Asteroid phase-curves from Gaia-calibrated data

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Due to the fact that relative photometry is rarely taken, accurate phase curves are only known for about few hundrets asteroids [1]. Performing relative measurements is typically avoided by planetary science astronomers owing to lack of photometric standards in the field of view and/or lack of photometric weather during observations. This problem can be completely solved with the Gaia mission catalogue [2]. Gaia is a space observatory launched in 2013 by the European Space Agency. The ongoing mission is currently cataloging approximately 1 billion astronomical objects. The first catalogue (DR1) was in 2016. Due to high photometric precision and accuracy of the Gaia measurements many of the catalogued stars are suitable to use as photometric standards. Most of the historical CCD images will contain Gaia photometric stars, making it possible to re-measure asteroid magnitudes and by placing them on a standard photometric system obtain relative measurements. Therefore the historical data (previously used for differential photometry only) can be utilized to obtain relative measurements and therefore determine accurate phase curves and phase curve parameters (slopes, phase integral, hight and width of the opposition surge, phase coeficient, amplitude of opposition etc.).

CALIBRATION OF HISTORIC CCD FRAMES

Historical CCD data

In this project we are planing a reduction and calibration of the historical CCD obtained during the course of the Deep Ecliptic Survey (DES), and at various telescopes and observatories during the past decades: Institute Astronomical Observatory, Adam Mickiewicz University, Center for Solar System Studies, and Lowell Observatory, summing up to around 7.3 TB of raw data and photometry for several thousands of asteroids.

Relative photometry and phase curves

CCD data from the different instruments will be reduced in a standard way by applying bias and flat-field corrections. The brightness of asteroids present in the Field-of-View (hereafter FoV), together with several comparison stars, will be measured with the aperture photometry to derive lightcurves. Those lightcurves will be scaled in instrumental magntudes in the passband used at the time of observations. In the past, at such stage the reduction was stopped and no attempts to standardize the photometry was attempted. That was due to the lack of apropriate photometric standards in the FoV. In the Gaia era this obstacle is removed and we can use the known G magnitudes to calibrate the asteroid lightcurves in the Gaia photometric system. In this project we will use a one-step, direct approach presented in Jordi et al. [3]. We will use stellar color indices from APASS catalogue [4] and asteroid color indices from the SDSS [5]. The resulting relative photometry will then be used to determine the magnitude shifts between the consequent lightcurves and fit phase functions.

[1] Shevchenko, Vasilij G., et al. 2016, "Asteroid observations at low phase angles. IV. Average parameters for the new H, G 1, G 2 magnitude system."PSS, 123 (2016): 101-116. [2] Prusti, Timo, et al. 2017, "The Gaia mission.", AA, 595 (2016): A1. [3] Jordi et al. 2010, Gaia broad band photometry, AA 523, A48

[4] Henden, Arne A., et al. "The AAVSO photometric all-sky survey (APASS)." *AAS Meeting Abstracts# 214*. Vol. 214. 2009. [5] Ivezic et al. 2002, Color confirmation of asteroid families, ApJ, 5, 2943