# Testing the inversion of the Gaia asteroid photometry combined with groundbased observations

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The potential of the sparse photometric data to provide physical information about asteroids has been extensively proven by several authors. Generally, the inversion methods used to derive such parameters are making use of the fact that a simplified version of the asteroids' real shape (triaxial ellipsoid, convex representation) is, in the majority of cases, good enough to describe the asteroid brightness variation due to its rotation for a given period. If the observations are spread over a variety of aspect angles, it is then possible to derive the direction of the asteroid spin axis.

The main challenge to be solved when inverting sparse data is the correct determination of the rotation period. One possible approach to solve this issue is to fit an asteroid model on a given period interval (Kaasalainen 2004). Using a convex representation of the asteroid's body shape, some authors have successfully used this technique to solve the inversion problem for a couple of hundreds of asteroids (e.g. Durech et al. 2008 or Hanus et al. 2013). If any "dense" lightcurve is available for the object, the interval is reduced to some boundaries around the observed period, saving a lot of computational time and increasing the solution reliability. But unfortunately obtaining full lightcurves of asteroids is a highly time consuming task, thus such observations are actually available only for ~4,000 asteroids (stored in the Minor Planet Lightcurve Database). It is estimated that the ESA Gaia mission will produce photometric measurements for more than 300,000 asteroids, which means that for the majority of inversion trials the period scanning shall be extended to all the possible period values, namely from 2 to 100 hours.

However, the inversion technique specifically developed to invert the Gaia sparse data of asteroids (Cellino et al. 2006), is based on a "genetic" algorithm, where the solution of the inversion problem is characterized by the best fit of a set of parameters that have been obtained by means of several random variations during a "genetic mutation". This solution is more efficient in terms of CPU time and its capability to derive the "correct" inversion solution have been shown in some experiments with Gaia simulated observations and also with real data collected during the ESA Hipparcos mission (Cellino et al. 2009). On the other hand, adding existing groundbased observations for a given asteroid is not speeding up the performance of this method (in fact the inversion become slower with the increasing number of data points) and whether such observations can improve or not this method performance is a topic that needs to be studied.

Now that all the parameters of the Gaia scanning law are fixed, we are able to predict exactly the observation sequence for solar-system objects. This means that we can plan to observe from the ground at the same time as Gaia. For example, we can very easily add a full rotational (dense) lightcurve around (or very close to) an isolated observation by Gaia. The link between the two data sets would then be very strong, as a single Gaia measurement provides a very precise absolute magnitude that can be used to calibrate the ground-based light curve. The question is: how many such lightcurves do we need (per object) to obtain a substantial improvement of the inversion? Maybe a single one? Or more?

Therefore, our work is thought to address such questions and lay the foundations for a collaboration involving coordinated observations from the ground. Moreover, we focus on assessing the reliability of the solutions derived with the Gaia inversion method under all the possible coordinates for the rotation pole, different rotation periods and checking the impact of "realistic" asteroids using simulations with nonconvex shape models. Such work is necessary to correctly analyze the results that will be generated at the end of Gaia's mission, when photometric observations of asteroids will be available.

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**References:** Cellino, A., Delbo, M., Zappala, V., Dell'Oro, A., Tanga, P., 2006, Advances in Space Research, 38, 9; Cellino, A., Hestroffer, D., Tanga, P., Mottola, S., Dell'Oro, A., 2009, A&A, 506, 935; Durech, J. et al. 2008, A&A, 493, 291; Hanus, J. et al. 2013, A&A, 551, A67; Kaasalainen, M., 2004, A&A, 422, L39–L42.