Inversion of Hipparcos photometric data using triaxial ellipsoid shape models including a Lommel-Seeliger scattering law

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Among the many expected results of the Gaia mission, there is an inversion of the sparse photometric data obtained during five years of operational lifetime for a number of asteroids of the order of 300,000. For each object, about 60–70 photometric measurements obtained in different epochs will be available. Gaia data will not consist of lightcurves (the most common product of ground-based photometry), but only of sets of "photometric snapshots" taken at very different epochs corresponding to very different observing circumstances. However, these data will all be taken by a single detector and without the problems affecting photometric observations performed from the ground (extinction, weather, etc.) and will also be intrinsically very accurate. Therefore we expect that, for most objects, it will be possible to invert the Gaia photometric data obtained, in order to derive from them basic information about the spin properties (rotation period, orientation of the spin axis), overall shape, and magnitude-phase angle relation.

Since Gaia will observe such a large number of asteroids, the search for a compromise between required CPU time and adopted shape model is necessary. In particular, the choice has been forcedly that of assuming a regular triaxial ellipsoid model shape. Though not being very realistic, triaxial ellipsoid shapes are fairly flexible and constitute reasonable approximations of the real shapes in many cases, as shown also by numerical simulations (Torppa et al., 2008). The inversion of asteroid photometric data is performed using a genetic algorithm approach. This has been found to be satisfactorily performing through application to asteroid photometric data obtained years ago by the Hipparcos satellite (Cellino et al., 2009).

In spite of being affected by large errors and also limited in terms of numbers of observations per object, application of the genetic algorithm developed for Gaia has been shown to be able to correctly invert Hipparcos data in about 50 % of the cases. The performances should be much improved in the case of the Gaia data, which are expected to be much better both in quantitative and in qualitative terms. One of the major limitations of the inversion approach adopted so far, however, has been that of substantially ignoring light-scattering effects. Recently, however, a formal treatment of the Lommel-Seeliger scattering law for objects having ideal triaxial shapes has been obtained at the University of Helsinki. These results have been exploited to implement such a treatment of light-scattering effects in the genetic algorithm of photometric inversion developed for Gaia. We present here the results of an application of the refined inversion algorithm to the old set of Hipparcos data. In addition, we present also the results of the inversion of the same data, but using a completely different algorithm, based on an MCMC approach (Muinonen et al., present meeting).

References: Cellino A., Hestroffer D., Tanga P., Mottola S., Dell'Oro, A., A&A 506, 935-954 (2009); Torppa J., Hentunen, V.-P., Pääkkönen, P., Kehusmaa, P., Muinonen, K., Icarus 198, 91-107 (2008).