Upgrades and Current SSA Activities at the Navy Precision Optical Interferometer

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ABSTRACT

We describe the current status of the Navy Precision Optical Interferometer (NPOI), and current SSA related activities. The NPOI group has added three new stations in the inner array, allowing us to observe with baselines as short as 8.8 m, which have been instrumental in the detection of fringes from glinting geostationary satellites on multiple occasions. We describe efforts underway to install three 1m telescopes and a new optical/near-infrared beam combiner, and the application of these new capabilities for the observation of geosats over an extended period outside the glinting season.

Keywords: geostationary satellites, imaging, optical interferometry

1. INTRODUCTION

The Navy Precision Optical Interferometer, located on Anderson Mesa, in Flagstaff, AZ, is a joint project between the Naval Research Laboratory, U.S. Naval Observatory and Lowell Observatory.[1,2] This interferometer is composed of two sub-arrays, an astrometric array composed of four fixed stations, and an imaging array composed of six movable telescopes that can be positioned in 30 stations placed along the arms of a Y shaped array. Besides being used for astrometric purposes, the NPOI has been instrumental in the observation of binary stars,[6,14] stellar diameters,[3] stellar structure,[8] and circumstellar disks.[13] The NPOI has also been used as a testbed for the develpment of new observational techniques, such as coherent integration[7] and differential phases.[10]

On the Space Situational Awareness field, the main accomplishment of the NPOI was the detection of interferometric fringes from glinting geosats on multiple occasions.[5] More recently, in 2015, we were able to detect interferometric fringes with multiple baselines.[11] The main results of these observations are presented in Fig. 1. These observations were done with a set of three stations, with baseline lenghts in the range 8.8 m to 18.6m. This figure shows the power spectrum of different channels observed in one of the spectrographs, where one can see that fringe power was detected at frequencis k=2 and 3, corresponding to baselines W04-AC and AC-E03. We did not detect a fringe corresponding to the longest baseline, W4-E3, which is attributed to the low fringe amplitude expected for this baseline.

The detection of fringes from glinting geosats on multiple baselines was due to recent improvements to the NPOI. In Sec. 2 we describe these improvements as well as other changes done to the instrument. In Sec. 3 we describe upcoming upgrades to the NPOI, which will increase its sensitivity and wavelength coverage, resulting in an extended window of time for the observation of geosats.

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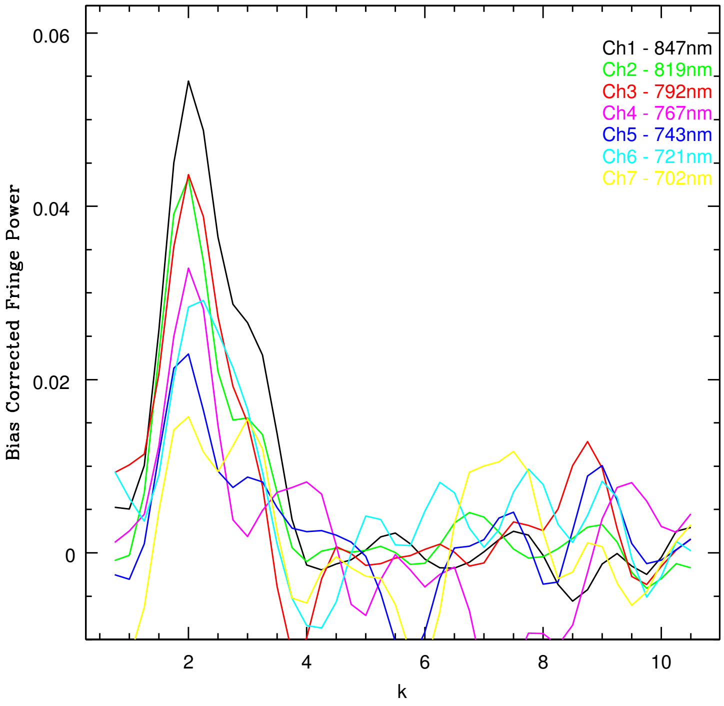

Figure 1. Power spectrum of the NPOI observations of DTV7S on the night of 2015-MAR-06. Each line corresponds to a different channel, following the legend on the top right. Baselines W04-E03, W04-AC and AC-E03 were observed with fringe frequencies k=1, 2 and 3, respectively. We detect W04-AC in all the channels presented in this figure, while AC-E03 is detected in the 4 reddest channels. No fringe was detected in the longest baseline, W04-E03, due to the fact that this is the longest baseline and the fringe amplitude was too low.

2. CURRENT ARRAY STATUS

The NPOI can combine light from up to six telescopes, being able to mix astrometric and imaging stations. Currently we use 50 cm siderostats, but are limited to a 12 cm effective diameter due to feed mirrors. The 12 cm effective diamater is a good match to the atmospheric coherence length of the site. In Fig. 2 we present the array layout and stations that are currently available and under commission. We recently commissioned stations W04, E03 and N03, which, when combined with AC, give us the short baselines (8.8 to 18.6 m) that are essential for the detection of glinting geosats. Stations E10 and W10, not shown in the figure, are almost fully commissioned, and can be combined to generate a 435 m long baseline. We are also commissioning stations N06 and N07. The small apertures and large number of reflections and windows through the system results in a small throughput and a detection limit of V∼6 mag. This detection limit constrains the work on geostationary satellite to the observations of glinting targets around the equinoxes.

