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Observations of Small Satellites and CubeSats Using the OSCOM System

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Abstract

The OSCOM system is specifically designed for Optical tracking and Spectral characterization of CubeSats for Operational Missions. It is capable of tracking and observing small satellites down to the CubeSat form-factor using low cost, high throughput telescopes and high frame rate CMOS cameras. By performing photometry on the acquired images of each satellite, a time resolved light curve can be produced to reveal if a satellite is 3-axis stabilized, spin stabilized or tumbling. If the shape of the satellite is known a priori then its attitude can be determined to independently verify if it is operating as expected. Since the failure rate of CubeSat missions is high, this information can help operators determine if their satellite is functioning nominally or determine the reason for its failure. In this poster, we will highlight the capabilities of the OSCOM system for small satellite and CubeSat photometry and present photometric light curves to demonstrate its capabilities.

Performing Small Satellite and CubeSat Observations

OSCOM is capable of tracking small satellites down to the CubeSat form factor. It primarily uses a Celestron 11" Rowe-Ackermann Schmidt Astrograph (RASA) which provides the wide field of view and fast focal ratio, *f*/2.2, for imaging dim objects, whose orbital elements may be slightly inaccurate. The 11" RASA was selected to provide the portability necessary to perform observations away from Embry-Riddle Aeronautical University's campus, while providing high quality photometry of unresolved objects. A Manta G-235 CMOS machine vision camera made by Allied Vision is the primary camera. By using CMOS instead of CCD, faster readout times can be achieved resulting in the time resolved light curves shown to the right. Combining this camera with the RASA results in a 1°x0.7° field of view. All images acquired of satellites undergo image reduction and photometry. During photometry, they are corrected for airmass and satellite range.

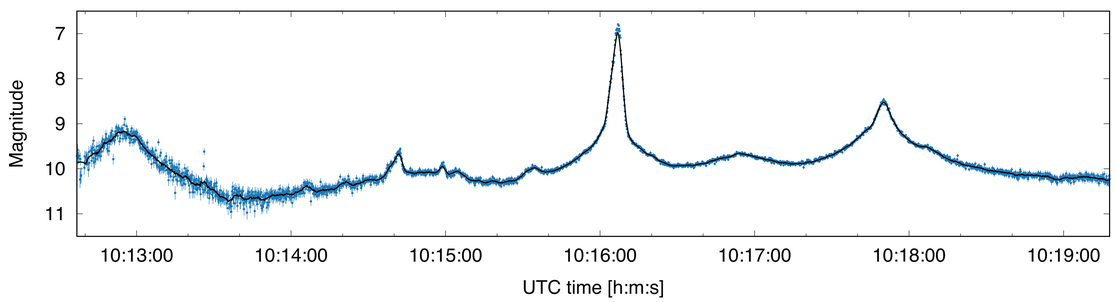
Description of Observed Satellites

To the right we present OSCOM produced light curves from a variety of small satellites, decreasing in size from 46 cm to 15 cm in diameter. Details describing each satellite's size, orbit, mission and information regarding how its data was acquired are located to the right of their respective light curve. DANDE is a 46 cm sphere while CANX-6 is a 20 cm cube nanosatellite. CINEMA-2 and DICE-2 are 3U and 1.5U CubeSats, respectively. All of these satellites, except for CANX-6, were designed to be spin stabilized, but their current status is unknown. A periodogram is located below the light curve of DICE-2, showing the various periods contained within the light curve. DICE had a total of 10 deployable booms resulting in a flash frequency pattern that was a multiple of the actual spin frequency. This flash pattern could be misconstrued as a high spin tumbling satellite. However, DICE CubeSats were expected to spin at 6 rpm when they were operational. This actual spin frequency only becomes apparent in the photometry curve due to OSCOM's high frame rate that was able to resolve the repeating double hump feature. This is high-lighted in the DICE photometry curve by two red ovals.

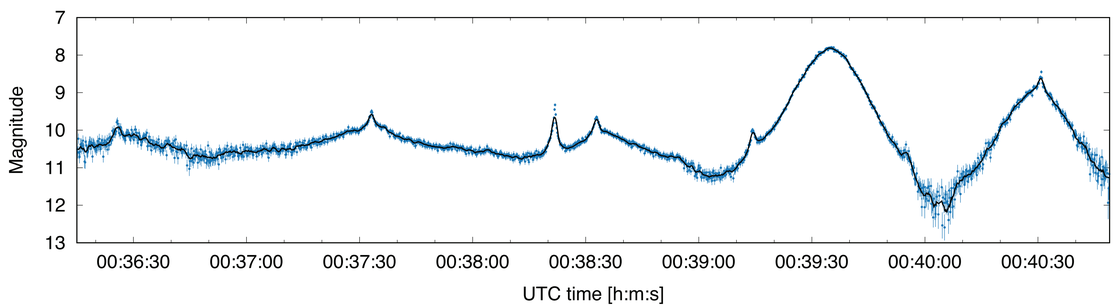
Future Work

OSCOM has been able to successfully track and image objects as small as 15cm. The detectability limit for smaller, dimmer objects is still unknown with the current OSCOM system. Future plans include observing calibration spheres, originally used for radar calibration, and NaK droplets. While calibration spheres are around 30 cm in diameter, slightly smaller than DANDE, NaK droplets are much smaller, around 5 cm. OSCOM also has plans to acquire a new 14" telescope, capable of imaging dimmer objects to help expand OSCOM's small satellite observational capabilities.

