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INSIGHTS INTO THE PROPERTIES OF THE ORION SPIRAL ARM. NGC 2302: FIRST RESULT

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We summarize the first results from a program aimed at determining the properties of the Local (Orion) arm - LOA, based on a large and homogeneous set of kinematic and photometric data. We have made a comprehensive study of the young LOA cluster NGC 2302, which includes a *UBVRI* photometric analysis and determination of its kinematic properties -proper motion (PM) and radial velocity (RV) - and of its orbital parameters.

1. THE LOCAL (ORION) ARM

Traditionally, the LOA has been considered to be a small inter-arm feature, but evidence has gathered indicating that it is substantial, and extends into the third Galactic quadrant (3GQ) to at least 10 kpc from the Sun. Remaining unknowns are: 1. Is it part of a less dense superposed grand design pattern, or is it simply a large bifurcation? 2. Does it rotate with the same angular velocity as the four canonical major arms? 3. Is it a transient feature, or will it persist similarly to the major arms?

These questions can be addressed studying the evolution of the LOA, by means of a robust sample of open clusters that trace the present location and extent of the LOA all the way into the 3GQ; and whose kinematics, distances, positions, and ages are known. Integration back in time of their orbits, over the intervals that correspond to their ages, leads to the location of their birthplaces, and thus to retrieving the past structure and motion of the LOA.

2. THE SURVEY

To this end, we have selected 29 open clusters from previous optical/radio studies by our group (see e.g. Vázquez et al., 2008 - Vaz08), and collected all the data required. They are young and intermediate-age clusters (∼4 Myr to ∼2 Gyr), located between 217° < l < 260°, and -5° < b < +5°, and at distances between ∼2-8 Kpc from the Sun. The distribution of our cluster sample in the Galactic plane is shown in Fig. 4 of Vaz08, where black circles depict probable LOA clusters.

Systemic RV for our clusters are being derived from spectra obtained at CTIO (Hydra@Blanco) and ESO (FLAMES@VLT). These set-ups were chosen aiming at a RV precision of ∼2-3 km sec^{-1}. Typically 50 to 100 stars in the field of each cluster were observed.

The *UBVRI* first epoch (1997) data (Moitinho, 2001) used for the photometric analysis leading to distances and ages, as well as the *R*-band second epoch data (12 year timebase) needed to determine the clusters systemic PM were secured with the CTIO 0.9m telescope. Complementary deep *VI* observations were carried out with the Dupont 2.5m telescope at LCO.

Our wealth of data is being reduced, and although we are a long way from our ultimate goal, the first results have been published. Once complete our survey will certainly contribute to a better understanding not only of the LOA, but also of the spiral structure of the Milky Way (MW).

3. NGC2302: FIRST RESULT

Here we report the first result from our survey: a deep, comprehensive, study of the young LOA open cluster NGC 2302 (see Costa at al., 2015), which includes a *UBVRI* photometric analysis, and the determination of its kinematic properties and orbital parameters.

A density analysis of star counts, made using stars within 0.1 mag of the cluster's photometric sequence, allowed us to determine the cluster structure, center and radius, and revealed a round concentration of stars within a radius of 2.5′, centered at α_{2000} = 102.965916°, δ_{2000} = -7.086300°

Photometric diagrams for several color combinations were built. Although they are heavily contaminated by field stars, a cluster sequence of bright stars ($V \leq 18$) is recognized in all diagrams (Fig. 1).

Making a geometric registration of our ad-hoc

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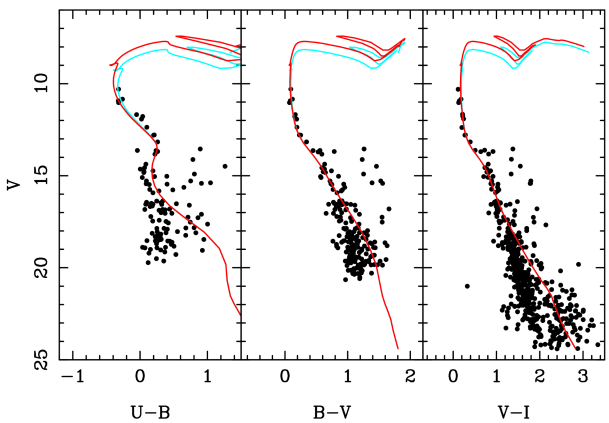

Fig. 1. CMDs of stars within the adopted radius of NGC 2302. Two isochrones from Marigo et al. (2008), displaced for a reddening of $E(B-V) = 0.23$ and for a distance modulus of $(m-M)_0 = 10.69$ (distance, $d = 1.40$ kpc), have been superposed; a $\log(t) = 7.90$ isochrone (80 Myr, red) and a $\log(t) = 8.00$ isochrone (100 Myr, light blue).

