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Analysis of open star cluster NGC 2632 with Gaia EDR3

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Abstract

The extensive research of open star cluster NGC2632 is presented based on data of Gaia EDR3. 1022 probable and possible members of the cluster were discovered. The kinematic and some other sensitive parameters of the open cluster NGC2632 were obtained and discussed.

1 Introduction

Recently, many expressions that previously seemed fantastic (for example, Artificial Intelligence, machine learning, neural networks and Big Data) become usual in scientific terminology, research articles, data processing techniques. The technologies behind these terms are increasingly becoming commonplace and a necessary tool for a modern researcher. In this regard, astronomy, as a multidisciplinary science, is at the forefront. It is known that one of the urgent fundamental problems of modern astronomy is a detailed study of our Galaxy and its components – star clusters, associations and complexes. With the introduction of high-precision and high-resolution observational equipment installed at new ground-based and orbital astronomical observatories, deep observational study of star clusters are receiving a new impetus. In this sense, the launch and successful operation of the Gaia orbital observatory (see, for example, Gaia Collaboration *et al.* (2016)) has made a truly revolutionary breakthrough in the amount and accuracy of observational data. The global goal of Gaia is to create a unique 5D - parametric observational survey of the stellar population, planets, comets, asteroids and exoplanets of our Galaxy up to a distance of 20 kpc from the Sun, as well as quasars that fall into the field of view. By now, observational data of the first, second stages (GaiaDR1 and DR2, 2016-2018) and third stage Early Release EDR3 (Gaia EDR3, 2020) have been obtained and made available, which we used in this work.

2 Object and research methods

The open star cluster NGC2632 = M44 = Melotte88 = MWSC1527 (RA = 08 40 24.0 Dec = + 19 40 00, 205.9195 +32.4843 Gal, ep=J2000) also known as Praesepe (in en., the Manger) cluster is one of the closest to the Earth (according to updated data, its distance from the Sun is about 187 pc) (Wu *et al.* (2009); Gaia Collaboration *et al.* (2018)) and rich open star clusters along with the Pleiades and Hyades (presumably genetically related to NGC2632, since they have the same kinematics and velocity vector in space, that probably means, they originated in one molecular cloud) is quite interesting and convenient object for the comprehensive study. At the same time it is very important qua an experimental laboratory for testing modern methods in the framework of international SAGE project we involved, as well as, for test-

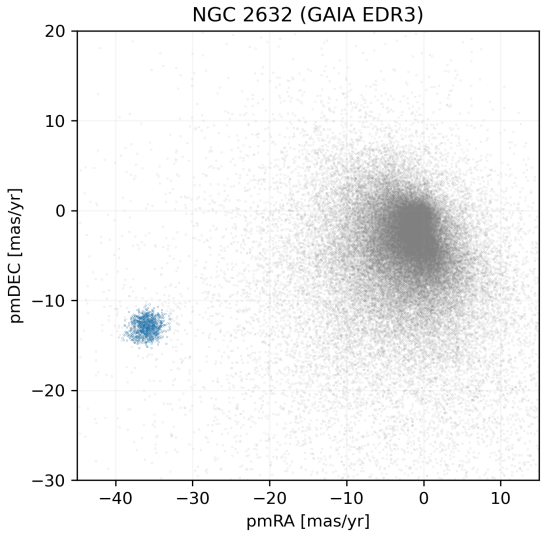

Figure 1: Stellar proper motions along the GAIA EDR3 data cone. A clear clustering is visible, corresponding to the objects which belong to NGC 2632 - this area highlighted in blue on the left part of the figure. These data was used for the primary selection of cluster members. The larger and more numerous group corresponds to the stars of the general field of the Galaxy.

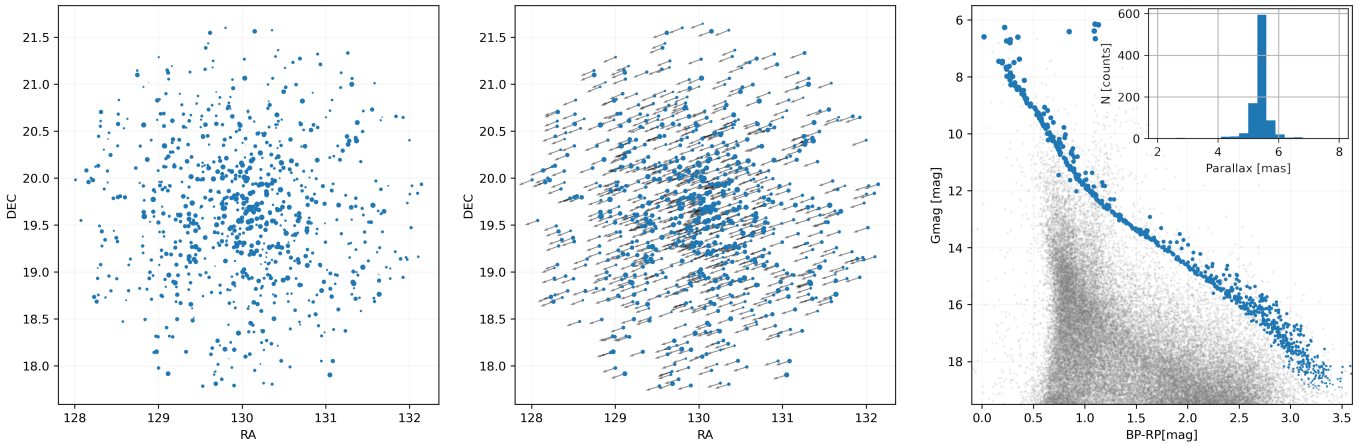

Figure 2: The spatial distribution of the selected members of the star cluster NGC 2632 (left panel) after preliminary filtering (for clarity, the relative magnitudes of the objects are shown by the sizes of the points), the same spatial distribution, but with superimposed motion vectors, demonstrating the consistency of the direction of motion (panel in the center). The corresponding color-magnitude diagram for the cluster stars (right panel), with a well-defined line of the Zero-Age Main Sequence. The histogram of parallaxes of the selected stars are shown inserted into the body of last figure in the right panel.

