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Star forming regions in nearby galaxies: a potential application for Gaia's observations

P. Drazinos[1], E. Kontizas[2], M. Kontizas[1], A. Karampelas[1], A. Dapergolas[2],
I. Bellas-Velidis[2], and E. Livanou[1]

[1] Department of Astrophysics, Astronomy & Mechanics, Faculty of Physics, University of Athens, GR-15783 Athens, Greece, e-mail: `pdrazinos@noa.gr`
[2] Institute for Astronomy and Astrophysics, National Observatory of Athens, P.O. Box 20048, GR-11810 Athens, Greece

Abstract. Our aim is to investigate whether Gaia can contribute to the study of star forming regions in nearby galaxies. A Friend of Friend algorithm has been applied to a number of galaxies in the Local Group to study star forming regions for the detection of young stellar structures. The detection limit of Gaia is G < 20 mag that corresponds to V ∼ 20.1 mag (for B-V values from -0.5 to 0.25) whereas the spatial resolution is comparable to HST. For a number of nearby galaxies (LMC, SMC, M31, M33, NGC 6822) the young main sequence stars within Gaia detection limit were selected from their CMD. Stellar structures were detected with sizes varying from small clusters up to stellar supercomplexes.

Key words. Gaia, Local Group, Galaxies

1. Introduction

A global space astrometry mission, Gaia will create an extraordinarily precise 3D map of about a billion stars throughout our Galaxy and beyond. Gaia will monitor each of its target stars about 70 times over a five-year period. It will precisely chart their positions, distances, movements, and changes in brightness. It is expected that Gaia will also observe millions of galaxies, most of them unresolved seen as point sources. A number of nearby galaxies that will be resolved in stars provide the opportunity to add another application for **Gaia's** observations. Our aim is to study some of the nearby galaxies that are expected to be resolved in stars by Gaia and to provide an estimate on the number of stars that fall within the Gaia detection limit (G=20). Additionally to identify and provide lists of young stellar structures in a number of Local Group galaxies, as the Magellanic Clouds, M31 and M33.

2. Data

Since Gaia is not yet in operation the only way to estimate the number of stars that will observe in nearby galaxies is to go through already published catalogs from other surveys and identify all catalog members that fall within Gaia's detection limits. In our study we present the results for five nearby galaxies, the Magellanic Clouds (LMC and SMC), M31, M33 and NGC 6822.

The LMC and SMC stellar catalogs are from the Magellanic Clouds Photometric

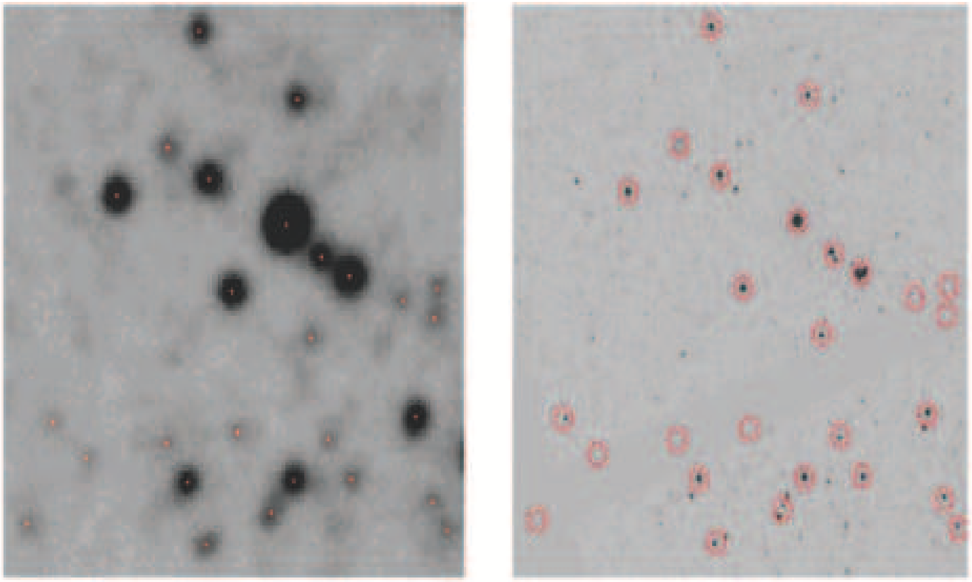

Fig. 1. Comparison of images of the same region of M31 (OB58) from KPNO on the left and HST WFPC2 on the right (Massey et al 2007).

