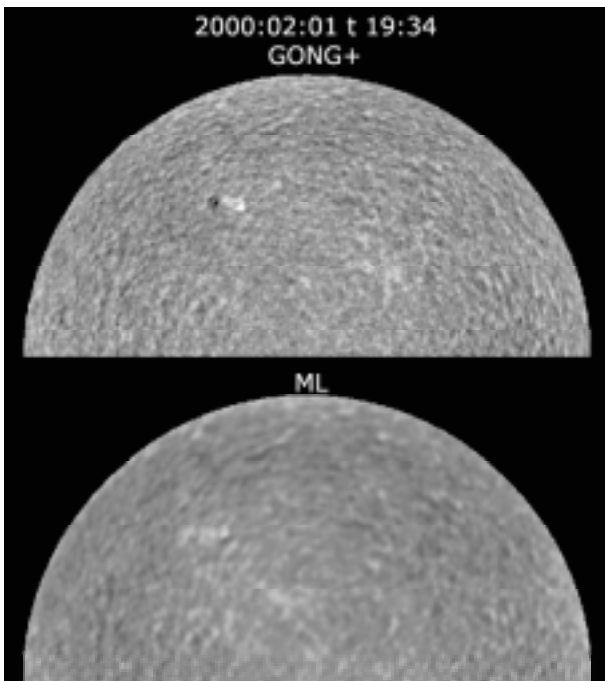


G O N G

GLOBAL OSCILLATION NETWORK GROUP

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The Global Oscillation Network Group (GONG) Project is a community-based program with the goals of operating a six-site helioseismic observing network, performing the basic data reduction and providing the data and software tools to the community, and coordinating analysis of the rich data set that is resulting. GONG data are available to any qualified investigator whose proposal has been accepted. Information on the status of the GONG project, the scientific investigations, as well as access to the data, is available on our WWW site at <http://www.gong.noao.edu>.



Comparison of GONG+ image (upper panel) and simultaneous GONG classic image (lower panel). Magnetic features are more conspicuous in the GONG+ image (upper panel), as only one polarization state is detected. During normal operations, the polarization will be modulated rapidly during a 60-second integration, and separate velocity and magnetic images will be obtained.

Difficulties with the GONG+ Data Acquisition System (DAS) kept our deployment teams at home, and working on other aspects of GONG+ production and acceptance testing. Nevertheless, the GONG+ prototype data, which have been collected intermittently throughout the testing process, are excellent. Deployment teams are currently on hold, but hope to be heading for Big Bear by mid-summer.

Operations

The arrival of 2000 brought with it a couple of unanticipated problems that briefly compromised instrument performance. Downtime from other causes was, in most cases, what we have come to expect for the first quarter of the year—mostly weather-related problems. However, because preventive maintenance trips did not occur during this time, network coverage was above average.

On 31 December 1999, several of the GONG staff watched each site as 0 hours UT approached. That moment passed uneventfully, but about 20 minutes later, the data computer CPUs began switching to the year 1980. Within a few hours, a fix was implemented, and the result was that some image files were labeled with an incorrect time stamp. A more troublesome Y2K problem did not show up until the next day when the instruments could not acquire the Sun after unstowing. The symptoms indicated that the turret was being given incorrect pointing commands, which we suspected was somehow related

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to the year change. The software routine calculating the solar position uses the Julian Day number associated with 1 January 2000, and the calculation for day numbers past that time was not being done correctly. By the time the correction was made, one to two days of images were lost at each site.

Winter months bring expected severe weather to the Big Bear and El Teide stations. These sites have each accumulated several days of downtime during this quarter. In the other hemisphere, the Learmonth site was stowed for 19 hours because of Cyclone Steve, which passed by uneventfully.

Several other problems occurred that resulted in considerable instrument downtime. At Udaipur (17 hours longitude), a fuse holder failed to make good electrical contact; subsequently, the waveplate rotator was not running. Additional downtime (34 hours) was incurred when the data computer hung and crashed the system. At El Teide, a power breaker tripped and the system was down for 27 hours. On another occasion, 27 hours were lost when a software task failed to load and run properly after a system reboot. The utility power at Mauna Loa was off on a couple of occasions, resulting in a total of 24 hours downtime. The CTIO instrument suffered a problem (30 hours of downtime) that had occurred last year at another site—the calibration wheel became stuck at the limit of its motion while taking a dark image for calibrations. Our previous experience led to a quick swap of a resolver board, bringing things back to proper working order. Exabyte problems were scattered around the network and account for several hours of downtime.