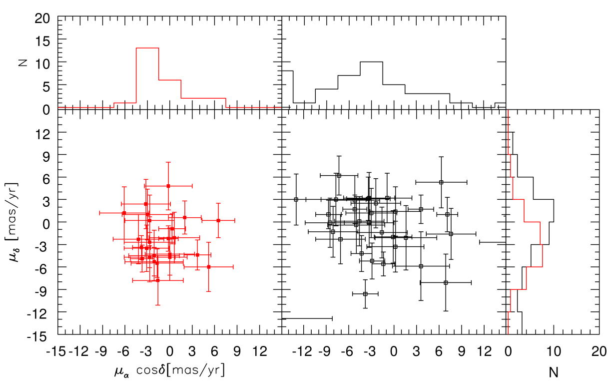

Fig. 2. PM diagram for stars with bona-fide RV *and* PM. Red dots depict stars considered as cluster members for all purposes, and black dots non-members.

first and second epoch CCD frames, we determined the systemic PM of NGC 2302 relative to the local field of disk stars, and, through a comparison with the UCAC4 catalog, we transformed this relative PM to absolute. We obtained an absolute PM for NGC 2302 of $\mu_\alpha \cos\delta$, μ_δ = (-2.09,-2.11) mas yr^{-1}, with a standard error of 0.40 mas yr^{-1} per coordinate (Fig. 2).

Using medium-resolution spectroscopy of 76 stars in the field of NGC 2302 (of which 26 were adopted as bona-fide cluster members), we derived its systemic RV, which turned out to be 31.2 km sec^{-1}, with a standard error of 0.7 km sec^{-1} (Fig. 3).

The cluster's kinematic data and distance allowed us to determine the space motion of NGC 2302 and its orbital parameters. To integrate the orbit, we adopted the model of Allen & Santillan (1991) for

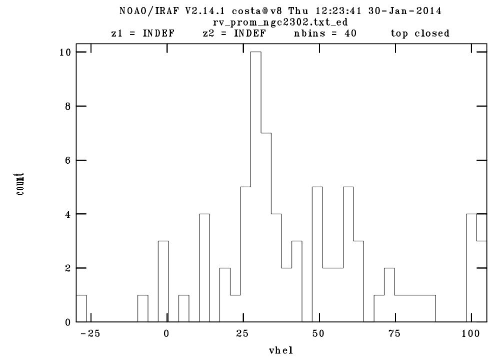

Fig. 3. Radial velocity histogram for 76 stars in the field of NGC 2302.

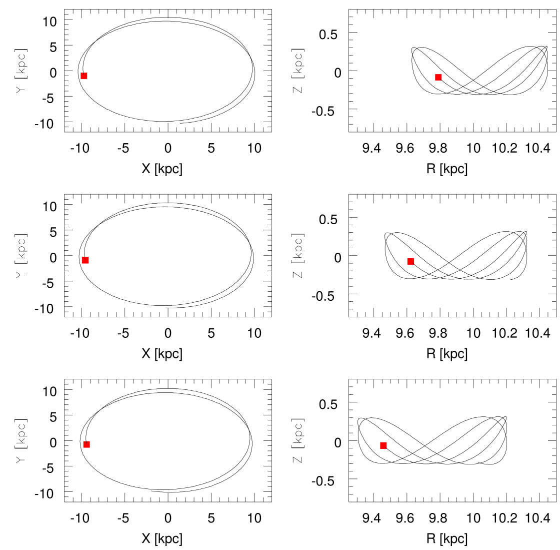

Fig. 4. Orbits calculated back in time for 1.5 Gyr, for assumed cluster distances of 1.2, 1.4, and 1.6 kpc. Red squares indicate the current location of the cluster.

the MW gravitational potential. This potential is time-independent, axisymmetric and fully analytic. Inspecting the shape of the orbits and the resulting orbital parameters, we conclude that NGC 2302 is a typical PopI object (Fig. 4). The eccentricity of the orbit is low, as is its epicyclical amplitude. The absolute maximum distance from the plane is that expected for a PopI object as well.

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