ing, deep improving (perfecting) the methods for study of star clusters and associations. The apparent diameter of open cluster NGC2632 was estimated as about 70 arcmin (Wang *et al.* (2014)), but it is most likely that the cluster's corona extends far beyond its visible contours. We have processed and analysed the extensive databases of Gaia DR1 - EDR3. The TOPCAT[1], ASteCA[2], StarGO software were applied, involving the principles of distributed computing in neural networks and machine learning. The set of functions included in the ASteCA code make use of positional and photometric data to obtain precise and objective values for a given cluster's center coordinates, radius, luminosity function and integrated color magnitude, as well as characterizing through a statistical estimator its probability of being a true physical cluster rather than a random overdensity of field stars. ASteCA incorporates a Bayesian field star decontamination algorithm capable of assigning membership probabilities using photometric data alone. An isochrone fitting process based on the generation of synthetic clusters from theoretical isochrones and selection of the best fit through a genetic algorithm is also present, which allows ASteCA to provide accurate estimates for a cluster's metallicity, age, extinction and distance values along with its uncertainties (Perren, G. I. *et al.* (2015)).

The standard dataset was loaded from the GAIA EDR3 I/350 Vizier catalog. In this work, we indicated the radius from the center of the cluster at 1.5°, with a limit of 19 magnitude, which is associated with the peculiarities of ASteCA operation (with a large amount of data, the algorithm does not work) and depends on the computing power of your computer.

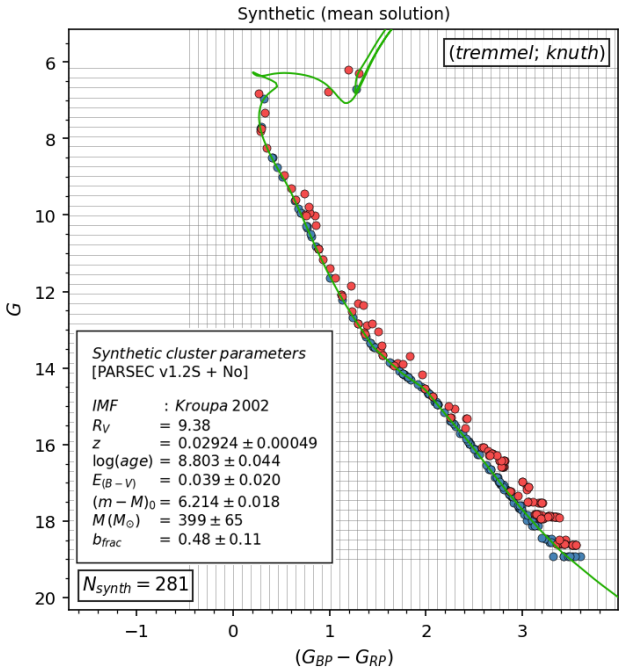

Figure 3: Resulting fit of PADOVA isochrones to estimate the age, distance modulus, and metallicity of cluster stars. Initial Mass Function has been borroved from (Kroupa (2002))

3 Results and discussion

The pictorial distribution of cluster members in projection onto the sky plane, a vector diagram of proper motions, his-

[1]http://www.star.bris.ac.uk/ mbt/topcat/
[2]https://github.com/asteca

tograms of the distribution of cluster stars by proper motions, radial velocities, parallaxes, the initial mass function and the luminosity function for members of the cluster were obtained on the basis of targeted processing of data on stars in the area of open cluster NGC2632. As an illustration, in Figure 1 we present a diagram of proper motions in a wide field (4 deg in diameter), covering open cluster NGC2632. General field stars which not associated with the open cluster are focused around pmRA | pmDE [0; 0], while cluster members are clearly revealed as a dark-blue spot around pmRA | pmDE [−36.383; −12.654] with [−32.582 ÷ −40.185; −12.424 ÷ −12.885], just below and to the left of the location of field stars. We have identified 1022 probable and less possible members, which exceeds the number of members of the cluster discovered before us (about 900). We have built a Hertzsprung-Russell evolutionary diagram of stars in the area of open cluster NGC2632, which is shown in Figure 2 (right panel). The dark-blue dots represent the stars - members of the open cluster NGC2632. The Zero Age Main Sequence (ZAMS), the giant star branch, and also subdwarfs and likely white dwarfs (below the ZAMS) are well distinguished. The gray dots represent the general field stars. The histogram with distribution of the cluster members' parallaxes is shown in Figure 3 demonstrating the sharp profile at 5-6 mas. Resulting fit of PADOVA isochrones to estimate the age, distance modulus, and metallicity of cluster stars is presented in Figure 3 : the main derived parameters of the cluster are given in the sector-tables inserted into the Figure body.

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