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MASSIVE PHOTOMETRY OF LOW-ALTITUDE ARTIFICIAL SATELLITES ON MINI-MEGA-TORTORA

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RESUMEN

El sistema de monitorización Mini-Mega-TORTORA (MMT-9) de gran campo de 9 canales de alta resolución temporal está en funcionamiento desde junio de 2014. El sistema tiene 0,1 s de resolución temporal para una detección efectiva límite alrededor de 10 mag (calibradas al filtro V) para objetos de movimiento rápido en estas escalas de tiempo. Además de su operación científica primaria, el sistema detecta 200-500 pistas de satélites cada noche, de baja altura y en órbitas de alta elipticidad. Usando estos datos hemos creado y apoyado a la base de datos pública disponible para estos satélites con estas características fotométricas.

ABSTRACT

The nine-channel Mini-Mega-TORTORA (MMT-9) optical wide-field monitoring system with high temporal resolution system is in operation since June 2014. The system has 0.1 s temporal resolution and effective detection limit around 10 mag (calibrated to V filter) for fast-moving objects on this timescale. In addition to its primary scientific operation, the system detects 200-500 tracks of satellites every night, both on low-altitude and high ellipticity orbits. Using these data we created and support the public database of photometric characteristics for these satellites, available online.

Key Words: astronomical databases: miscellaneous

Our many years of experience of observations with single-channel FAVOR monitoring system (Karpov et al. 2005, 2010) has shown that such systems are a well-suited instruments for studying low-altitude artificial satellites of Earth. The Mini-Mega-TORTORA (MMT-9) what started its operation in mid-2014 (Karpov et al. 2013; Beskin et al. 2014; Biryukov et al. 2015) is a nine-channel system having both wider field of view (900 square degrees), better temporal (0.1 s) and angular (16″ per pixel) resolution, and a deeper detection limit. One of its tasks is the study of artificial satellites.

The accuracy of coordinate determination of MMT real-time transient detection pipeline (Karpov et al. 2010), which is typically 5-30″, is quite enough for reliable identification of satellites on low and medium-altitude orbits, and due to it we have already collected an unprecedented amount of unique high resolution photometric information for these objects. To publish it, we created and support the online database[6]. Its public part contains all the satellites observed by Mini-Mega-TORTORA that have been launched by countries other than Russian Federation and have been identified using publicly available orbital elements (US Department of Defence 2015; McCants 2015). After the first year and a half of operation, the database contains the information for 4503 low- and medium-altitude satellites.

The database includes the following parameters for every satellite track observed: light curves in apparent and standard magnitudes (calibrated to 1000 km distance and 90° phase angle), distance and phase angle over time, whether the satellite was inside the penumbra, and a light curve period if it displays a periodicity. For every satellite it also contains the general information and classification of activity taken from public sources (active, inactive, debris etc), as well as variability type estimated by us (periodic variability, variable but aperiodic, non-variable). Among 4503 objects in database 1631 are aperiodic and 849 are periodic.

The periodicity of satellite light curve may be caused by either rotation of an object as a whole (which is typical for both inactive satellites, upper stages or debris, see Figure 1, and active satellites

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[6]The database is published at `http://mmt.favor2.info/satellites` and `http://astroguard.ru/satellites`

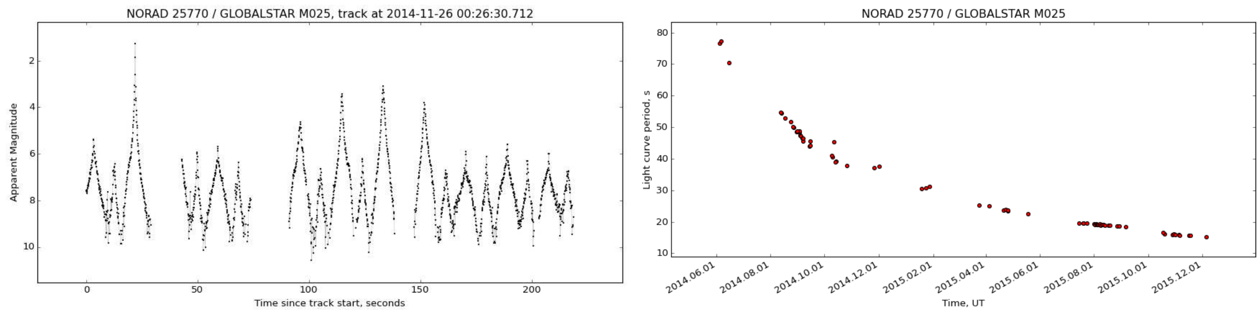

Fig. 1. Light curve of an inactive satellite and its period evolution over time.

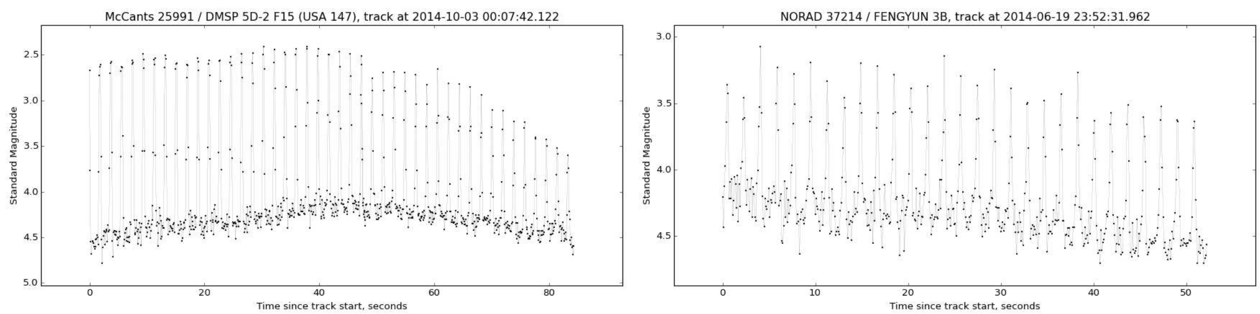

Fig. 2. Rapid variability of active satellites due to antennae rotation with 1.8 seconds period.

stabilized by rotation), or some rotating element like an antenna (see Figure 2). The rotation period of inactive objects often changes over time (see right panel of Figure 1) due to either interaction with the atmosphere or some residual technological processes inside the object itself.

The database presents all this information in an easy to use and fully searchable manner, and we hope it will be useful to various tasks of a space surveillance.

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