Astronomy and Astrophysics in the Gaia sky
Proceedings IAU Symposium No. 330, 2017
A. Recio-Blanco, P. de Laverny, A.G.A. Brown & T. Prusti, eds.

doi:10.1017/S1743921317005580

Magellanic Clouds Proper Motion and Rotation with Gaia DR1

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Abstract. We used the Gaia data release 1 to study the proper motion fields of the Large and Small Magellanic Clouds (LMC, SMC) on the basis of the Tycho-Gaia Astrometric Solution (van der Marel & Sahlmann 2016). The Gaia LMC and SMC proper motions have similar accuracy and agree to within the uncertainties with existing HST proper motion measurements. Since Gaia probes the young stellar population and uses different methods with different systematics, this provides an external validation of both data sets and their underlying approaches.

Keywords. Magellanic Clouds, Local Group, galaxies: kinematics and dynamics, astrometry

1. Introduction

Precise proper motions can inform us on the dynamics of galaxies, in particular those of the relatively nearby Local Group. The Hipparcos survey was not sufficiently precise for detailed studies, thus most proper motions studies of Local Group dynamics relied on measurements with the Hubble Space Telescope (HST, e.g. van der Marel & Kallivayalil 2014) and VLBI. This picture is changing with the Gaia survey and we studied the dynamics of the LMC and SMC using the first Gaia Data Release (DR1, Gaia Collaboration et al. 2016a,b) proper motions of individual bright stars (van der Marel & Sahlmann 2016). The highest-precision Gaia proper motions available in DR1 were obtained for Hipparcos stars as part of the Tycho-Gaia Astrometric Solution (TGAS) catalog. We retrieved TGAS proper motions for 29 Hipparcos stars in the LMC and for 8 Hipparcos stars in the SMC, mostly B and A supergiants, a sample that was studied by Kroupa & Bastian (1997).

2. LMC proper motion and rotation

The LMC center-of-mass proper motions measured with Gaia and HST have similar accuracy and agree to within the uncertainties. In Figure 1, clockwise stellar motion is clearly evident. This qualitatively validates the accuracy of the TGAS data, and confirms that the stars belong to the LMC. We modelled the LMC proper motion field to derive its kinematic and geometric parameters. Although the Gaia and HST studies probe different stellar populations, we find excellent agreement in terms of the derived LMC parameters.

3. SMC results

The SMC center-of-mass proper motions measured with Gaia and HST have similar accuracy and agree to within the uncertainties. No rotation in the plane of the sky is evident, because the SMC is smaller than the LMC, and the TGAS stars are closer to the galaxy center then they are for the LMC.

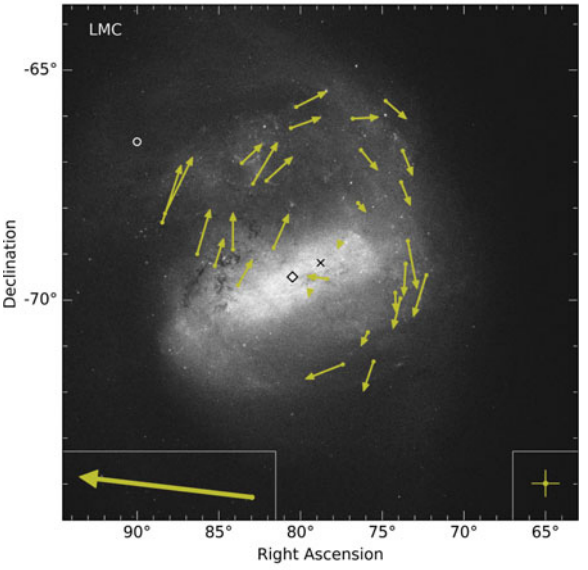

Figure 1. Spatially variable component of the observed Gaia TGAS proper motion field for the LMC, overlaid on a representation of the Gaia DR1 source density. Solid dots show the positions of the 29 sample stars and arrows correspond to the individual Gaia proper motions minus the best-fit center-of-mass motion (bottom left inset). Clockwise rotation is clearly evident. The bottom right inset shows the median proper motion uncertainty. The panel is centered on the dynamical center (cross). The locations of the southern ecliptic pole (open circle) and the JWST astrometric calibration field (diamond, see Sahlmann *et al.* in this volume) are indicated.

4. Conclusions

We have used the Gaia DR1 to obtain new insights into the motions and internal kinematics of the Magellanic Clouds. Within the uncertainties, the results inferred from Gaia are consistent with existing HST studies. Since Gaia probes the young stellar population and uses different methods with different systematics, this provides an external validation of both data sets and their underlying approaches. Both Gaia and HST (van der Marel & Kallivayalil 2014) confidently detect and quantify the rotation of the LMC disk. In a follow-up search for LMC runaway stars, Lennon et al. (2016) discovered a candidate hypervelocity star based on its TGAS proper motion.

Acknowledgements

This work has made use of data from the European Space Agency (ESA) mission *Gaia* (https://www.cosmos.esa.int/gaia), processed by the *Gaia* Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the *Gaia* Multilateral Agreement.

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https://doi.org/10.1017/S1743921317005580 Published online by Cambridge University Press