Currently there are two beam combiners in use, with the original beam combiner (NPOI Classic), that observes with 16 channels in the wavelength range 550-850 nm,[2] being the instrument of choice for the observation of geosats. We have recently commissioned the New Classic fringe engine,[9,12] which increases the number of baselines and channels that can be simultaneously observed, and also allows for longer integration times. A second beam combiner, VISION,[4] have recently been commissioned. This is a six-beam focal plane combiner using polarization-maintaining single-mode fibers to spatially filter the light. VISION can observe with spectral resolutions of 200 to 1000, significantly higher than NPOI Classic, but currently has a detection limit V∼3 mag.

3. NPOI UPGRADES

Over the next two years (2017-2018) several upgrades will be done to the NPOI system, which will significantly improve our scientific and SSA capabilities. Through NRL funding we will be installing three 1 m telescopes equiped with adaptive optics, starting in 2017 (see also presentation by van Belle in this conference). These telescopes will be movable, with a compact initial configuration, with baseline lenghts of 7.8, 8.2 and 15.5 m (Fig. 2). In addition to larger apertures, we will also be commissioning a near-infrared beam combiner. The higher sensitivity enabled by higher apertures with adaptive optics, combined with the near-infrared beam combiner, which is a wavelength range where satellites are brighter, due to higher reflectivity, will allow us to observe geosats through a longer period of time. By not being constrained to observations of geosats during glinting season, these upgrades will allow us to develop new observational and data reduction techniques taylored towards the observations of geosats and other targets in similar orbits.

Other important upgrades, currently underway, include the installation of new cameras for the VISION beam combiner, which will solve the current sensitivity issue and allow it to observe fainter targets. The New Classic fringe tracker is being integrated into the operations system and regular operations. The use of this fringe tracker will allow us to use a larger number of channels and employ the full bootstrapping capabilities of instrument, which is turn will allow us to operate longer baselines and achieve better resolution. We are also designing and building a CCD-based angle tracker and new electronic controllers for the Fast delay lines. These improvements will increase the our fringe tracking stability, which is also represent a gain in sensitivity.

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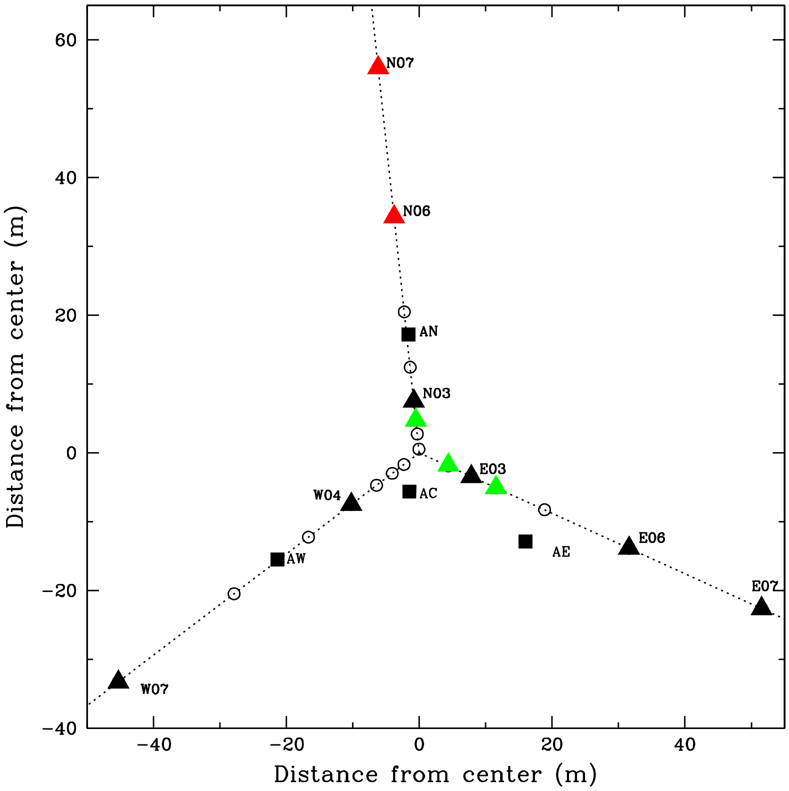

Figure 2. NPOI array configuration. The astrometric stations are shown as black squares. The currently commissioned imaging stations are shown as black triangles. The imaging stations that are currently being commissioned are shown as red triangles. Notice that stations E10 and W10, which form a baseline of 435 m, are not shown in this plot. The 3 stations that will be used for the 1 m telescopes, N02, E02 and E04 are shown as green triangles.

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