Palomar 5 and its Tidal Tails:

A Search for New Members in the Tidal Stream

P. B. Kuzma[1], G. S. Da Costa, S. C. Keller & E. Maunder

Research School of Astronomy & Astrophysics, Australian National University

Mount Stromlo Observatory via Cotter Road, Weston, ACT, 2611

[1] pete.kuzma@anu.edu.au

ABSTRACT

The tidal tails of the globular cluster Palomar 5 offer an exceptional opportunity to study galactic tidal forces and their role in disrupting globular clusters. We present the results of a search for members of Palomar 5 and its associated tidal tails that covers a substantially larger area along the tails than previous work. Using kinematics and metallicities, derived from low and intermediate resolution spectra obtained with AAOmega at the AAT, as well as photometric information from the SDSS, we identify 39 new red giant branch stars and one blue horizontal branch star along 20° of the tails (17° in the trailing tail, 3° in the leading tail). Eight tidal-tail stars found in previous work are also recovered in this study. Within the cluster itself, we identify seven new members and confirm 12 previously known member stars. In total, we present velocity data for 67 stars in the cluster and the tidal tails. We derive a radial velocity for Pal 5 of -56.9 ± 0.3 km s^{-1} with an intrinsic velocity dispersion of $1.2_{-0.2}^{+0.3}$ km s^{-1}. We also confirm and extend the identification of a linear velocity gradient along the tails, finding a gradient of 1.01 ± 0.14 km s^{-1} deg^{-1} across the entire extent of our sample. The intrinsic velocity dispersion along the extent of the tails is found to be $1.93_{-0.36}^{+0.40}$ km s^{-1}. Our results confirm and extend previous studies that have revealed the tails as kinematically cold structures, and will allow further constraints to be placed on the orbit of Pal 5 ultimately permitting a greater understanding of the Galaxy's potential.

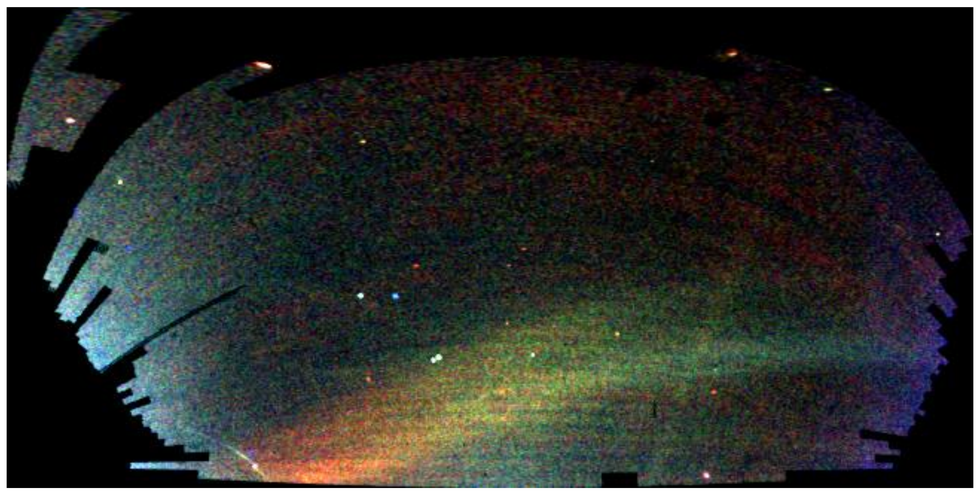

Fig. 1: Field of Streams (SDSS data release 6) from Belokurov et al. 2006. Note Pal 5 in the bottom left hand corner.

Selection Criteria

For stars to be nominated as members of either the tail or cluster, they had to meet a four different criteria. Those are:

- Radial velocities: Line-of-sight heliocentric velocities calculated through cross-correlation. For cluster members, stars had to have a velocity consistent with the known radial velocity of Pal 5: -58.7 ± 0.14 km s^{-1} (Odenkirchen et al. 2002).
- Photometric discrimination: Stars had to lie within or very close to the Colour-Magnitude diagram of Pal 5.
- Giant/Dwarf discrimination: We separated the contaminating field dwarfs from the giants we are interested in through the relationship between the equivalent widths of the Mg I features (8807 Ang and the triplet at ~5172 Ang) and the Ca II triplet (Battagalia & Starkenburg 2012).
- Metallicity: Infer [Fe/H] of the stars through the equivalent widths of the Ca II triplet through the 'Reduced Equivalent Method' (Armandroff & Da Costa 1991).

Velocity Gradient

The linear gradient along the 8.5° tail that was observed by Odenkirchen et al. 2009 was found to continue up along the 20° we have observed. Along the tail, we present a linear gradient of 1.01 ± 0.14 km s^{-1} deg^{-1}, calculated through a weighted least-squares fit, weights being the inverse square of the observational errors. Using the maximum likelihood technique mentioned previously, we calculated an intrinsic velocity dispersion of $1.93_{-0.36}^{+0.40}$ km s^{-1}. This low dispersion is indicative of the narrowness of the tail.

