Report of the activity of the quintuplet "Star clusters"

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Abstract

During 2018, we devoted our activity to two different aspects. The former consists in the preparation of tools to exploit LSST data, such as the calibration of stellar colours to provide photometric metallicity through the results of high-resolution spectral surveys, e.g. Gaia-ESO, and such as the creation of algorithms for star cluster detection that make use of both photometric and astrometric data. The latter concerns in our participation and involvement in the White Papers (WPs) for LSST cadence optimisation to which we have contributed with a WP on the detection and characterisation of star clusters in the Galactic Plane proposing to include it in the main Wide-Fast-Deep (WFD) survey.

1 Quintuplet Information 2018

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2 Quintuplet Information 2019

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1. **Scientific Collaborations:** LSST Stars, Milky Way & Local Volume Science Collaboration

3 Scientific Activity

Our group actively participated to the call for white papers (WPs) on cadence optimization. We participated to several WPs and we submitted our own WP *Investigating the population of Galactic star formation regions and star clusters within a Wide-Fast-Deep Coverage of the Galactic Plane* (PIs: Loredana Prisinzano -OAPa and Laura Magrini-OAA) in collaboration with the LSST Italian group of the Observatory of Palermo. More than 30 researchers from Italy, US, Chile, Spain, etc. participated to this WP, including members and collaborators of our quintuplet. In our WP, we propose to include the Galactic Plane in the Wide-Fast-Deep (WFD) survey to allow a deeper systematic survey of star clusters and star forming regions (SFRs) in our Galaxy. In particular, the observations obtained with LSST will make a big difference in Galactic regions that have been poorly studied in the past, such as the anti-center and the disk beyond the Galactic center, and they will have a strong impact in discovering new distant SFRs.

Our project long-term project consists in developing and calibrating a tool to determine stellar metallicity from the LSST photometry (see [2] for a photometric metallicity scale for open clusters). Specifically, we aim to derive stellar metallicity using the colours derived by LSST spectral bands. Spectroscopic metallicities of benchmark stars and star clusters observed for the final data release of the Gaia-ESO Survey will be used as calibrators. As done for the SDSS [1], it is possible to convert the photometric colours in an estimate of [Fe/H], since for a given spectral type, a star with enhanced metal content (i.e. large [Fe/H]) produces less flux in the blue portion of its optical spectrum. For SDSS, it has been possible to find a function that relates all photometric colours to [Fe/H]. We have simulated the computation of a correlation between colours and metallicity for LSST using SDSS photometric data and the results of DR5 of Gaia-ESO. In Figure 1, we show our preliminary results (left panel) to be compared with the results of the SEGUE-SLOAN sample of [1]. At survey completion, LSST will provide for stars with $0.2 < g - r < 0.6$ and apparent magnitude $g < 23.5$ an error on the u-g color of 0.05 mag, a practical limit for robust metallicity studies. This will translate in a metallicity measurement accurate to 0.2 dex or better for at least 200 million F/G main-sequence stars brighter than $g < 23.5$, generating an incredible revolution in Galactic studies.

Our group prepared several tools to perform star cluster detection making use of both photometric and astrometric data. We developed several tools useful for cluster detection and characterization. The tools have been used on Gaia DR2 data, providing excellent results.

i) UPMASK: it is a tool that allows the identification of members of star clusters based on clustering algorithm. This tool makes use of both photometry and astrometry. It has been successfully used on Gaia DR2 data where it has allowed the membership determination of 1200 clusters [3]. It has proven to be effective also in the detection of new star clusters [4].

ii) DBSCAN: it is based on a density clustering algorithm. It consists in a supervised learning method such as an artificial neural network (ANN) to automatically distinguish between real star clusters and statistical overdensities. This tool was tested on Gaia DR2 data [5].

iii) BASE9: an already existing Bayesian tool (BASE9) has been intensively tested to derive ages, distances, extinction on about 300 clusters based on Gaia DR2 photometry (Bossini, Vallenari, Cantat Gaudin, Carrera et al 2018, A&A, submitted).

