A Pristine Look at Extended Globular Cluster Structures

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ABSTRACT

An exciting recent development in Galactic Astronomy has been the discovery that several Milky Way Globular Clusters (GCs) possess significantly extended structures, sometimes reaching out to a few hundred parsecs (corresponding to many half-mass radii). The number of GCs with extended structures (either in the form of tails or spherical diffuse envelopes) is unknown but has grown since the release of the Gaia Space Mission. The Gaia mission has transformed our view of these low-density structures, enabling member stars to be efficiently and reliably separated from the dominant foreground/background contaminant populations. However, Gaia does lack metallicities for a lot of the stars found in and around GCs. The Pristine survey provides metallicities for millions of stars, complementing the astrometric data from Gaia, and offers the opportunity to explore the stellar populations at the tidal radius and beyond for many Milky Way GCs. In this contribution, we explore a selection of GCs with extended structure and present the survey findings of [Fe/H] distributions beyond the tidal radii. We plan to follow-up on interesting detections with the Prime Focus Spectrograph on the 8-m Subaru Telescope, which will revolutions GC peripheral science.

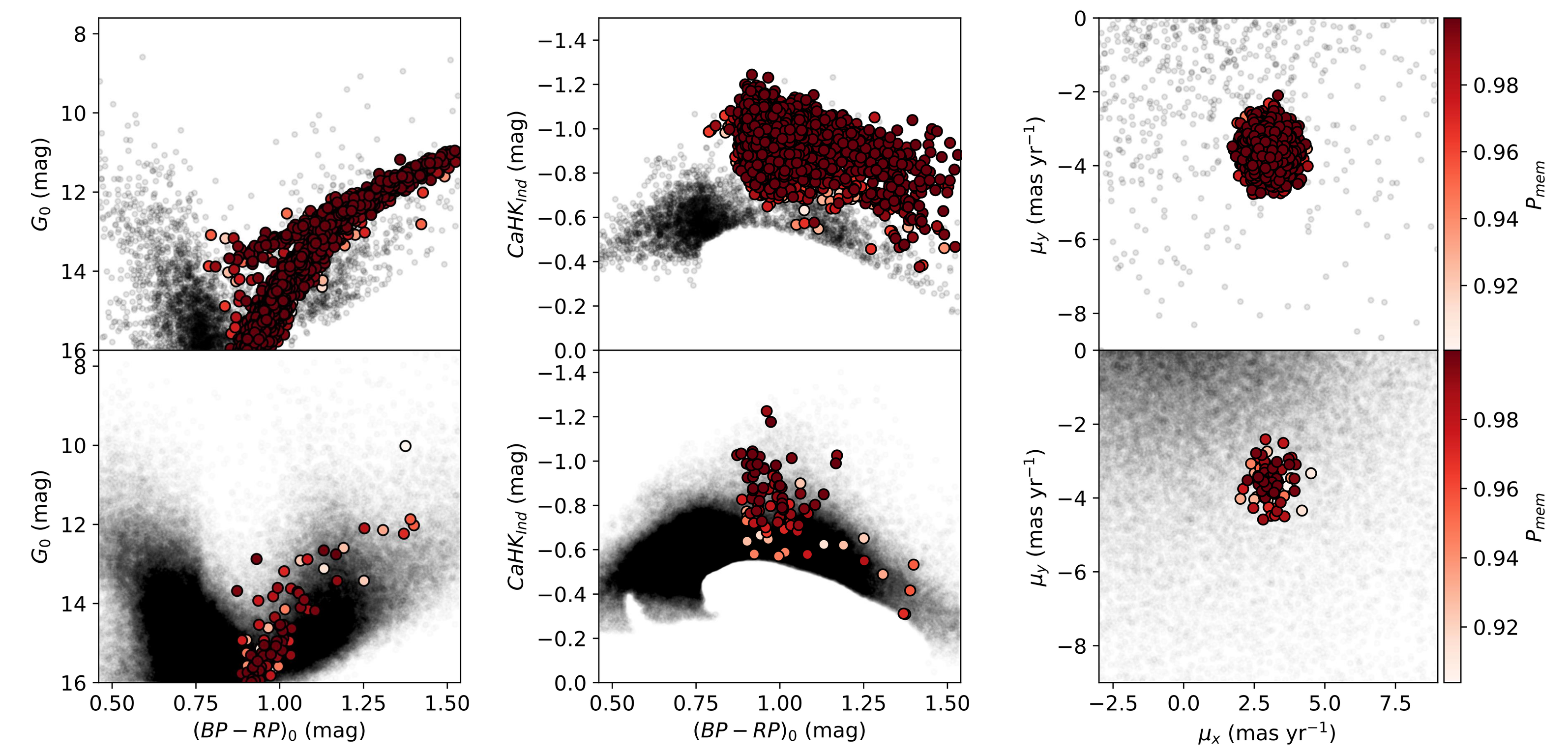

Fig 1: The three parameters spaces explored for Omega Centauri (Kuzma & Ishigaki, submitted). Left: Colour-magnitude, middle: colour-colour, and right: proper motion. Top row: all stars within the tidal radius. Bottom row: all stars outside the tidal radius. Coloured points are labelled by membership probability, and the black points are the field stars.

