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## ATMOSPHERIC TURBULENCE SIMULATIONS WITH SPATIAL LIGHT MODULATORS

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Atmospheric turbulence in the optical path of incoming stellar light transforms a plane wavefront into a distorted wavefront. This leads to loss of resolution achievable in a telescope. The correction of these distortions is the goal of adaptive optics. We are designing an experiment to recreate the effects of turbulence on an optical bench. This experiment aims to reproduce the effects observed in an artificial sodium laser star when viewed by a 30m class telescope. The edge of such large telescopes see the sodium artificial star as an elongated rather than a circle. In the bench experiment the turbulence distortions are achieved by directing the light beam through a glass plate whose surface is etched to imitate the phase distortions caused by the atmosphere, this plate is called a phase screen. Phase screens are made much bigger than the incident beam of light and we move this phase plate to simulate the effect of a changing atmosphere. To test new turbulence patterns one needs several different phase screens, which are expensive and hard to make. Our work involves computing numerical simulations of turbulence and testing algorithms to correct the phase distortion.We would then like to test these algorithms on our bench before testing on the telescope. To make these tests more realistic we would like to apply the same simulated turbulence patterns to our phase screen. This is almost impossible to do with phase screens, therefore we are planning to replace phase screens with spatial phase modulators that can be programmed to introduce a phase shift to the incident light at a time resolution of milliseconds. Integration of spatial phase modulators in optical benches as phase screens will allow for much more flexible experiments permitting a perfect correlation between the numerical simulations and the physical experiments.

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## EXTINCTION COEFFICIENTS WITH AN ALLSKY CAMERA

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All sky cameras are a great alternative to the study of atmospheric conditions in an astronomical site. We show how to compute the instantaneous coefficients of atmospheric extinction for various moments in the same night. The images used were obtained by the camera SASCA (SOAR AllSky Camera) located at Cerro Pachon. To estimate the extinction coefficients we developed a method to measure the brightness of several stars at different air masses for the same instant. We developed a Python program that calculates azimuth and altitude for the stars and then converts them to pixel coordinates on the CCD. Comparing the positions calculated for a group of stars with their actual positions on the images, we can determine the distortion caused by the camera. After finding out the distortions we know exactly in which pixel a star falls on any date and time. At this point we created tables of star positions and did the photometry of them all on each image using the IRAF routine PHOT. These photometry tables are subsequently converted into multiple tables with apparent magnitude versus air mass for each star at a given instant. Our results show that the extinction coefficient calculated for different atmospheric moments is within two sigma of the values of the coefficients obtained through the monitoring of a single star at different air masses, demonstrating the feasibility of our approach.

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## THE HARD X-RAY TELESCOPES FOR MIRAX AND PROTOMIRAX

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The Monitor e Imageador de Raios X (MIRAX), under development at the National Institute for Space Research (INPE), Brazil, is a hard X-ray astronomy experiment that will be launched in low-Earth orbit (650 km altitude, 15° inclination) onboard the Lattes satellite mission in 2018. MIRAX

consists essentially in two coded-aperture imaging telescopes equipped with cadmium-zinc-telluride (CZT) solid-state room-temperature semiconductor detectors. One telescope (T1) has been in development at INPE′s Astrophysics Division and will fly in a high altitude (∼43 km) balloon in 2014 for testing and demonstration; this development is called the *protoMIRAX project*. T1 uses an array of 13×13 CZT planar detectors with dimensions 10mm×10mm×2mm and a 1 mm-thick lead coded mask with 20 mm openings in a 13×13 Modified Uniformly Redundant Array (MURA) basic pattern. It will have a $20^\circ \times 20^\circ$ fully-coded field-of-view (FC-FOV) and an angular resolution of 1.5°. T1 will be mounted in a balloon gondola with an attitude control and pointing systems as well as a 500 kbps telemetry and command capability for real-time operation and data acquisition. The imaging CZT detectors for the second telescope (T2) are being developed at the Harvard Smithsonian Center for Astrophysics (CfA). The detector plane for T2 will have a 0.6 mm spatial resolution and an area of 250 $cm^2$. A 0.3mm-thick tungsten mask with a random pattern will provide images with 6′ angular resolution with a $20^\circ \times 20^\circ$ FWHM FOV. In this presentation we will describe the current status of MIRAX and present results of the protoMIRAX detector, telescope and balloon gondola developments.

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## GEMS/GSAOI: FROM COMMISSIONING TO OPERATIONS AND SCIENCE RESULTS

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The Gemini Multi-conjugate Adaptive Optics System (GeMS) and the Gemini South Adaptive Optics Imager (GSAOI) are unique and complex facility Gemini instruments. GeMS/GSAOI provide a uniform, diffraction limited image quality at near-infrared (NIR) wavelengths over a field of view of 85” x 85” on the sky. The GeMS/GSAOI commissioning started at the beginning of 2011. After ∼2 years of dedicated work and more than 90 nights of on-sky commissioning, at the end of 2012 GeMS/GSAOI started to produce the first science results. In this presentation we describe in details the system performance, on-sky efficiency and present the scientific results produced by GeMS/GSAOI during the system verification process.

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## MMTRON

T. de Graauw[1]

Millimetron is a 10-meter cooled space observatory that is optimized for the far-infrared and submm wavelength range. The facility has two operating modes: one can operate as a single-dish observatory or as an element of a space-earth VLBI system. It will have scientific capabilities that can address various key problems in astronomy and astrophysics such as the formation and evolution of stars and planetary systems, evolution of galaxies, quasars, etc. The telescope will be deployed in space and the panels of the primary mirror are to be adjustable to achieve an rms accuracy less than 10 micron. The telescope and instrument compartment will be cooled down to 4.5K by passive cooling and mechanical coolers. The instrument package is to include a set of heterodyne receivers operating in several bands between from 500 and 5000 GHz, a submm array camera/spectrometer and a mm array camera/spectrometer covering 50 micron to 3 mm. Millimetron is proposed as a Russian-led mission and is to include a wide international collaboration. Currently, the mission scheduled to be launched in 2020.

[1] ALMA.

## SURFACE LAYER TURBULENCE PROFILING WITH THE SL-SLODAR AND LUSCI AT ESO PARANAL OBSERVATORY

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