PLANS FOR MT. WILSON - CRIMEAN OBSERVATORY HIGH-DEGREE HELIOSEISMOLOGY NETWORK

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ABSTRACT
The National Science Foundation has recently approved a three-year program for the establishment of a two-station helioseismology network which will combine the instrument now located at the 60-Foot Solar Tower Telescope of the Mt. Wilson Observatory with a new instrument which will soon be installed at the Crimean Astrophysical Observatory.
INTRODUCTION

Overall Project Goal
The goal of this project is the establishment of a joint two-station US/Crimean network of ground-based helioseismic observing stations which will be suitable for observing solar oscillations of moderately high degree ($\ell \leq 600$) on a nearly uninterrupted basis for a few months of each year. This network of stations is designed to provide a multi-year baseline of observations of anticipated temporal variability in solar internal and atmospheric structure prior to the launch of the NASA-supported Solar Oscillation Investigation (SOI) experiment onboard the planned NASA-ESA Solar and Heliospheric Observatory (SOHO) mission, which is now scheduled for late 1995.

This project is designed to combine an existing, NASA-supported, high-degree helioseismic observing facility, which is now in operation at the 60-Foot Solar Tower Telescope of the Mount Wilson Observatory (MWO), with the installation of a simpler, personal computer-based observing system at the Solar Tower of the Crimean Astrophysical Observatory (CrAO).

DESCRIPTION OF PLANNED SECOND STATION

The CrAO is located southwest of the city of Simferopol in the center of the Crimean Peninsula. It is located at Nauchny in the mountains between Simferopol and Yalta. It is located at an elevation of 676 meters, at a longitude of 34°1'E, and at a latitude of 44°32'N. Its longitude separation from MWO is thus 10.2 hours. The weather pattern at the CrAO is ideally phased with that of the MWO such that both observatories should be getting the best coverage of the sun during the summer months. Calculations which we have recently done in which we required that the altitude of the sun was constantly above 15 degrees from the local horizon at either of the two sites suggest that under clear weather conditions the two-station network will be able to provide solar coverage of up to 22 hours per day between June and October of each year.

The infrastructure of the CrAO is ideally suited for a project such as this one, which requires the presence of both skilled observers and technicians in order to insure that the equipment remains operational and that the images being obtained there will be suitable for merger with those from MWO. Since we are planning to obtain images having $2^{10}$ pixels eventually, our project requires access to a dedicated solar telescope with a built-in guiding system which is capable of keeping the solar image still to such a level during a sequence of successive exposures. The telescope must also have a location for a light beam which can be provided to this project from sunrise to sunset on every available observing day. The Solar Tower at the CrAO meets all of these criteria.

The coelostat mirrors of the CrAO Solar Tower are located at the top of the tower. Their design provides a non-rotating beam of unfocussed sunlight which travels vertically downward just as is the case at the MWO 60-Foot Solar Tower. An objective lens of 3 meter focal length will be mounted in the beam from the main coelostat mirrors at a height of about 2.5 meters above the base of the inner one of the two concentric towers which comprise the CrAO Solar Tower. An additional mirror will be installed on top of the base of the inner
tower. This mirror will re-direct the converging beam from the objective lens horizontally along an optical bench which will also be installed at the base of the tower. Additional lenses, the mechanical shutter, the MOF cells, the rotating quarterwave plate, and the camera of the new data acquisition system will all be mounted on the new horizontal bench which will run from the base of the inner tower to the wall of the outer tower.

DESCRIPTION OF FUTURE CRAO OBSERVING SYSTEM

The equipment which will be installed at the CrAO for this project comprises a portable solar image acquisition and archival system. This system forms images of the sun on a commercial television camera. In front of the camera the system currently employs a Na magneto-optical filter (MOF) which provides the capability of obtaining nearly monochromatic solar filtergrams. This MOF was originally developed in Italy by Dr. Alessandro Cacciani. Several versions of it have been in regular use at the MWO 60-Foot Solar Tower Telescope since it was first brought from Italy to the US in late 1981. The filter has been described in great detail in numerous articles in the open scientific literature.