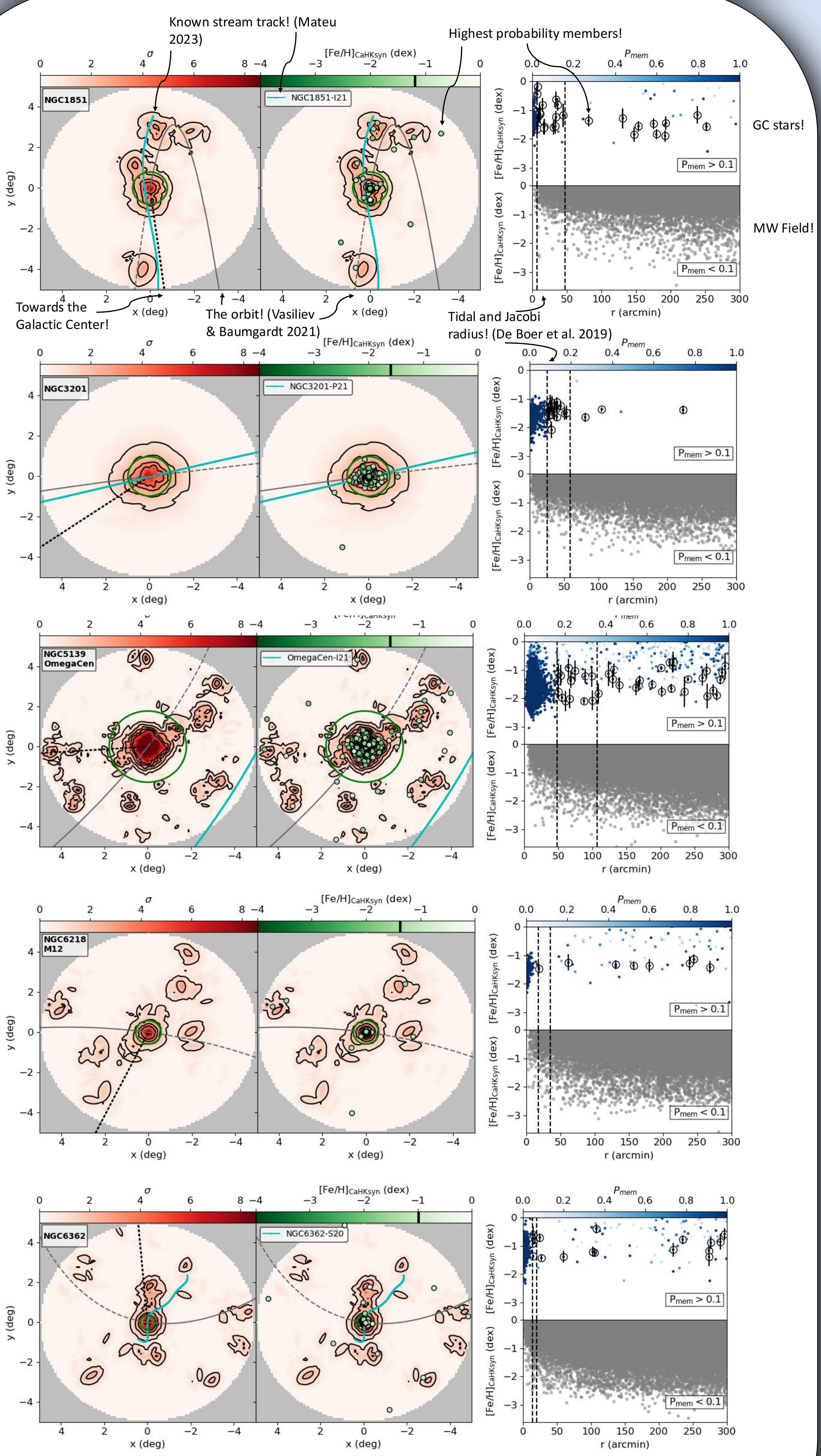

Fig. 2: 2D surface density maps from the Pristine-Gaia-Synthetic catalogue (left and middle). Right: Metallicity vs clustercentric radius. Each GC displays their orbit, any known streams, and the direction to the Galctic Centre. Jacobi Radius is shown by the green circle.

THE METHOD

We have utilised the Pristine-Gaia-Synthetic catalogue (Martin et al. 2021) to search of extended tidal structure around Milky Way GCs. We adopted a *k*-nearest neighbour algorithm to identify GC-like stars in a 10 degree diameter field of view centred on 30 GCs across three parameters spaces:

- Gaia Colour-Magnitude, $(G_{BP,0}-G_{RP,0}, G_0)$
- Pristine-Gaia Colour-Colour, $(G_{BP,0}-G_{RP,0}, (CaHK_0 - G_0) - 2.5(G_{BP,0}-G_{RP,0}))$
- Gaia Proper motions, (μ_x, μ_y)

Each star is assigned a probability of cluster membership through a gaussian mixture model approach with the above *k*-nearest neighbour probabilities. We demonstrate this with Omega Centauri in Fig. 1 (Kuzma and Ishigaki, submitted).

We explored the 2D density maps and the distribution of the highest memberships through an adaptive smoothing kernel, allowing for the high-density regions of cluster members to be smoothed with a smaller kernel, while low density regions are smoothing with a larger kernel (Fig. 2). We also explore the metallicities of potential members as a function of radius to explore how they are distributed.

TOWARDS SUBARU AND PFS

Due to the faint nature of these structures, the line-of-sight velocities and detailed chemistry needed to comprehend the peripheries of GCs fully are not available. However, new multiplex instruments and telescopes will soon commence science operations. Prime Focus Spectrograph (PFS) is a fibre-fed multiobject spectrograph possessing 2400 fibres on the 8-m Subaru Telescope at Mauna Kea Observatory. The combination of 2400 fibres on a 8-m class telescope will be extremely effective in covering the GC inner regions, outer periphery and the extended tidal structure to unprecedented photometric depths.
GC morphologies, 3D velocity dispersions, and chemistry as a function of radius are all important to understanding how GCs evolve and disrupt, their origins as either in-situ or accreted GCs and how the contribute to the overall assembly of the MW halo.

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