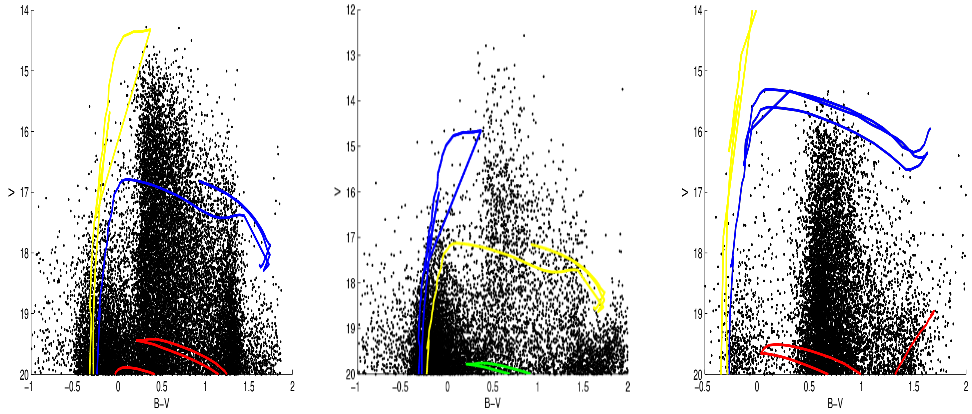

Fig. 2. CMD's of M31 (left), M33 (middle) and NGC 6822 (right) with isochrones for 6.6, 10 and 50 Myrs.

Survey (Zaritsky et al 2002, 2004). This catalog was also used to provide data for the Gaia Universe Model Snapshot (Robin et al 2012 and M. K. Beltceheva et al 2011). The observations for the survey were made with the Las Campanas Swope 1m Telescope (scale:**0.”7 /pixel).**

The other three stellar catalogs for, M31, M33 and NGC 6822 are taken from Local Group Galaxy Survey (Massey et al 2007). M31 and M33 were observed with the Kitt Peak National Observatory (KPNO) 4m telescope (scale:**0.”261 /pixel)** and NGC 6822 observed with the Cerro Tololo Inter American Observatory (CTIO) 4m telescope.

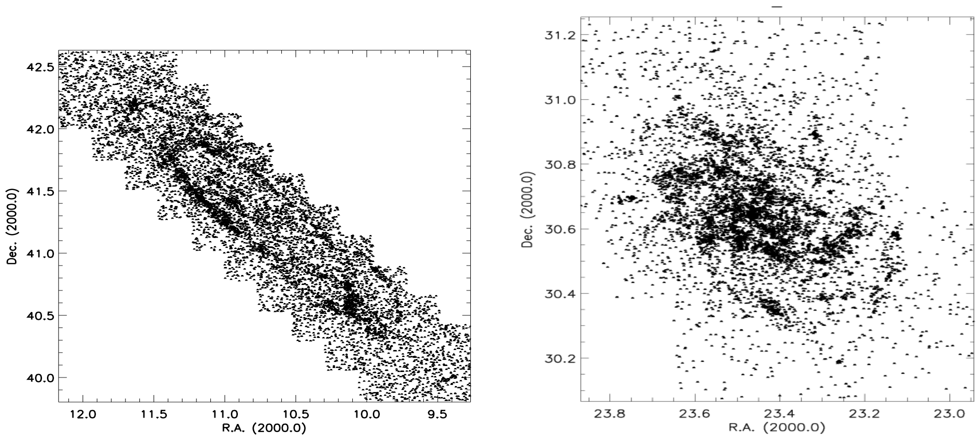

Fig. 3. M31 (left) and M33 (right) mapped with stars expected to be observed by Gaia.