In place of the PDP-11 minicomputer and associated array processor which we have been employing at the MWO 60-Foot Tower since the summer of 1987 to operate our 1024x1024 pixel CCD camera and to acquire and to store full-disk filtergrams there, the system which will be operating at the CrAO employs a commercially-available clone of the IBM PC/AT. A PC/AT was selected so that the new system would be simpler to operate and more portable than the current MWO system is. The existing PC/AT was purchased with USC funds. It employs an Intel 80386 CPU board running at 25 MHz.

The PC/AT also communicates with an LSI 11/02 which controls the operation of the system's shutter, the MOF, and the camera. The LSI 11 which we are proposing to employ at the CRAO is a unit which was previously employed at MWO between 1983 and 1986. This LSI 11 is currently in use with the PC/AT there. This LSI 11 controls the real-time observing functions through a set of circuit boards which were designed in the early 1980s and then fabricated at the MWO. The solar images are generated by a Panasonic GP-MF702 MOS camera. This camera has 649x493 pixels. A key aspect of this camera is the square-pixel shape of the individual pixels. Each pixel covers an area of 13.5 microns on a side. Because of the square aspect ratio of the individual pixels, we are actually employing an area of 490x490 pixels on the camera chip for our images. The images generated by this camera are then grabbed and digitized by a set of PC-compatible image processing boards which allow us to acquire images at 30 Hz. This three-board image processing set forms the Coreco Oculus OC500 Image Processing System. This system allows us to add together successive 8-bit camera exposures at a frame rate of 30 Hz until a summation image having a depth of up to 16 bits is generated. We are currently operating the system with accumulations of 90 exposures which last three seconds in duration.

By tuning the MOF once during each minute of every clear observing day, we are then able to use the camera and its associated image processing boards to transfer two such filtergrams (one from the red wings of the two Na D lines and the second from the blue wings of these same two lines) every minute onto
the 376MB hard disk which is located within the PC/AT. As soon as this pair of solar filtergrams (padded out with 22 extra rows and columns to a size of 512x512 pixels in order to maintain compatibility with some of our existing software routines which expect image dimensions to be in powers of two) has been acquired and stored on the disk, the pair is immediately transferred from the disk and written out during the same minute to an Exabyte 8mm helical-scan tape drive.

We will soon be purchasing a True Time GPS radio frequency Universal Time clock for the PC/AT. We will utilize this clock to provide the timing synchronization signals to the clock board that is located in the LSI 11/02. The use of this new clock along with our existing True Time WWVB clock at the 60-Foot Tower will allow us to synchronize the frame acquisitions at the two observing stations to within a few milliseconds.

OBSERVATIONS WITH NEW SYSTEM AT MT. WILSON

We have recently completed the integration of the new data acquisition and storage system at MWO. We have also prepared a videotape which contains sequences of both Dopplergrams and filtergrams which were obtained with the new system on July 29, 1992. We have been employing the new system to obtain daily observations since July 28, 1992. Since that date we have obtained data on 69 out of the 75 possible observing days.

FUTURE PLANS

Once we have completed our current testing of the entire PC-based system at the MWO 60-Foot Tower, we will be ready to transfer that system to the Solar Tower at the CrAO. We anticipate that this transfer will take place in the spring of 1993. Once the new equipment has been installed at the CrAO Tower, CrAO personnel will take over the on-going operation of the acquisition system.

After the 8mm cassettes have been created at CrAO, they will be shipped to USC, where we have already begun processing these filtergrams with only minor modifications to our existing CCD data reduction software pipeline. Because the spatial resolution of the two systems will not be identical, at least initially, we plan to compute the spherical harmonic coefficient time series separately for each station and to then merge the two time series of a given \((\ell, m)\) mode that we have obtained at the two stations for a given day into a single, merged time series of coefficients. It is these merged time series which we then plan to convert into power spectra. For those \(\ell\) values where the second station does not have adequate spatial resolution to generate meaningful spherical harmonic coefficients, we plan to continue using only the time series of Mt. Wilson 60-Foot observations.

Once the new system has been demonstrated to operate successfully at CrAO with the existing Panasonic camera, we plan to build an additional 1024x1024 pixel camera so that the second station will ultimately have the same spatial resolution as does the existing MWO station. The frame grabber which we are now using is also compatible with the 1024x1024 pixel format.