A Search For Optically Faint GEO Debris

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ABSTRACT

Existing optical surveys for debris at geosynchronous orbit (GEO) have been conducted with meter class telescopes, which have detection limits in the range of 18^{th}-19^{th} magnitude. We report on a new search for optically faint debris at GEO using the 6.5-m Magellan telescope 'Walter Baade' at Las Campanas Observatory in Chile. Our goal is to go as faint as possible and characterize the brightness distribution of debris fainter than R = 20^{th} magnitude, corresponding to a size smaller than 10 cm assuming an albedo of 0.175. We wish to compare the inferred size distribution for GEO debris with that for LEO debris.

We describe preliminary results obtained during 9.4 hours of observing time during 25-27 March 2011. We used the IMACS f/2 instrument, which has a mosaic of 8 CCDs, and a field of view of 30 arc-minutes in diameter. This is the widest field of view of any instrument on either Magellan telescope. All observations were obtained through a Sloan r' filter. The limiting magnitude for 5 second exposures is measured to be fainter tan R = 21.

With this small field of view and the limited observing time, our objective was to search for optically faint objects from the Titan 3C Transtage (1968-081) fragmentation in 1992. Eight debris pieces and the parent rocket body are in the Space Surveillance Network public catalog. We successfully tracked two cataloged pieces of Titan debris (SSN # 25001 and 33519) with the 6.5-m telescope, followed by a survey for objects on similar orbits but with a spread in mean anomaly.

To detect bright objects over a wider field of view (1.6x1.6 degrees), we observed the same field centers at the same time through a similar filter with the 0.6-m MODEST (Michigan Orbital DEbris Survey Telescope), located 100 km to the south of Magellan at Cerro Tololo Inter-American Observatory, Chile.

We will describe our experiences using Magellan, a telescope never used previously for orbital debris research, and our initial results.

1. INTRODUCTION

There have been extensive surveys of the population of objects at GEO using meter class or smaller telescopes. Examples are the results from the European Space Debris Facility in the Canary Islands, MODEST (the Michigan orbital DEbris Survey Telescope at Cerro Tololo in Chile, and the CDT in New Mexico. With short exposures, all of these telescopes have detection limits brighter than 20^{th} magnitude, or for an albedo of 0.175, a physical size of larger than 10 cm. A major unanswered question in debris research today is what is the distribution of debris at

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14. ABSTRACT

Existing optical surveys for debris at geosynchronous orbit (GEO) have been conducted with meter class telescopes which have detection limits in the range of 18th-19th magnitude. We report on a new search for optically faint debris at GEO using the 6.5-m Magellan telescope ?Walter Baade? at Las Campanas Observatory in Chile. Our goal is to go as faint as possible and characterize the brightness distribution of debris fainter than R = 20th magnitude corresponding to a size smaller than 10 cm assuming an albedo of 0.175. We wish to compare the inferred size distribution for GEO debris with that for LEO debris. We describe preliminary results obtained during 9.4 hours of observing time during 25-27 March 2011. We used the IMACS f/2 instrument, which has a mosaic of 8 CCDs, and a field of view of 30 arc-minutes in diameter. This is the widest field of view of any instrument on either Magellan telescope. All observations were obtained through a Sloan r? filter. The limiting magnitude for 5 second exposures is measured to be fainter tan R = 21. With this small field of view and the limited observing time, our objective was to search for optically faint objects from the Titan 3C Transtage (1968-081) fragmentation in 1992. Eight debris pieces and the parent rocket body are in the Space Surveillance Network public catalog. We successfully tracked two cataloged pieces of Titan debris (SSN # 25001 and 33519) with the 6.5-m telescope, followed by a survey for objects on similar orbits but with a spread in mean anomaly. To detect bright objects over a wider field of view (1.6x1.6 degrees), we observed the same field centers at the same time through a similar filter with the 0.6-m MODEST (Michigan Orbital DEbris Survey Telescope), located 100 km to the south of Magellan at Cerro Tololo Inter-American Observatory, Chile. We will describe our experiences using Magellan, a telescope never used previously for orbital debris research, and our initial results.

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GEO for magnitudes fainter than 20th. Does the number of objects continue to rise with fainter and fainter magnitudes? How does the faint debris population compare with the debris population at LEO?