Data Management and Analysis

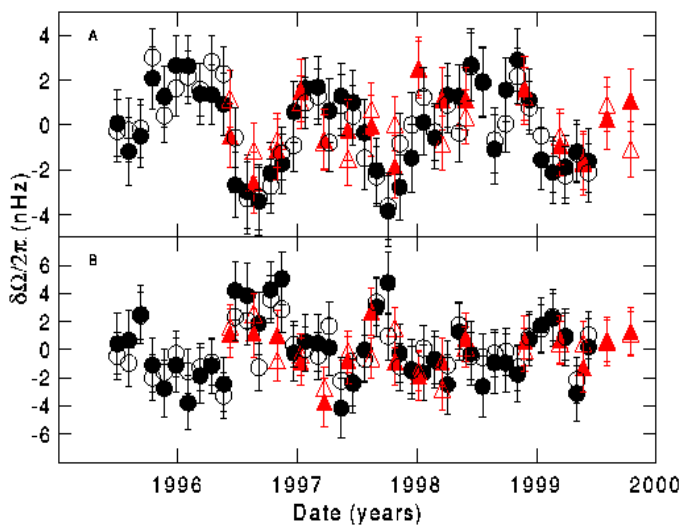
During the past quarter, the DMAC produced month-long (36-day) velocity time series, and power spectra for GONG months 43 and 44 (ending 990906), with respective fill factors of

0.83 and 0.86, and tables of mode frequencies that were computed from the power spectra using the three-month-long time series centered at GONG months 42 and 43.

The main development activity currently underway in the DMAC is related to the development and testing of the GONG+ camera and data system upgrade.

Data Algorithm Developments (and Some Science)

Peakfitting has progressed up through month 44, and analysis of the results shows the continuing evolution of the torsional oscillation pattern described in the last newsletter. In addition, a paper by R. Howe et al. in the 31 March 2000 issue of *Science* (287, 2456-2460) describes exciting new observations of a periodic 1.3-year variation in the rotation rate at the tachocline. This variation is presumably related to the solar cycle, and is the first

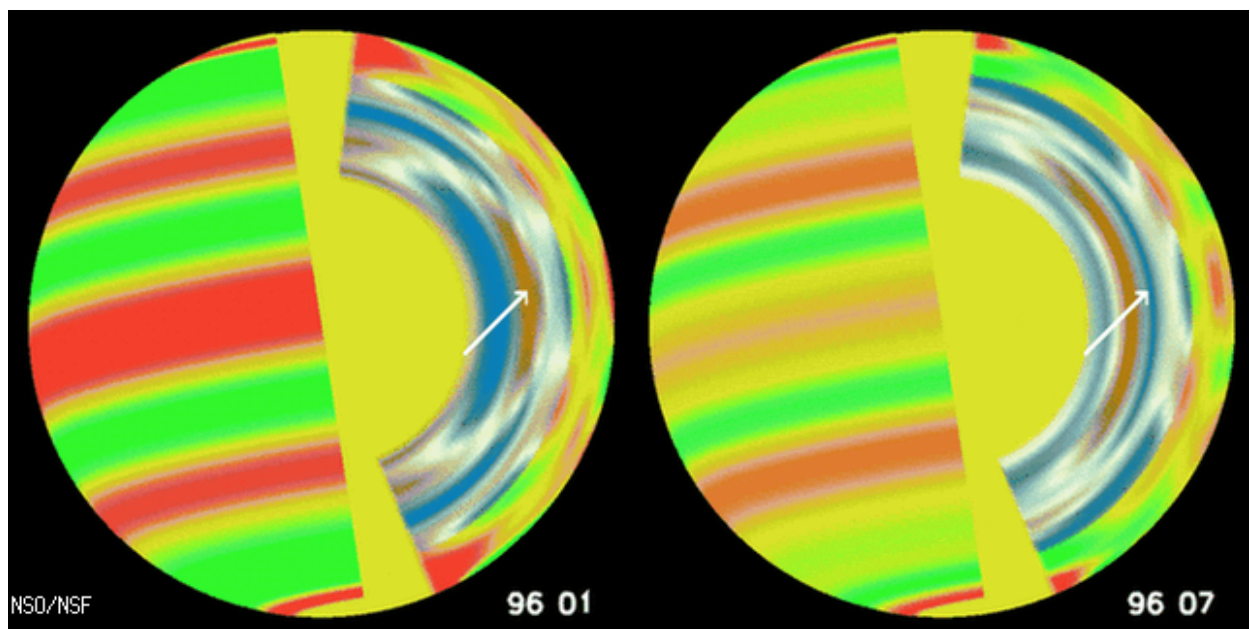


Variations with time of the difference of the rotation rate from the temporal mean at two radii deep within the Sun. Panel "A" is at 0.72 R (above the tachocline) and "B" is at 0.63 R (below it), both located in the equator. Results obtained from GONG data for two different inversions are shown with black symbols, those from MDI with red symbols.

