Uncovering the Monoceros Ring

Lane, Richard R.[1*]; Conn, Blair C.[2]; Lewis, Geraint F.[1]; Gil-Merino, Rodrigo[1]; Irwin, Mike J.[3]; Ibata, Rodrigo A.[4]; Martin, Nicolas F.[5]; Bellazzini, Michele[6]

Richard Lane
Institute ofAstronomy,
School of Physics,
University of Sydney

The MRi

The Monoceros Ring (MRi) is the only known, extant, in-Plane accretion event in the Milky Way (MW). Because in-plane accretion drives the evolution of galactic discs – directly depositing material onto the disc – our understanding of the MRi is directly related to our understanding of the evolving MW disc. Since its discovery (Newberg *et al.* 2002), the MRi has been traced around much of the Galaxy (Rocha-Pinto *et al.* 2003; Ibata *et al.* 2003; Conn *et al*. 2005) and has been shown to exist at two distinct distances (Conn *et al*. 2007; distances determined using photometric parallax, see below). The MRi was finally shown to entirely encircle the MW in the current study (Conn *et al.* 2008). The common interpretation is that the MRi is an in-Plane tidal stream exhibiting multiple wraps of the MW, although it has been suggested that the only known progenitor candidate – the Canis Major overdensity (Martin *et al.* 2004) – may be a line of sight effect of the Galactic Warp (Momany *et al.* 2004). The MRi may have instead been formed by a glancing blow from a passing dwarf galaxy (Younger *et al*. 2008). The only two comprehensive numerical models of the breakup of the MRi progenitor (Martin *et al.* 2004; Peñarrubia *et al.* 2005) have been overlaid with all known detections of the MRi for comparison, and are shown in Figure 1.

Photometric Parallax

This distance measurement method can be used for distance determination where accurate photometry is available for a large number of stars (see Juric *et al.* [2008] for a discussion). Accurate multiband CCD photometry obtained during this survey, combined with its large sky coverage, ensures that this method is ideal; accurate photometry can be used to estimate the stellar luminosity, and hence distance, for each star. Uncertainties are essentially removed since we are only concerned with MS stars which have a definite colour-luminosity relation (see Figure 2).

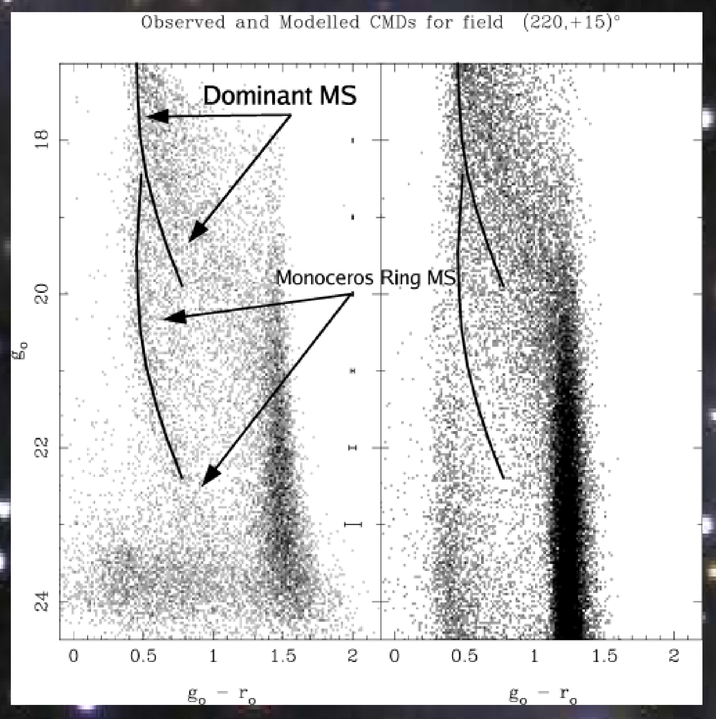
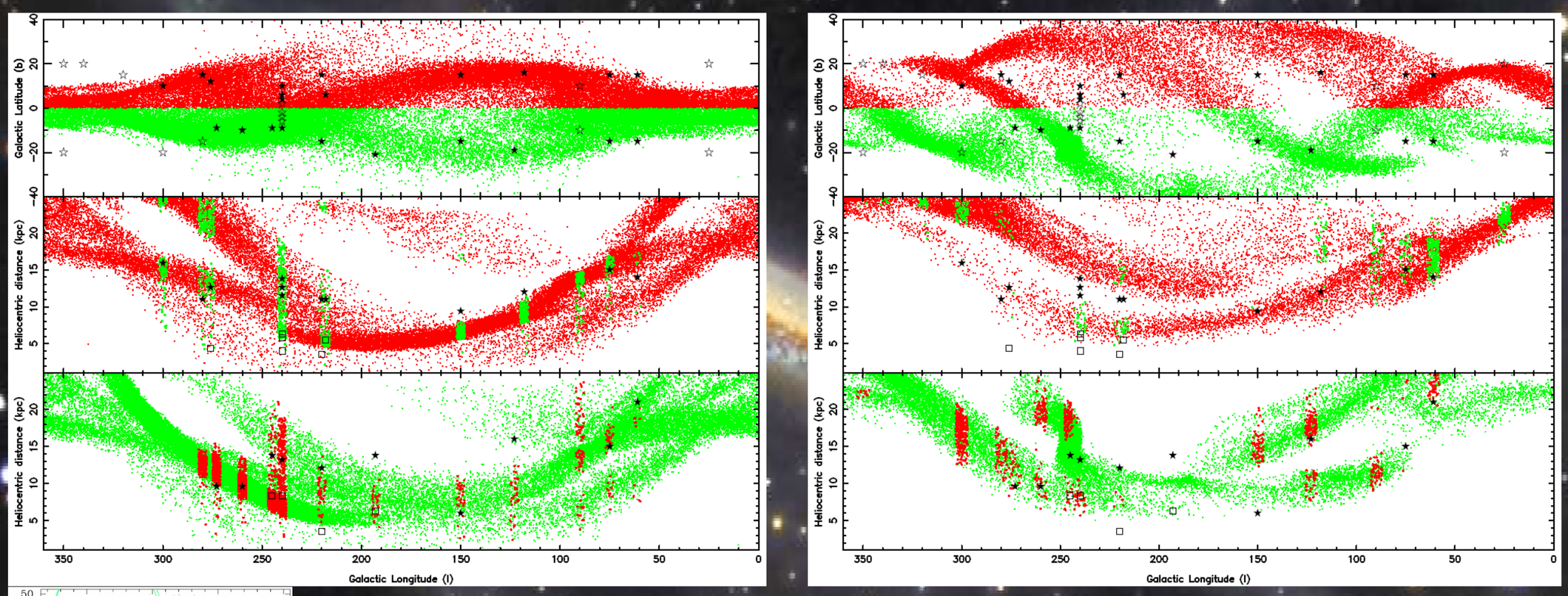


