MW-Gaia STSM

Improving the analysis of Gaia photometric data for solar system objects

Dr. Alberto Cellino from INAF (Torino) spent a week (17-23/11/2019) at the Helsinki University thanks to a GP1 STSM grant to collaborate with Prof. K. Muinonen and his collaborators on the possibility to improve the performances of some algorithms developed to analyse sparse photometric measurements of asteroids observed by the Gaia space mission of the European Space Agency (ESA). This investigation was timely and important because of three main reasons:

1. A. Cellino had developed for the Gaia Data Processing and Analysis Consortium (DPAC), responsible for the ESA of the preliminary analysis of Gaia data, a genetic algorithm to derive the spin and shape properties of the observed objects, assuming that the shapes of the objects can be suitably represented as triaxial ellipsoids.

2. An analysis of Gaia photometric data for asteroids became possible after the release of a first and limited sample of data in the second Gaia Data Release (GDR2). A. Cellino and collaborators, including K. Muinonen, published a paper on the Astronomy and Astrophysics journal, presenting a first encouraging attempt at deriving reliable spin and shape properties of some asteroids based on Gaia GDR2 photometric data.

3. The Finnish Team led by K. Muinonen obtained some important results concerning specifically the treatment of light scattering by the surfaces of bodies having a triaxial ellipsoid shape, as predicted by a so-called Lommel-Seeliger light scattering model. A paper based on these results was in preparation.

The activities mentioned above in item (3) made possible the implementation of a better determination of the relation between magnitude and phase angle (the latter describing the illumination conditions of the objects at different epochs of observations). In particular, it was then possible to obtain a more accurate value of the slope of the expected linear relation between magnitude and phase angle, for asteroids observed in the range of phase angles covered by Gaia observations. In turn, this opens interesting possibilities to obtain better determinations of the albedo of the observed asteroids, the albedo being a parameter related to surface composition and light scattering properties.

Main achievements

During his STSM in Helsinki, A. Cellino and K. Muinonen worked together to improve the algorithm of analysis of Gaia photometric data, taking profit of the previous results described above. They implemented a new version of the numerical code, and carried out some preliminary tests. The results have shown that, with respect to the previous version of the algorithm, the performances in terms of determination of albedo values seems significantly improved. This is based on a comparison with albedo values already published in the literature for a first sample of asteroids published in GDR2.

The obtained results allowed them to be more confident about the possibility to systematically exploiting Gaia photometric data of asteroids to derive from them reliable estimates of the albedo, through further improvement and a better calibration of the

relation between phase-magnitude slope and albedo. This can be done, in particular, by making use of polarimetric data to derive more accurate albedo determinations for a number of asteroids to be used to calibrate the relation between the albedo and the phase-magnitude relation. Asteroid polarimetry is another subject in which both A. Cellino and the Helsinki team are deeply involved, and an analysis of the state of the art in asteroid polarimetry and its possible application to Gaia data was the subject of extensive discussions during the stay in Helsinki of A. Cellino. This might lead therefore to further developments aimed at a better exploitation of Gaia asteroid data.