

# Asteroid spins, shapes and orbits from GAIA photo- and astrometry

Mikko Kaasalainen<sup>1</sup>, Daniel Hestroffer<sup>2</sup>, and Paolo Tanga<sup>3</sup>

<sup>1</sup>Department of Mathematics and Statistics, University of Helsinki

<sup>2</sup>IMCCE, UMR CNRS 8028, observatoire de Paris

<sup>3</sup>OCA/Cassiopée, Nice

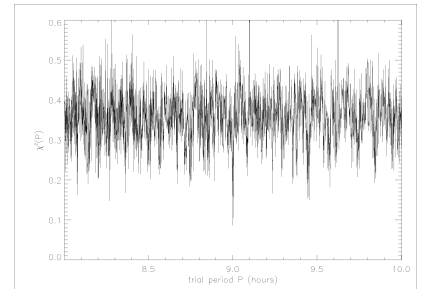
- GAIA's sparse asteroid observations are sufficient for physical modelling
- Photometry: spin states and basic global shapes
- Combined photo- and astrometry: improved precision, accurate orbits
- Of order 10 000 asteroids can be analyzed in this mode

## Asteroid models from photometric data

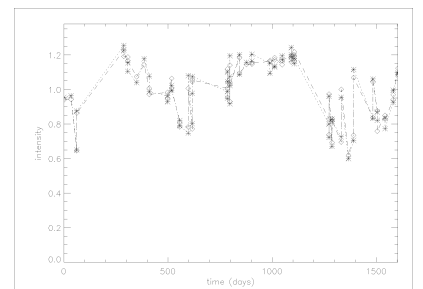
- "Fast-track" mode: shape/spin/photometric properties from sparse calibrated data sets (Kaasalainen 2004, A&A 422, L39)
- Underlying general physical model introduces very strict constraints so there are no aliasing problems
- Absolute photometry (especially solar phase behaviour) can be represented sufficiently accurately with various scattering models (e.g., one with a simple exponential-linear phase function factor)
- Best sidereal period peaks strongly in the initial trial period scan => fast and completely automatic procedure
- Also ground-based observations can be conducted in fast-track mode: this will be implemented with Pan-STARRS and other surveys (combine with GAIA data)
- Interesting targets can be targeted for more detailed photometric or other (radar, adaptive optics) observations (multi-data inversion)
- Typically get pole within 2 to 15 degrees, basic shape dimension ratios within 15 %; photometric calibration within 0.05 mag is sufficient, so no problem for GAIA's expected 0.01 mag

## Simultaneous inversion of photometry and astrometry

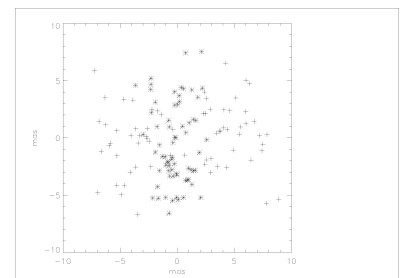
- Improve shape, orbit and spin by minimizing the residual centre-of-mass deviation after photocentre offset correction (Kaasalainen and Tanga 2004, A&A 416, 367) together with the photometric data residual
- Get also size and the additional parameters of orbital dynamics such as perturbing masses as the orbit is fitted down to GAIA's noise level <1 mas
- Photometric part takes care of stability and global solution
- Removes the possible twofold pole ambiguity in photometry



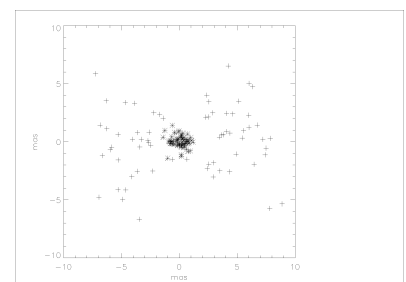
Initial period search for typical GAIA data (MBA, 69 data points during the mission) finds the lowest residual at the correct period 9 h



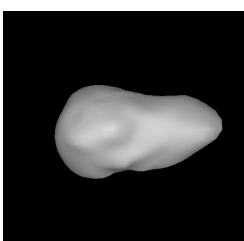
Observations (asterisks) and model fit (diamonds) for the above case. Noise level and rms fit are both 0.03 mag.



Astrometric photocentre offsets (luses) and the CM residuals (asterisks) for the above case using shape/spin model from GAIA photometry only.



CM residuals using the model from combined astro- and photometry (left). The MBA-target is 180 km at its widest.



The model shape (left) used in the simulations shown here, and a shape solution from the combined astro- and photoemtric inverse problem (right).