Fig. 1 below shows the histogram of R magnitudes of objects detected with the 0.6-m MODEST during the years 2007 through 2010.

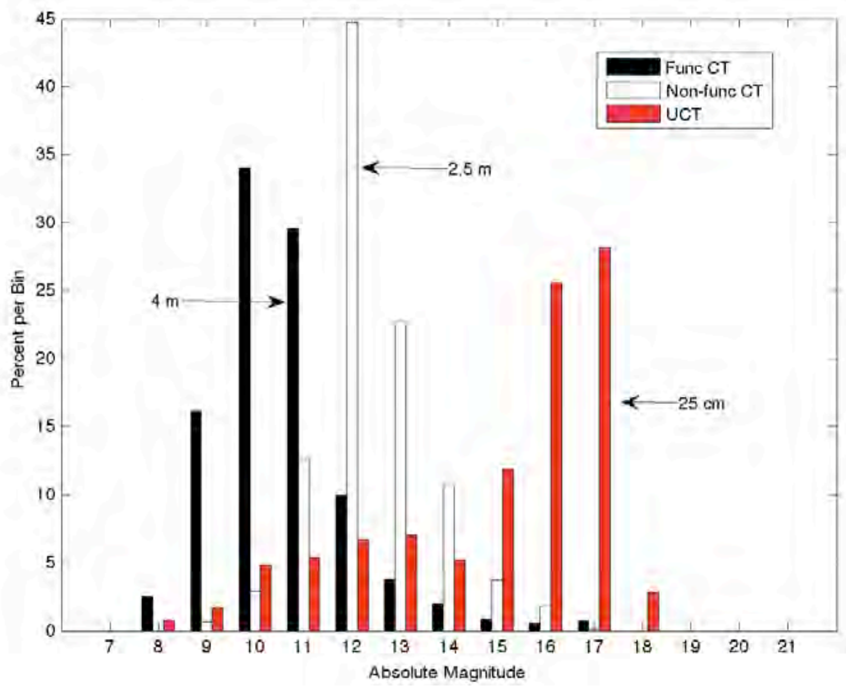

Fig. 1. Histogram of R magnitudes of GEO objects detected during 2007-2010 with the 0.6-m MODEST.

To reach fainter optical limits requires use of larger telescopes. Detectors on all small GEO survey instruments are usually CCDs, with peak quantum efficiencies over 90% in the visual part of the spectrum. Taking longer exposures does not help because of the increased possibility for contamination from the longer star streaks.

In this paper we report on observations made with the 6.5-m Magellan telescope 'Walter Baade' at Las Companas Observatory in Chile. This telescope is collaboration between the Carnegie Institution of Washington, Harvard University, the Massachusetts Institute of Technology, the University of Arizona, and the University of Michigan. Observing time for orbital debris observations was obtained through the University of Michigan.

2. OBSERVING DETAILS

The instrument used on Baade was the IMACS (Inamori-Magellan Areal Camera and Spectrograph) in f/2 imaging mode. This instrument has the widest field of view (30 arc-minute diameter) of any instrument on either Magellan. The CCD camera has 8 blue sensitive E2V CCDs. There are small gaps between the individual CCDs in the detector mosaic.

The telescope can track at non-sidereal rates, allowing tracking at the rates expected for GEO and near-GEO objects.

Our exposures were each 5 seconds long through a Sloan r' filter, the widest filter in the visual part of the spectrum in the standard filter load for the instrument. Fig. 2 below shows one frame tracking the Titan debris object SSN 33513. With a 5 second exposure, the detector saturates at R = 15th magnitude. The limiting magnitude is measured to be fainter than R = 21st.