Figure 2: A colour magnitude diagram (CMD), and the applied photometric parallax, of one of our survey fields (*left panel*), and a comparison Besançon Galactic model field ([*right panel*] http://bison.obs-besancon.fr/modele/). The black curves show the locations of the Main Sequence (MS) features of the Galaxy and MRi in this field. Note the lack of an MRi MS in the model field. The offset between these two sequences relates to a Heliocentric distance to the MRi of 11.0 ±1.6 kpc.

Numerical Models



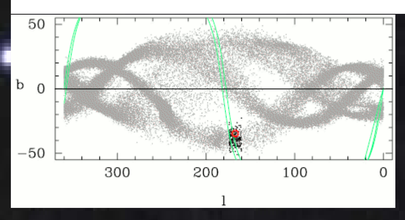


Figure 1: Comparison of the Martin *et al.* (2004 [*left image*]) and Peñarrubia *et al.* (2005 [*right image*]) numerical simulations of the MRi stream overlaid with the MRi detections from previous surveys. Here the top panels show Galactic coordinates, the centre panels show only points above the Galactic Plane versus Heliocentric distance and the lower panel is points below the Galactic Plane. In the centre and lower panels, the points with the opposite colour (i.e., green instead of red or vice versa) are the modelled MRi distances in the direction of the observed fields. Filled stars represent observed fields with positive MRi detections and empty stars represent fields with no MRi detections. Empty squares show the location of the proposed Canis Major feature at that longitude. The inset *(lower left)* shows the Peñurrubia *et al.* (2005) model (grey dots) overlaid with the Sagittarius dwarf orbital plane (green parallel lines), the Cassetti-Dinescu *et al.* (2008) MRi detections (black dots) and their target region for their Sagittarius dwarf member search (red circle).

So, What's Next?

Despite the current survey showing that the MRi extends around the entire Galaxy, both above and below the Plane, and at two distinct distances (reminiscent of a tidally stripped stellar stream exhibiting multiple wraps of the Galaxy), its origins are still uncertain. Due to the Planar location and the enormous extent of the MRi, it is very difficult to determine a definite formation scenario. The popular interpretation of the MRi – that the Canis Major overdensity is the progenitor of this tidally stripped stream of stars encircling the Galaxy – and that it may have been created by a glancing encounter with a passing dwarf galaxy, are therefore both feasible explanations for this important object.

Supporting the tidal breakup scenario, however, a recent survey attempting to trace the Sagittarius dwarf stream (Casetti-Dinescu *et al.* 2008) detected MRi stars at exactly the predicted location from a numerical model of the breakup of a dwarf galaxy progenitor (inset – Figure 1).

Further spectroscopic and imaging studies are in progress to determine velocity and density profiles of the MRi, using data obtained with Subaru/Suprime-Cam, AAT/AAOmega and the MSSSO 40”/WFI. With the continued probing of the outer Disc, via surveys such as these, the origins of this object, and its relation to the evolution of the Galactic disc, will be revealed.

References

Casetti-Dinescu *et al.* 2008, AJ, 135, 2013
Conn *et al*. 2005, MNRAS, 362, 475
Conn *et al*. 2007, MNRAS 376, 939
Conn *et al.* 2008 [submitted to MNRAS]
Ibata *et al.* 2003, MNRAS, 340, L21
Juric *et al.* 2008, ApJ, 673, 864
Martin *et al.* 2004, MNRAS, 348, 12
Momany *et al.* 2004, A&A, 421, L29
Newberg *et al.* 2002, ApJ, 569, 245
Peñarrubia *et al.* 2005, ApJ, 626, 128
Rocha-Pinto *et al.* 2003, ApJ, 594, 115
Younger *et al.* 2008, ApJ, 676, 21

* rlane@physics.usyd.edu.au

[1]: IoA, University of Sydney
[2]: ESO
[3]: IoA Cambridge
[4]: Strasbourg Observatory
[5]: MPIA
[6]: Bologna Observatory

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