GEO DEBRIS OBSERVATION OF PMO

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Abstract

This paper summarizes observations and results obtained by Purple Mountain Observatory in March 2007 of space debris at geosynchronous orbit (GEO) in support of WG1 Action Item 23.4, International 2007 Optical Debris Campaign in Higher Earth Orbit, organized by the Inter-Agency Space Debris Coordination Committee (IADC). The main goal of Pmo's work is to develop the observational techniques of Higher Earth Orbit Space debris for the future work. A new telescope designed for debris observation is also described here.

1. Introduction

Several international space debris campaign in Higher Earth Orbit have been organized by IADC during the last years. As the member of IADC, CNSA has also been invited. Because of the lack of appropriate telescope, this work could not been carry out. With the help of Dr. Zhao Haibin, who manages the Near Earth Object Survey Telescope of China (CNEOS), we take part in AI23.4. The main goal of the work is to develop the observational techniques of Higher Earth Orbit Space debris for the future works. All of the work described here was supported by Center for Space Object & Debris Research, CAS.

This paper summarizes observations and results obtained by Purple Mountain Observatory in March 2008 of space debris at geosynchronous orbit (GEO) in support of WG1 Action Item 23.4, International 2008 Optical Debris Campaign in Higher Earth Orbit, organized by the Inter-Agency Space Debris Coordination Committee (IADC). The goal of this action item is statistical studies of the debris population both at GEO and in the navigation satellite orbits with mean motions near 2 revs/day.

2. Description of observational techniques

All data was obtained with the PMO's CNEOS Telescope located at the Xuyi Observatory (longitude = 118.5 degrees East, latitude = 32.7 degrees North, altitude = 180.9 meters). Fig.1 shows the dome of this telescope. The CNEOS Telescope is a classical astronomical Schmidt telescope with 1.04 meter aperture. A 4k x 4k pixel CCD is equipped on the focal plane. The total field of view is about 2.0 x 2.0 square degrees and the pixel size is 1.7 arcseconds. This telescope is not equipped with filter system. Since the purpose of this campaign is to go as faint as possible, and not to do colors, observing without a filter will not get problems.

Figure 1. Dome of the PMO's CNEOS Telescope at the Xuyi Observatory.

The observing techniques to be used are consistent with previous IADC optical campaigns. This will permit comparison of the data obtained in this campaign with data from previous campaigns.

Previous IADC GEO campaigns observed a section of sky close to the anti-solar point (but out of eclipse) for maximum reflected brightness. The next night the telescope is offset by 1.2 degrees in declination (dec),

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and the observations are repeated at the same right ascension (ra). For the 2008 observing runs, since the Sun is moving North in declination, the anti-solar point is moving south, and so the nightly declination offsets are towards the south to keep as close to the anti-solar point as possible. Table 1 shows the observing fields, which have been observed by PMO, of March 2008 in this campaign. The observing fields of following months have not been observed because of bad rain season.

The observation mode we chose can be briefed as such several steps:

1. Point the telescope to the specified ra and dec
2. Turn the drive off.
3. Take a single exposure.
4. Reset the telescope to the first ra and dec.
5. Repeat the process for the time period of the observations.

The faintest objects can be detected if the telescope tracks at the same rate as the object so that the object is detected as a point source, with most of its flux in the smallest number of pixels, and not as a streak. Stars will appear as streaks in these observations.

However, not all GEO objects travel at the same rate and thus some objects will appear as short streaks. In order to keep streak losses low, the exposure times are kept short (typically a few seconds).

Each clear night, we takes a 5 second exposure every about 40 seconds at a constant right ascension and declination. Typically over 700 images are obtained each night. During the 8 minutes that it takes a GEO object to drift across the field of view, up to 12 independent detections of each source are made.

Fig.2 shows a representative image from a typical observing sequence. Three active satellites are visible.