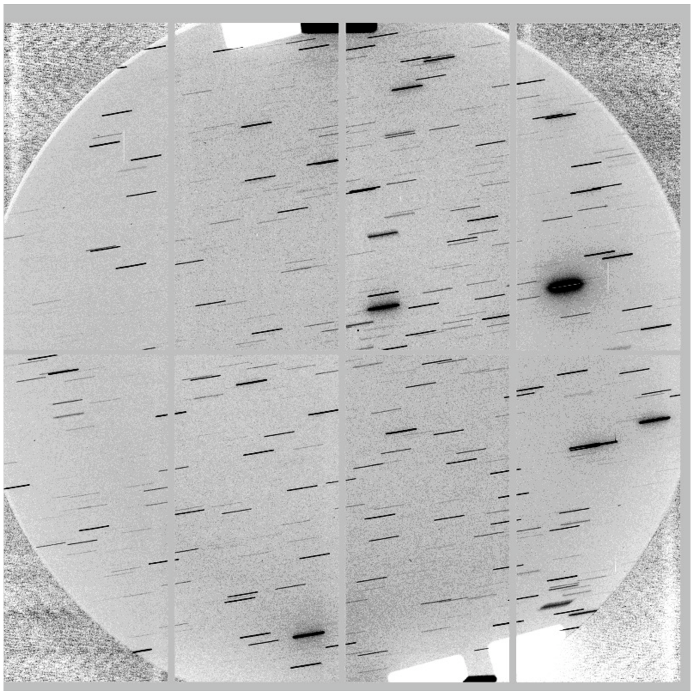

Fig. 2. Five second exposure of SSN 33513 obtained with IMACS f/2 on Magellan.

With this narrow field of view (0.5 degrees), and the limited observing time likely to be available on a telescope this size, Magellan is bet suited for specialized debris studies, and not large surveys. Thus in our first run in March 2011 we elected to study the question: is there optically faint debris on circular orbits associated with the Titan 1968-081 breakup of 21 February 1992? This is one of the few breakups known to have occurred at GEO. Eight pieces of debris plus the transtage itself are in the public U.S. Space Surveillance Network catalog.

We observed both the visible debris pieces and pseudo debris pieces with the same TLE elements but with different mean anomalies. Our pseudo mean anomalies were offset by 15 degrees. The standard sequence was to do 30 five second exposures with the telescope tracking the object at the appropriate non-sidereal rates, followed by a second set of 30 five second exposures with the tracking off and the telescope fixed.are peresneted

The observations were calibrated photometrically by observations of Landolt (2009) standard stars.

3. RESULTS

In 6 hours of photometric observing time we detected 19 objects multiple times, as determined by manual reviw of all the images. We are looking for objects with hour angle rates -2 < HA rate < 2, and declination rates -5 < DEC rate < 5. These rates correspond to motions expected for GEO objects in circular orbits.

The detections group into three types: streaks, resolved and partially resolved glints, and streaks of uneven brightness. Examples are presented below in figures 3 through 5. Each sub-image is 51.6x51.6 arc-seconds in size.

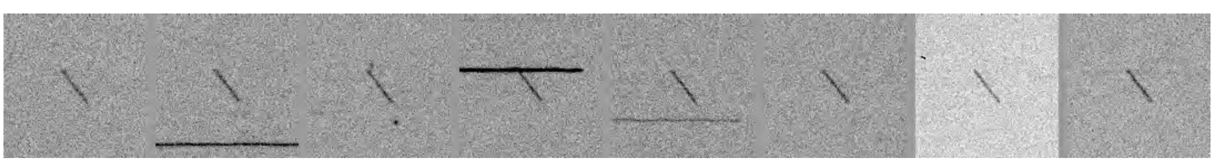

Fig. 3. An object detected as a uniform short streak. The primary motion is north to south.

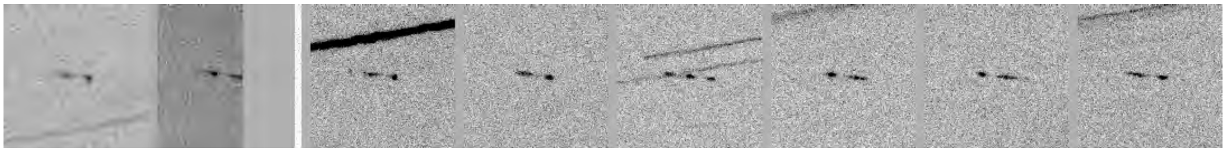

Fig. 4. An object detected as a series of unequal brightness glints. The primary motion is east to west.

Fig. 5. Object detected as non-uniform streak.

4. SUMMARY

In 6 hours of imaging under photometric conditions, we detected 19 objects in more than one image. 12 have observed angular rates which are consistent with them being objects in circular orbit at GEO. 25% of the GEO objects show glints.

The detection rate with Magellan of objects with GEO rates is approximately 10 per hour per square degree.

All of these conclusions are obviously tentative given the small number statistics.