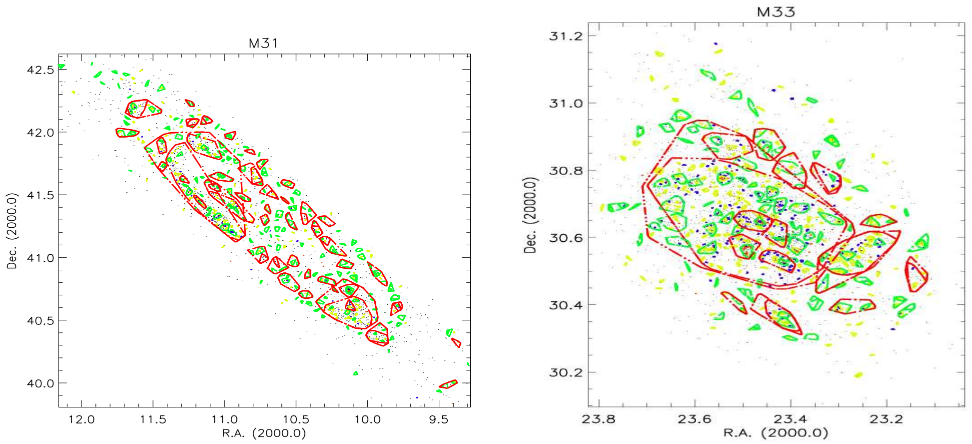

Fig. 4. Young stellar structures in M31 (left) and M33 (right) (Orange less than 30pc, Blue from 30pc to 100pc, Yellow from 100pc to 300pc, Green from 300pc to 1kpc and Red larger than 1kpc.)

(scale:**0.”27/pixel).** All galaxies presented here were observed with ground based telescopes. One of Gaia’s advantages is high resolution observations from space, in both surveys (MCPS and LGGS) the average seeing reported was much lower than the resolution of each instrument. The resolution of GAIA is comparable to Hubble Space Telescope (HST) which can be used as a measure of comparison with existing observations. In Figure 1, targets that are observed as single stars with KPNO on the left are resolved into multiple targets when observed with HST WFPC2 on the right.

In Figure 2, **CMD’s** of galaxies resolved in stars (Massey et al 2007). The red line indicates the detection limit of young blue stars $V \approx 20$**.** The subsample of young stars was used for the identification of young stellar structures in section 3.

Fig. 5. Young stellar structures in SMC mapped with stars estimated to be observed by Gaia's spectroscopic instrument.

3. Number of stars within Gaia detection limits

In the Gaia Universe Model simulation (Robin et al 2012) it was estimated that about 9 million stars in both LMC/SMC fall within G=20 and 1.2 million stars are within the spectroscopic instrument limits ($G \approx 16$) that will provide radial velocities. For M31 about 12,000 stars were found within G=20, 10,000 stars for M33 and about 1400 stars for NGC 6822. In Figure 3, an estimation of how Gaia will observe M31 and M33 as resolved galaxies. Due to the high resolution of Gaia the number of stars to be observed is expected to be much higher than the numbers presented in this study.

4. Detection of young stellar structures

From the stars that fall within G=20 we selected a subsample of young main sequence bright stars in order to identify young stellar formations. A technique using a Friend of Friend (FoF) algorithm (Drazinos et al 2013) was used. The identified structures were varying in size, from a few pc up to a few kpc. In Figures 4 and 5 M31, M33 and SMC respectively are mapped with the identified structures. In the case of SMC these structures consists of stars within Gaia's spectroscopic instrument detection limit, G=16.

5. Conclusions

Even though Gaia's primary objective is to observe billions of stars within our galaxy, will also provide millions of observations of extragalactic objects. We present an estimation of the obervations of Gaia of resolved galaxies in the local group. Only within the Magellanic clouds Gaia is estimated to observe more than 8 million stars. The resolved galaxies provide an opportunity to study these galaxies using a homogeneous data set of observations. A new application of the expected data is the identification of young stellar formations using a FoF algorithm.

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