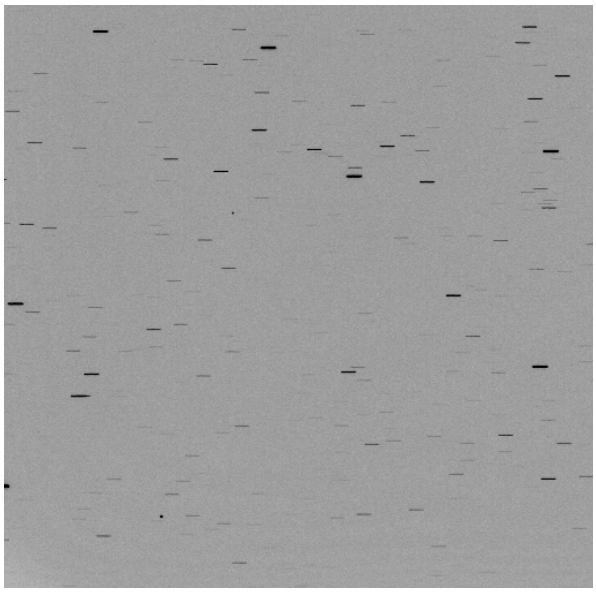

Figure 2. PMO CNEOS Telescope's example image, which is a 5 second exposure, obtained on the geostationary belt. There are 2 stationkeeping satellites in the image. The short streaks are remnants of star subtraction.

3. Observational results

In 5 clear nights, we conducted the observations with the CNEOS Telescope. Tab.1 and Tab.2 give the overview of these observations, Tab.3 gives the result of observations. Above 2500 observation detections were identified to be the space debris. The faintest magnitude of these detections can up to about 19. All magnitudes have not been reduced from apparent magnitudes to so-called absolute magnitudes by correcting for the illumination phase angle.

Table 1 Observation fields of March 2008

UT Date	RA (Field 1)	RA (Field 2)	Declination
4 Mar	10h14m	12h14m	8.40 deg
5 Mar	10h14m	12h14m	7.20 deg
7 Mar	10h14m	12h14m	4.80 deg
9 Mar	10h14m	12h14m	2.40 deg
10 Mar	10h14m	12h14m	1.20 deg

Table 2. Overview of PMO's observations

Date	Frames	Observe Time	Image Data
04/03/2008	100	3 hours	3.2GB
05/03/2008	550	6 hours	17.6GB
07/03/2008	550	5hours	17.6GB
09/03/2008	600	5hours	19.2GB
10/03/2008	550	6hours	17.6GB

Table 3. Observation results

Date	Observed detections	Correlated detections	Correlated objects
04/03/2008	39	0	0
05/03/2008	830	8	4
07/03/2008	594	30	8
09/03/2008	669	80	24
10/03/2008	534	53	16

4. Conclusion

The CNEOS telescope was not designed for debris observation, many sources do not have adequate independent detections for orbit determination. This problem make the following data analysis work become infeasible. A 90cm telescope (Fig.3) designed for debris observation is being developed now. The routine GEO debris survey will be done by this telescope in China, and we will carry out the IADC campaign perfectly.

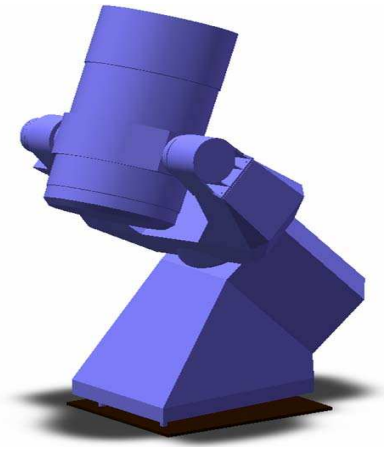

Figure 3 A 90cm designed for GEO debris observation

5. Acknowledgement

All of the work described here was supported by Center for Space Object & Debris Research, CAS. The observations were carried out by PMO's CNEOS Telescope located at the Xuyi Observatory, with the help of Dr. Zhao Haibin.