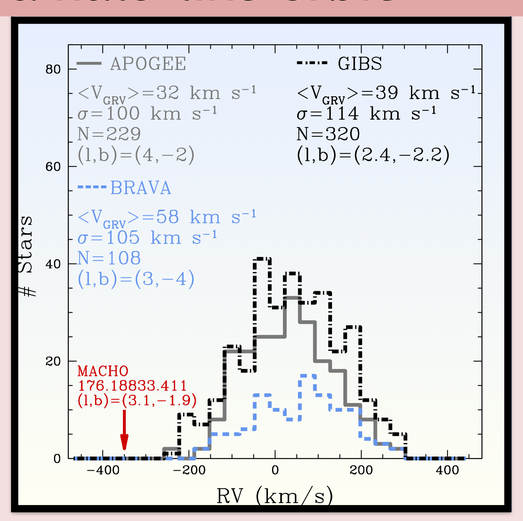
BRAVA-RR Observations	
Telescope	*Anglo-Australian 4m Telescope*
Instrument	*AAOmega multifiber spectrograph*
Resolution	*~10,000*
SNR	*10*
Wavelenth Regime	*8300 - 8800 Angstroms to probe the Calcium Triplet*
Num RRL	*195*



Six examples of BRAVA-RR Lyrae radial velocity light curves phased by their optical period. The Liu (1991) RR Lyrae radial velocity template scaled by the stars V-amplitude is over-plotted.

RESULTS I:

A high-velocity bulge RRL on a halo-like orbit

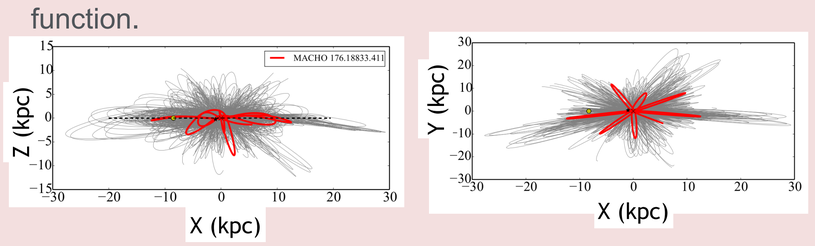


The velocity distribution of APOGEE giants (solid), BRAVA giants (dashed) and GIBS RCGs (dashed-dot) situated spatially close to MACHO~176.18833.411 (arrow).

MACHO 176.18833.411 is an RRL toward the Galactic bulge with the unusual radial velocity of -372±8 km/s and true space velocity of-482±22 km/s relative to the Galactic rest frame.

Stars of such high velocity are rare among bulge giants, and the more precise distance of the RRL makes it possible to explore its origin in greater detail, by integrating its orbit.

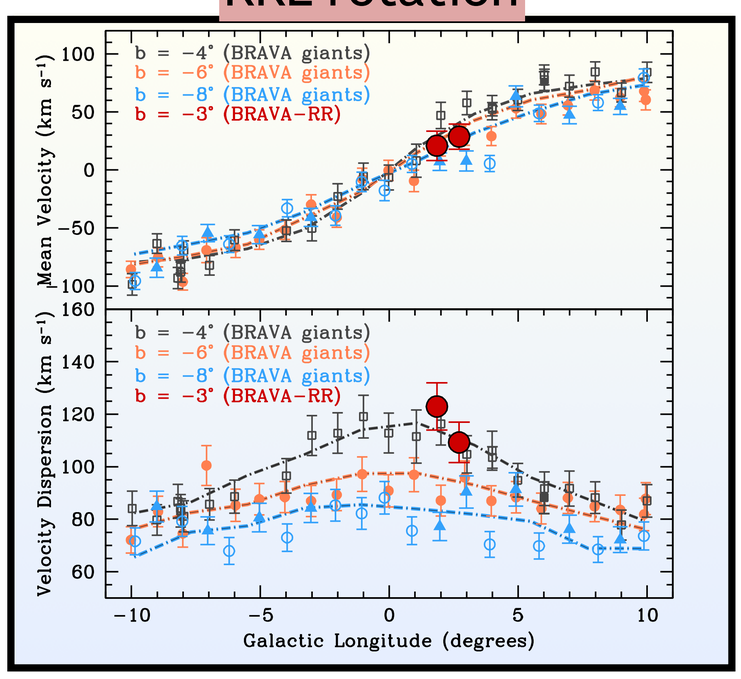
This star is most likely a halo interloper and therefore suggests that contamination of RR Lyrae stars from the inner halo may reach ~5% in this area of the sky. Halo contamination is not insignificant when attempting to trace out the metal-poor tail of the bulge's metallicity distribution function.



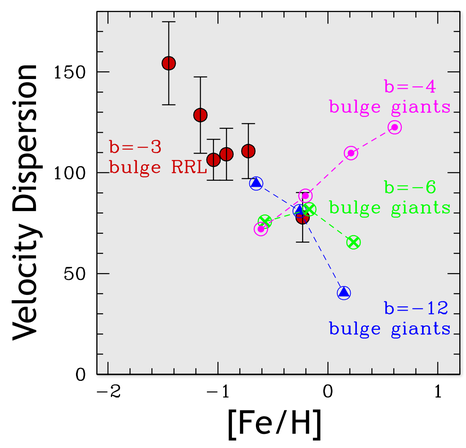
A 1 Gyr orbital integration for MACHO~176.18833.411.The open circle represents the Sun, the black 'x' represents the Galactic center and the black asterisk represents the current position of the RRL. The thin grey lines are 100 draws of the orbital integration to illustrate the uncertainty of the orbit. MACHO~176.18833.411 has an orbit consistent with that of the halo.

RESULTS II:

RRL rotation



The mean velocity and velocity dispersion of the bulge RR Lyrae stars are similar to that of the bulge giants and red clump giants.



The mean velocity dispersion of the bulge RR Lyrae stars as a function of metallcitiy.

The bulge RR Lyrae stars show decreasing velocity dispersion with increasing [Fe/H]. This mimics very closely the trend shown by the bulge metal-poor component identified as having spheroid kinematics (b=-12), while the bulge giants closer to the plane (b=-4) follow the trend of the bulge metal-rich component identified with disk/bar kinematics. Here we see with the bulge RR Lyrae stars the signature of an old spheroid population at b=-3.