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A complete analysis of NGC2516 with Gaia EDR3 data

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ABSTRACT

Context. xxx
Aims. xxx
Methods. xxx
Results. xxx

Key words. open clusters and associations: general – methods: data analysis – methods: statistical – open clusters and associations: individual: NGC2516

1. Introduction

The NGC 2516 open cluster (also known as: Melotte 82, Caldwell 96, Collinder 172, or Southern Beehive) is a bright cluster visible with the naked eye in the southern skies, almost at the center of the Carina constellation. It is one of the approximately one hundred cataloged clusters located at a distance less than 500 pc away from the solar system. Because of its closeness, young age (~ 100 Myr), and clear photometric sequence, it has been observed and studied consistently for almost one hundred years. Raab (1922) classified it as a "very large, thin, irregular, well defined cluster containing a very great number of stars, many of which are very bright". More than 600 references are returned today in a quick SIMBAD bibliography search.[1]

In Fig. 1 we show a Digitized Sky Survey (DSS) frame centered on NGC 2516, obtained from the Aladin Sky Atlas.[2]

Recently Borodina et al. (2021) showed that cluster masses increase linearly with binary fraction, when binary stars are taken into account. This is: cluster masses are underestimated if the presence of binaries is neglected.

Kouwenhoven & de Grijs (2009) demonstrated a similar but inverse effect for the dynamical masses, i.e. that not taking binary systems into account results in an overestimation of the dynamical mass.

In Perren et al. (2015)...

This paper is organized as follows: in Section 2 we present the data used in this work. Sections 3 and 4 show the structural and membership analysis, respectively. xxx Results are summarized in Section 6. Finally, our conclusions are given in Section 7.

figs/NGC2516_DSS.png

Fig. 1. NGC 2516, DSS colored image from the Aladin Sky Atlas.

2. Gaia EDR3 data

The data used throughout this article is taken from the Gaia EDR3 survey (Gaia Collaboration et al. 2020). We downloaded a region of 4x4 deg^2 centered on (α_{2016} = 119.5167, δ_{2016} = −60.7533), using the Vizier[3] service.

A magnitude cut on G = 18 mag was imposed on the data resulting in a total of 114512 sources for the complete frame. Of these, only 882 sources contained missing information in either the parallax, proper motions, or photometry, and were thus discarded from the fundamental parameters analysis. The reason for

[1] http://simbad.u-strasbg.fr/simbad/
[2] https://aladin.u-strasbg.fr/
[3] https://vizier.u-strasbg.fr/viz-bin/VizieR

using only stars with $G \leq 18$ mag is that below $G \approx 18.5$ mag the Gaia color $BP - RP$ starts to become more negative, shifting the stars towards a non-physical (bluer) region of the color-magnitude diagram (CMD). This effect is attributed to an overestimation of the flux in the BP passband for faint sources (Godoy-Rivera et al. 2021). This artifact in the photometry would obviously have a negative impact on the CMD analysis, presented in Sect. 5. In addition, below $G = 18$ mag the uncertainties of not only the photometry but also the proper motions and parallax start exponentially growing to very large values. This cut allows us to keep the sub-sample of data with the lowest uncertainties.

As shown in Fabricius et al. (2020), a 100% completeness of Gaia EDR3 data is guaranteed up to $G = 20$ mag for regions of density below 2×10^5 deg^{-2}. Our downloaded Gaia EDR3 frame containing NGC 2516 has a maximum density that is smaller than $\sim 1.1\times10^5$ deg^{-2} at its peak. Hence, this guarantees that the studied cluster sequence is complete down to the lowest-mass stars. This is an important fact to establish, since the estimated total cluster mass depends heavily on the total number of identified true members.

In Fig. 2 we show the final Gaia EDR3 data analyzed in this work. The (α^*, δ^*) coordinates are displaced to the cluster's center, and the right ascension is multiplied by the cosine of the declination. In all four plots the position of the cluster visibly stands out from the remaining field stars.

3. Structural properties

The region surrounding this cluster shows a markedly non-uniform distribution of field stars. This contamination appears mostly above $G \approx 15$ mag, as seen in Fig3.

4. Membership analysis

In this section we present the Gaia EDR3 data used throughout the analysis, as well as the membership estimation method and the final set of most likely member stars.

The 4x4 deg^2 field centered on NGC 2516 shows a pyUPMASK

4.1. Sanity check

Number of members estimated through a field density analysis. Number of members estimated by filtering stars

5. Estimation of fundamental parameters

xxx

5.1. Fundamental parameters with `AsteCA`

xxx

5.2. Identification of single/binary systems

xxx

5.3. Estimation of masses for binary systems

In Borodina et al. (2021) the authors use a quadratic mass-luminosity relation for main sequence stars, to estimate the masses for the primary and secondary stars in a binary system.

6. Results

González & Lapasset (2000)

Jeffries et al. (2001)
Sung et al. (2002)
Piskunov et al. (2007)
Piskunov et al. (2008)
de Grijs et al. (2008)
Kouwenhoven & de Grijs (2009)
Jilinski et al. (2009) analyzes the orbit
Silaj & Landstreet (2014)
Liu & Pang (2019)
Jackson et al. (2016)
Jackson et al. (2020)
Pang et al. (2021)
Cantat-Gaudin et al. (2020)
Borodina et al. (2021)

7. Conclusions

xxx

Acknowledgements. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France (Wenger et al. 2000). This research has made use of the VizieR catalogue access tool, CDS, Strasbourg, France (DOI: 10.26093/cds/vizier). The original description of the VizieR service was published in Ochsenbein et al. (2000). This research has made use of "Aladin sky atlas" developed at CDS, Strasbourg Observatory, France (Bonnarel et al. 2000; Boch & Fernique 2014).

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figs/NGC2516_4_plots.png

Fig. 2. A: (transformed) right ascension and declination for the full frame. B: CMD for all the sources. C: vector-point diagram (VPD) for the proper motions, centered and zoomed on the cluster's estimated systemic values. D: Histogram of the parallax values, in the range [-0.5, 3.5] mas.

figs/dens_map.png

Fig. 3. Density maps of the NGC 2516 frame, N is the number of stars in each plot. Left: complete frame. Center: stars brighter than G = 15 mag. Right: low mass stars below G = 15 mag.

figs/dens_vs_rad.png

Fig. 4. Density estimation versus distance to the center of NGC 2516.