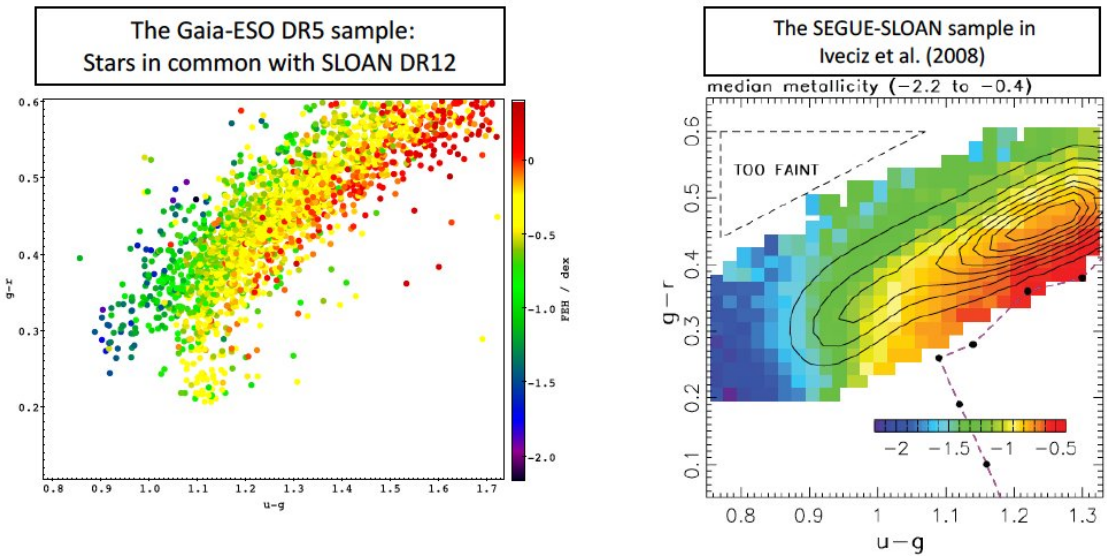

Figure 1: $g-r$ vs. $u-g$ colours of stars in common between SLOAN DR12 and Gaia-ESO DR5 (left panel). The colour code indicates the metallicity from Gaia ESO DR5. In the right panel, we show the results of [1] for the SEGUE-SLOAN sample.

4 Scientific and technical deliverables

White Papers for the call on LSST cadence optimisation (November 30, 2018):

1. *Investigating the population of Galactic star formation regions and star clusters within a Wide-Fast-Deep Coverage of the Galactic Plane*, PIs Loredana Prisinzano and **Laura Magrini**, co-Is **Germano Sacco, Antonella Vallenari, Diego Bossini**
2. *Young Stars and their Variability with LSST* PIs Sara Bonito and Patrick Hartigan, co-Is **Laura Magrini and Germano Sacco**
3. *unVEil the darknesS of The gAlactic buLgE (VESTALE)*, PIs Giuseppe Bono and Massimo Dall'Ora, co-Is **Laura Magrini and Germano Sacco**

1. **List of attached documents:**

Investigating the population of Galactic star formation regions and star clusters within a Wide-Fast-Deep Coverage of the Galactic Plane, PIs Loredana Prisinzano and Laura Magrini

5 Other information

Participation to LSST meetings in 2018:

1. LSST TVS 2018, Osservatorio Astronomico di Capodimonte, April 9-11 2018 (participants: Laura Magrini & Germano Sacco)

2. LSST@Europe3, Lyon, June 11-15 2018 (Member of the SOC: Antonella Vallenari). The talk of Laura Magrini "A calibration of LSST photometric metallicity using spectroscopic ground-based survey results" was accepted in Session 4: LSST Science: Stars, Milky Way, and Local Volume but finally she could not participate to the meeting.
3. LSST 2018, Osservatorio Astronomico di Palermo, October 8-10 2018 (participant: Germano Sacco)

6 References

References

[1] Ivezić, Ž., Sesar, B., Jurić, M., et al. 2008, ApJ, 684, 287

[2] Netopil & Paunzen, 2013, A&A, 557

[3] Cantat-Gaudin, T., Jordi, C., Vallenari, A., et al. 2018, A&A, 618, A93

[4] Cantat-Gaudin, T., Krone-Martins, A., Sedaghat, N., et al. 2018, arXiv:1810.05494

[5] Castro-Ginard, A., Jordi, C., Luri, X., et al. 2018, A&A, 618, A59