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Space Debris Detection, Tracking and Characterization (1)

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SPACE DEBRIS CHARACTERIZATION THROUGH THE SLOVAK DEBRIS LIGHT CURVE CATALOGUE

Abstract

Since 2017 the Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava, Slovakia (FMPI CU) has been gathering data of space debris population, namely its astrometric and photometric measurements. For observations we used our own 70-cm Newton design telescope (AGO70), situated at the FMPI's Astronomical and Geophysical Observatory in Modra, Slovakia (AGO) which is dedicated to the space debris research. We acquired photometric data for more than 200 objects, such as defunct spacecrafts, abandoned upper stages and fragmentation debris. The main aim was to establish our own light curve catalogue to be used for further research. Observed objects were situated on different types of orbit, from highly eccentric Geosynchronous Transfer Orbits (GTO) and Molniya orbits, to Geosynchronous Earth Orbits (GEO).

For each observed object we acquired at least two light curves, brightness measurements over time, with different sampling to avoid aliasing effect during the processing. We used Phase Dispersion Minimization (PDM) method to extract the apparent (synodic) period from the light curve. The goal during this processing is to construct a phase diagram, which is a plot constructed from a single light curve measurement points which are folded into a specific time interval with a length of synodic period. Each constructed phase diagram was fitted with a Fourier eight harmonic function to obtain the basic characteristics about the phase, such as amplitude value, number of extrema (minima and maxima) and shape of the maxima.

In our work we present in detail our space debris light curve catalogue which is freely available for scientific community. We analyze the obtained space debris light curves, namely their phase diagrams (phase functions), toward the characterization and identification of objects. Firstly, we discuss the image acquisition with AGO70 which was optimized to avoid aliasing effects. Secondly, we present the data preprocessing such as image calibration, data screening and data detrending. Thirdly, we describe the phase diagram construction and synodic period estimation. Next, we introduce the space debris characterization according to the phase diagram shape. Last, but not least, we describe the formalism behind the errors estimation during the processing.