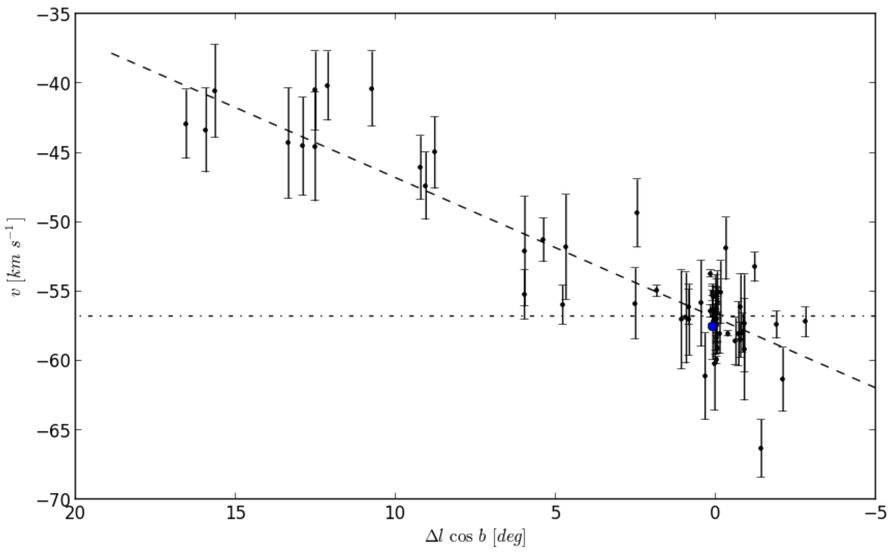

Fig. 3: Gradient across the tail where Δl = 0 l
s Pal 5. Blue point indicates the blue horizontal branch star.

Pete Kuzma is a PhD student at the Research School of Astronomy and Astrophysics, Australian National University. In his thesis, he uses wide field imagers to look for stellar streams in the vicinity of distant globular clusters.

Membership

Candidates stars were subjected to the following order of criteria to meet.

Cluster:
1. Radial Velocities
2. Photometry
3. Dwarf/Giant Separation
4. Metallicity

Tidal Debris:
1. Dwarf/Giant Separation
2. Metallicity
3. Radial Velocities
4. Photometry

The cluster region was defined to all stars within a nominal radius of 8.3` of Pal 5's center. Stars in the tail that belong to Pal 5 would have the same metallicity as those in the cluster, therefore we applied our metallicity criteria before radial velocity cuts in the tail. In total, 67 stars were named as members of Pal 5 and its tidal debris. For the cluster, 19 stars passed all four criteria, 7 of which are presented for the first time. 12 stars have been previously discovered (Odenkircken et al. 2002). The cluster kinematics were determined through a maximum likelihood technique (Walker et al. 2006). In the tidal debris, 47 stars met out criteria. 7 of those stars were nominated by Odenkirchen et al. 2009.

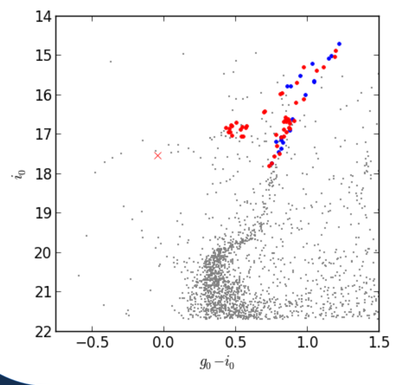

Fig. 2: The stars we have determined as members are plotted on the extinction-corrected CMD of Pal 5 from the SDSS data. The red points indicate stars determined as members in the tidal debris, while the blue points show stars within the nominal radius. BHB star displayed with a cross.

Palomar 5 – Target locations

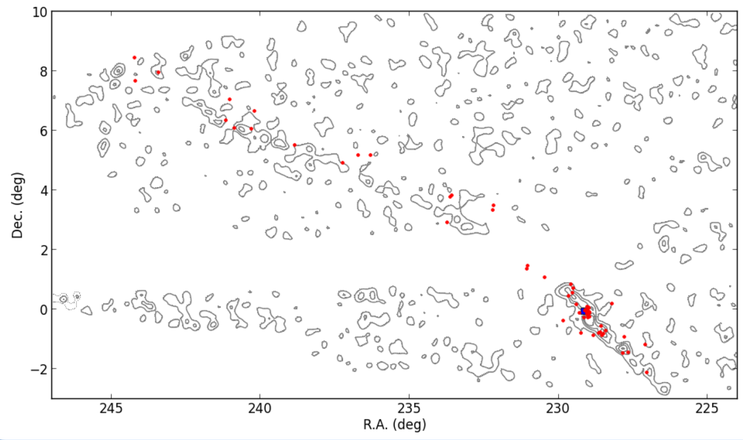

Fig. 4: The location of the candidate stars along the tail observed. The red points indicate the red giant candidates the and blue square is the blue horizontal branch star. Contours from main sequence turn-off stars and horizontal branch stars from SDSS data release 4 (Grillmair and Dionatos 2006).

References

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