Transient Optical Sky Survey

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1 TOSS

The Transient Optical Sky Survey (TOSS) is a system of optical telescopes to survey the sky to a limit of 20th magnitude and to catalog transients by comparing the luminosity of observed objects from consecutive observing sessions. The plan is to make a map of the entire dark sky each night.

2 Motivation

A transient is any object in the sky which has varying luminosity with respect to time. TOSS will scan the sky for ANY detectable transient objects. The most common types of transients are: Near Earth Objects, Occultation caused by planets, Microlensing, Supernovae, Black Hole flares, Variable stars and the Optical components of gamma ray bursts.

3 An Example: Black Hole Flare

A black hole flare is the radiation caused by the accretion of captured gas of a tidally disrupted star by a Super Massive Black Hole. Figure 1 shows a conceptual drawing of a neutron star disrupted by a Super Massive Black Hole. Figure 2 shows a graph of the estimated number of flares of maximum magnitude m=17 at a distance up to 300 Mpc expected to be seen for a given fraction of sky observed.

FIG. 1: Neutron star disrupted by a Super Massive Black Hole

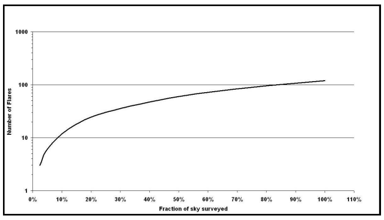

FIG. 2: Theoretical representation of the number of detectable Black Hole flares (m=17) up to z=0.07 for a percentage of sky surveyed

4 TOSS Primary goals

The experiment is designed to observe the visible sky to about 20th magnitude once per night. This is the goal of the final configuration. The immediate goal is to build the prototype which should also get to 20th magnitude but on a much smaller portion of the sky. The system is modular and scalable to achieve the final goal at a later stage.

5 TOSS basic characteristics

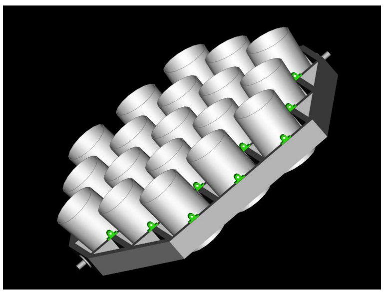

FIG. 3: Conceptual mount holding up to 19 telescopes

Earth Based: The observations are made nightly with duration of 6 hours and repeated following nights. Figure 3 shows a mount design that can be duplicated and/or scaled up to fit the needs of the project.

Telescopes: Low cost commercially available telescopes are used for the prototype–a 14 inch Celestron and a 16 inch MEADE. A set of 30 telescopes will have the capability to cover 1400 sq. deg of the sky per night. Each telescope has a field of view of 0.5 deg and is fixed in declination, tracking only in RA. The ultimate goal is to have the configuration be located in both hemispheres so that the entire visible sky is mapped. Figure 4 shows the optical layout of the telescope modules and the mount.

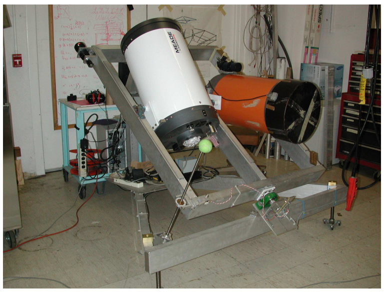

FIG. 4: Celestron 14 inch aperture, f/11 and MEADE (16 inch aperture, f/11, on aluminum mount designed to hold up to six telescopes)

6 The calculations

1. In our large-field images, resolution far from the optical axis will not be diffraction-limited or sky-limited but rather limited by optical aberrations. Vignetting causes points away from optical axis to receive less illumination. Objects off axis will be spread over more pixels, increasing noise and therefore the point-spread function (PSF) has much larger radius in those regions. These effects reduce the signal to noise ratio. Images near the edge of the field of view are improved by post-processing via deconvolution to take the effect of the PSF into account. Figure 5 shows the point source spreading in MEADE 16".

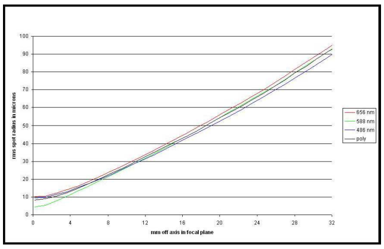

FIG. 5: Each curve represents a different wavelength of light, and traces the rms spot size of the image with respect to its distance from axis on the focal plane

2.The Signal to Noise ratio and limiting magnitude calculations were made given the following assumptions with respect to the test camera and the sky/athmospheric conditions: (1) CCD with a pixel size of 9 microns, (2) dark current of 1 electron/sec, (3) read noise of 15 electrons, (4) binning was performed over the aberrated PSF, (5) ideal sky (sky background of 0.01 photons/(sec-square cm-square arcsec)), (6) seeing disc of 1 arcsec. Figure 6 shows individual S/N curves for sources of magnitude between 15 and 21 and for images appearing at different distances (in the focal plane)from the center of the detector.

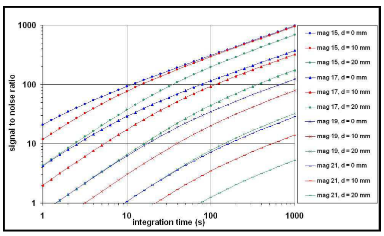

FIG. 6: Each curve represents the signal to noise ratio for a given magnitude of the source and a distance of 0, 10 or 20 mm in the focal plane from the center of the CCD. Each mm on the CCD corresponds to 50 arcsec on the sky

3. Limiting magnitude was calculated for Signal to Noise ratio of 10. Figure 7 shows limiting magnitude curves for various seeing conditions, assuming binning over the aberrated PSF, ideal sky and CCD characteristics previously described.

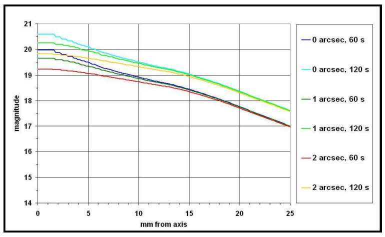

FIG. 7: Limiting Magnitude (for seeing of 0, 1 and 2 arcseconds and integration time of 60 and 120 seconds) drawn vs distance in the focal plane from the axis in mm. Each mm on the CCD corresponds to 50 arcsec on the sky

7 The housing

1. A dome tent enclosure was designed to accommodate the prototype TOSS structure on the roof of Broida (UCSB's Physics Department Building). Figure 8 shows the construction of the tent.

FIG. 8: The dome tent structure which will house the prototype TOSS configuration

2. Another enclosure in form of a shed will house the final configuration of TOSS. It has a retractable roof, is fully powered and weatherproof and is currently on location at White Mountain's Barcroft Station.

8 The Site-White Mountain's Barcroft Station

White Mountain was chosen for its high altitude (12,500-13,000 feet), low water vapor and short distance to Santa Barbara. The location was previously one of the candidates for the Keck telescopes. Remote access allows running of the telescopes when personnel are not available. Figure 9 and 10 show the Barcroft Station and Observatory. TOSS will be located either at the Station or the Observatory.

FIG. 9: Barcroft Station at 12,500 ft

FIG. 10: Barcroft Observatory, housing UCSB's millimeter wave telescope at 13,000 ft

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