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indication of dynamical behavior in the radiative zone. Considerable press interest was generated (see <http://www.nso.noao.edu/press/tach/>). These results were obtained from helioseismic analysis of data obtained during the past four years with GONG and the SOI/MDI instrument on board the SOHO spacecraft. The largest temporal changes in the rotation rate are found both above and below the 'tachocline,' a layer of intense rotational shear located at the interface between the convection zone and the deeper radiative interior, at a depth of about 30% by radius into the Sun. The variations near the equator are strikingly out of phase above and below the tachocline, and involve changes in rotation rate of about 6 nHz, which is a substantial fraction of the 30 nHz difference in angular velocity with radius across the tachocline.

The solar magnetic dynamo is thought to operate within the tachocline, with the differential rotation there having a crucial role in generating the strong magnetic fields involved in the cycles of solar activity. The strengthening magnetic fields should feed back on the rotational shear in which they are embedded. Although the magnetic fields are difficult to detect directly at such great depths within the Sun, helioseismology is able to probe the rotation profile at those depths, including how it might change with time. The reported discovery of periodic changes in the rotation rate near the tachocline as the Sun's magnetic cycle progresses provides the first indications of dynamical changes that may accompany the operation of the solar dynamo.



Cutaway images of solar rotation showing a peak and a trough of the 0.72R variation. The color table near surface shows faster rotation in red, slower in green, and yellow as intermediate; color table below 0.85 R has faster rotation in red and slower in blue. The left-hand side of each sphere shows the surface view. The arrow-tip indicates the position of interest.

The data for the Mercury transit of 15 November 1999 have been reduced. This event was observed with the new GONG+ camera system at Tucson, and with the current "GONG Classic" system at Mauna Loa and Big Bear. The goal of the observation was to determine the accuracy of our determination of terrestrial north using solar drift scans. The mean difference between the predicted (ephemerides) angle of Mercury at each minute and the measured angle (both relative to Solar North) is $0.013^\circ \pm 0.007$ for GONG+. For the Mauna Loa GONG Classic data, the difference is $0.042^\circ \pm 0.029$ ignoring refraction and $0.037^\circ \pm 0.029$ with refraction.

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We thus conclude that there is about a 0.01° offset in our determination of terrestrial north. This is an order of magnitude less than the uncertainty in Carrington's elements for the solar P angle. An error of 0.01° in the P angle is estimated to produce a maximum velocity error of 2 m/s near the limb in local helioseismology. The transit reduction was a very useful exercise, as it motivated a number of improvements in the software used to analyze the drift-scan data. This, in turn, will be important for the scientific productivity of the GONG+ data. It is, in principle, possible to improve Carrington's elements by reducing long time-series of helioseismic data with different P angles and studying the distribution of power with azimuthal degree. However, this is a very computationally expensive project.

The current numerical interpolator used in the remapping step, which is central to both global and local helioseismology, is a cubic convolution. While this has been adequate for GONG Classic, it is not accurate enough at the higher spatial frequencies present in GONG+ data. We are thus developing a new algorithm based on Fourier interpolation.

We are also developing a new version of *peakfind*. The current algorithm has been translated into C and is modularized. This package is currently being tested by running it on a standard 3-GM time series at all degrees. When this is finished, we will run the standard comparisons on both the new and the previous results. After establishing that the new version is working as well as the old one, we will begin to add new features such as asymmetric line profiles, low- ℓ leaks, and multi-dimensional fitting. The new code will be much simpler to modify than the original "spaghetti" code, and it is also more portable.

GONG+ Camera Development

A problem in the Data Acquisition System was revealed during acceptance testing, that resulted in excessive performance dependence upon temperature and power supply voltage. Intensive investigation, by both GONG and vendor personnel, produced a design modification that appears to have eliminated the problem.

Unfortunately, this has necessitated a deployment delay to allow for a repetition of acceptance testing.

We are working on two lesser problems with the SMD cameras. Operation at the Tucson observing facility has shown that serial communications with the camera, heavily used to introduce offsets in the video data, will be lost during prolonged operation. Many of the cameras also show poor temperature control when operated for lengthy periods.

Loss of serial communications was initially identified as a loss of system synchronization. Oddly, this problem has only been seen at the Tucson observing facility and not in our laboratory. A temporary open-loop software solution has been implemented while we determine the cause. This is not expected to be a serious impediment to deployment.

Although acceptable temperature regulation was observed during initial tests, we later found that prolonged operation resulted in the camera warming up until temperature regulation could no longer be maintained. The problem was traced to poor thermal bonding of the temperature sensor and thermoelectric cooler to the CCD imager. An effective modification has been developed and is being fitted into all of the cameras.

We have greater confidence in the system that will be deployed because of the additional testing and scrutiny that it has been given.

