EPSC Abstracts
Vol. 13, EPSC-DPS2019-249-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

A new debiasing approach for archive asteroid astrometry with Gaia DR2

Paolo Tanga and Federica Spoto
Université Côte d'Azur, Observatoire de la Côte d'Azur, Laboratoire Lagrange/CNRS UMR7293 (paolo.tanga@ oca.eu)

Abstract

As shown in the past, differences in zonal errors in old astrometric catalogs are at the origin of large residuals and poor statistical properties in the orbit computation of asteroids, whose astrometry has been calibrated by such catalogs. The increase in astrometric accuracy brought by the Gaia mission of ESA is the source of new challenges for the correct computation of improved asteroid orbits, especially when astrometric measurements reduced with previous catalogs are included. We explain a new approach to debiasing, devoted to the mitigation of zonal error in the available pre-Gaia asteroid astrometry.

1. Introduction

The Gaia consortium has published on April 25, 2018, the game-changing Data Release 2, nearly reaching the full potential of the mission in terms of astrometric accuracy.

A full star catalogue, with positions and proper motions, has been provided in a strongly improved, self-consistent reference frame registered on ICRS. The astrometric measurements and G band photometry for 14,099 asteroids have also been published.

The use of asteroid observations by Gaia has been thoroughly described in [1], including the delicate task of computing asteroid orbits. The results show that typical post-fit residuals are of the order of the milli-arcsecond when the observations and the data model are properly exploited.

Such an accuracy confirms previous expectations and paves the way to the measurement of subtle dynamical effects, such the Yarkovsky thermal acceleration. However, all secular effects require a time span of astrometry longer than provided by the duration of Gaia alone. For such reason, the joint exploitation of Gaia astrometry with observations obtained in the past (over several decades) is required.

This is a very delicate task as systematic errors present in the previous astrometric catalogues, used as a reference in small-field astrometry, must be reduced as much as possible to avoid a strong deterioration of the results [2].

Such systematic errors are mainly introduced by three sources that can differ among catalogues:

- Instrumental effects, due to the astrometric technique, the field-of-view, optical distortions, observations strategy, etc.

- Differences in the reference frame.

- The presence and quality of proper motions.

2. Debiasing approach

A full correction of such problems would require a new data reduction of the original data (i.e. restarting from plate coordinates of the sources) that would refer all positions to Gaia DR2. Of course, this is an overwhelming task given the amount of observations, and even impossible when the original data are not accessible or lost.

However, a mitigation of the astrometry problems can also be obtained by a so-called debiasing, performed by directly comparing the old catalogue positions to a reference catalogue. Local errors can be estimated by the difference on positions (and proper motions) on sky patches.

This approach was implemented by [3] and [4] who used a fixed healpix tessellation covering the whole sky, and a selection of the PPMXL catalogue (in common to SMASS to compute proper motions) as a reference.

Here we introduce a new approach, not based on a fixed tessellation common to all catalogues, but on sky patches surrounding each asteroid position to be corrected. The main advantages of this technique are two: no discontinuities are introduced, as in the fixed tessellation case; several parameters of the original

observation can be fine-tuned (for instance field of view size and magnitude depth).

We implemented this approach as it appears much more flexible and with an ample margin of improvement when ancillary information is available. Also, it appears to be better suited to exploit the full potential of Gaia, that provides a dense and homogeneous sample of reference stars with a negligible contribution of systematic errors.

3. Results and conclusions

We fully tested our approach on the positions of a few 1000s asteroids with a simplified version, that assumes a fixed field of view (radius of 0.5 degrees) and limiting magnitude (V~15). Many expected patterns emerge from the difference of past astrometric catalogues with Gaia DR2.

Our validations of the method rests on the computation of refined orbits by joining DR2 observations and old astrometry. The improvement in the residuals is clearly visible.

A more evolved version has then been implemented, with additional information on the field of view and magnitude depth, customized by survey when possible. Our results, future developments and a strategy for sharing the debiasing outcome will be discussed.

Acknowledgements

We acknowledge the support of the BQR program of Observatoire de la Côte d'Azur, of the CNES fellowship program, of the French Programme National de Planetologie.

References

[1] The Gaia collaboration, Spoto, F. et al., Gaia Data Release 2. Observations of Solar System objects. A&A 616, A13, 2018.

[2] Carpino, M. et al., Error statistics of asteroid optical astrometric observations, Icarus 166, 2, 248, 2003.

[3] Chesley, S. et al., Treatment of star catalog biases in asteroid astrometric observations, Icarus 210, 1, 156, 2010.

[4] Farnocchia, D. et al. Star catalog position and proper motion corrections in asteroid astrometry. Icarus 245, 94, 2015.