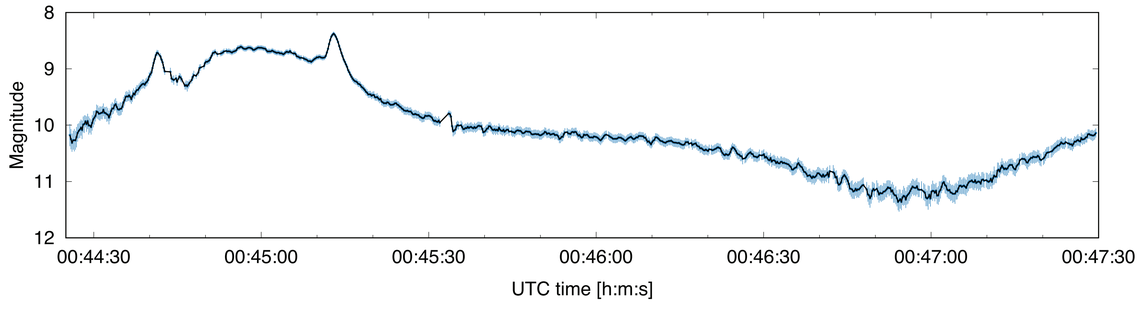
DANDE



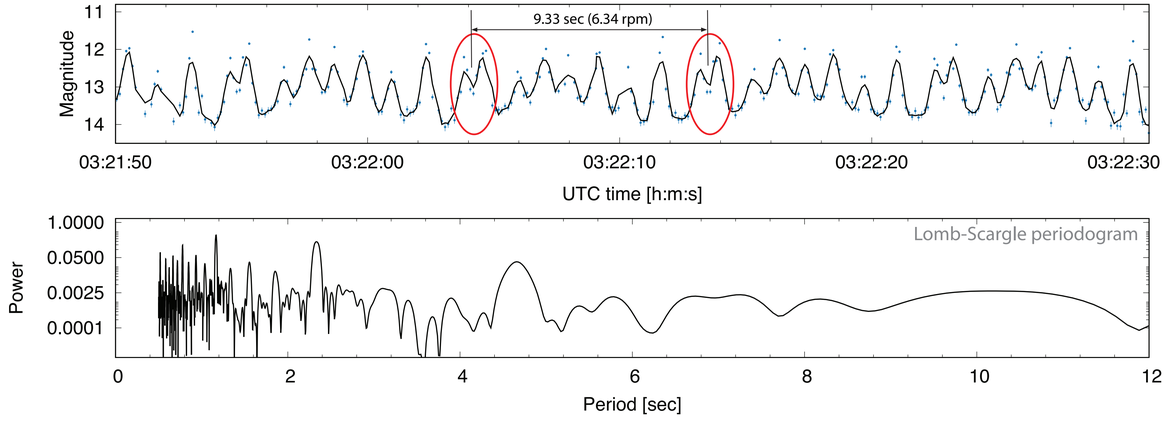
CANX-6



CINEMA-2 (KHUSat-1)

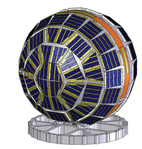


DICE-2



Drag and Atmospheric Neutral Density Explorer

NORAD ID: 39267
Mission: Atmospheric drag measurements
Orbit: 321 x 1362 km, 81.0° inclination
Dimensions: 46 cm diameter
Status: Communication lost in January, 2014
Attitude control: Unknown, Previously spin stabilized
Camera gain: 0.18 e^-/ADU
Exposure time: 150 ms
Frame rate: 6.7 fps
Observed location: Daytona Beach, FL
Observation date: 2016-01-18


CU Boulder

Canadian Advanced Nanosatellite eXperiment-6

NORAD ID: 32784
Mission: Identification and detection of maritime vessels
Orbit: 599 x 619 km, 97.6° inclination
Dimensions: 20 cm cube
Status: Last known to be operational in 2012
Attitude control: Permanent magnets, Roll axis uncontrolled
Camera gain: 0.05 e^-/ADU
Exposure time: 150 ms
Frame rate: 6.7 fps
Observation site: Daytona Beach, FL
Observation date: 2016-04-09


UTIAS-SFL

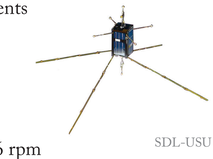
CubeSat for Ions, Neutrals, Electrons, & Magnetic fields

NORAD ID: 39426
Mission: Mapping energy neutral atoms
Orbit: 589 x 739 km, 97.7° inclination
Dimensions: 3U (30 cm x 10 cm x 10 cm)
Status: Last known to be operational in 2014
Attitude control: Unknown, Previously spin stabilized at 4 rpm
Camera gain: 0.05 e^-/ADU
Exposure time: 200 ms
Frame rate: 5.0 fps
Observation site: Daytona Beach, FL
Observation date: 2016-09-08


CINEMA Consortium

Dynamic Ionosphere CubeSat Experiment-2

NORAD ID: 37852
Mission: Ionospheric plasma density measurements
Orbit: 437 x 682 km, 101.7° inclination
Dimensions: 1.5U (15 cm x 10 cm x 10 cm)
Status: Failed E field boom deployment, last known to be operational in 2014
Attitude control: Unknown, Previously spin stabilized at 6 rpm
Camera gain: 2.0 e^-/ADU
Exposure time: 125 ms
Frame rate: 7.6 fps
Observation site: Needham, MA
Observation date: 2015-08-01


SDL-USU