

GONG Newsletter

Number 3

December 31, 1986

The *GONG* project has been extremely busy since Newsletter #2; the site survey installation has been completed, a laboratory has been established and the breadboard instrument development is well underway, data acquisition and analysis activities have gotten a good start, a Plan for Membership in *GONG* has been drafted, and last — but far from least — the National Science Foundation has funded the project! We hope that you will find this issue informative, and we particularly direct your attention to the *Invitation to Participate* which is just that.

Instrument Development

Overview

Considerable progress has occurred since the last newsletter, in three major areas. First is the assembly and testing of a breadboard system to serve as a testbed for the individual components. Second is the design and construction of a field prototype instrument. Third is design of the instrument control and data acquisition system. Substantial progress in all of these areas has been made thanks to the skills and dedication of a fine group of people working on the *GONG* project within NOAO.

Breadboard System

Various optical designs for the *GONG* instrument were studied and one was selected during the summer. The breadboard design emulates the provisional prototype design in most, but not all, aspects. The breadboard is more complicated because of the need to separate and study the performance of individual elements. Each element of the optical system will be studied to identify any problems that might degrade overall performance. Our immediate goal is to produce a time series of Doppler shift measurements using a single detector in the final focal plane; imaging tests will follow shortly thereafter.

All of the parts required for the breadboard are either in hand, under construction or on order. A basement laboratory in the NOAO Tucson building now receives sunlight from a heliostat built by Bob Hartlmeier and installed on the roof in November. A large number of tests are underway in this lab thanks to the hard work of many people but especially Rob Hubbard, Warren Ball and Raleigh Drake. The heliostat has been aligned by Rob Hubbard and performs well. The spectrum of image motion was measured. An autoguider that uses a quadrant diode to detect solar image motion has been designed by Warren Ball. This system will feed slow correction signals to the motors of the heliostat by year end. Rapid image motions will be corrected by a fast guiding system consisting of a light weight mirror actuated by three

piezoelectric supports. This system is being designed by Khairy Abdel-Gawad.

The stabilized solar image is fed to a horizontal optical table that supports the telescope optical system. The first critical optical element is a 5\AA passband, two-period interference filter. A vendor has been selected who will fabricate this filter using ion-assisted deposition techniques to help insure long term stability. Delivery of the first filter is expected around the first of the year. A temperature-controlled oven is ready to receive this filter. A program between the *GONG* project, the Optical Sciences Center of the University of Arizona and the vendor has been set up by Raleigh Drake to evaluate the long term stability of the new ion-assisted filters. We expect this program to start in February.

The next critical element of the breadboard is a 1\AA passband, birefringent filter. A temperature-controlled oven for this filter was designed by Arden Petri and is currently under construction. Even with millidegree-temperature-stability performance of this oven, a simple birefringent filter would drift too much to meet our requirements. Therefore a design was specified in which the temperature sensitivity of calcite is compensated by an opposite sensitivity of a suitable piece of ADP. This concept was successfully tested using some pieces of calcite kindly loaned to us by Alan Title. Implementation of this scheme in the breadboard requires the fabrication of quite thin pieces of ADP, a problem that was neatly solved by Frank Vaughn using a precision vacuum chuck. Excellent pieces of ADP were obtained from a vendor in quantity sufficient for all of the *GONG* instruments and tests of the temperature sensitivity of this material were recently concluded. Except for three compound-quartz half-wave plates, the remaining optical elements for the breadboard filter are finished. A sufficient quantity of high-quality calcite for all of the *GONG* filters was tested and purchased earlier this year.

The next element is the heart of the instrument, the Michelson interferometer. Design studies led to the selection of an interferometer that consists of a glass (BK-7) polarizing beam splitter cube that has one arm of BK-7 and the other arm of air (actually dry nitrogen). The mirror in the air arm is supported by a spacer made of material with a thermal expansion coefficient and thickness that results in a temperature compensated, wide-field interferometer. A strong desire for long term stability of the interferometer led to a design that uses no cements; the pieces are joined by optical contacting. A problem arose in the selection of the material for the air arm spacer. An expansion coefficient larger than available in any glass was needed. This led to the selection of several metal alloys with the correct properties. The problem of firmly contacting metal to glass was nicely solved by Frank Vaughn, Raleigh Drake and Don Kucera. Three different alloys are currently being tested for long term stability of the contact joints. A tricky part of the assembly is to adjust the thickness of the metal spacer to a tolerance of about 1 micron in order to obtain a flat, wide field. The contacting process that was developed allows this adjustment to be made during assembly in a reversible way. A vendor has been selected who will supply the major part of the interferometer assembly with the final assembly to be done in house. Unfortunately, the vendor has specified a six-month delivery. We are proceeding with this order but several alternatives were explored. As a result, in-house fabrication of an entire interferometer is underway (except for the polarizing beam splitter

coating). In the meantime we are using an interferometer made by Harry Ramsey and kindly loaned by Lockheed. The oven that holds the interferometer was finished during the summer.

The next critical element is a half-wave plate that must be rotated with a precisely controlled speed and phase. In collaboration with a motor manufacturer, George Streater designed and Arnold Green constructed a prototype motor that appears to have the necessary performance. A significant concern is the possible effect of vibration from the motor that drives the rotating half-wave plate. To address this concern, a series of accelerometer tests of the motor have been made. It is not yet clear whether the measured levels of vibration are deleterious or not. The motor is also undergoing tests using an optical method to determine how smoothly it rotates. Warren Ball designed a servo loop to control the speed and phase of the motor using stabilized laser light to produce an error signal. This design is under construction. The half-wave plate has tight tolerances and a design study led to the selection of a compound construction of quartz and magnesium fluoride, optically contacted, antireflection coated and having the same retardation at the control laser and solar wavelengths. This component is being fabricated by an outside vendor.

The stabilized laser is the next major element of the system. This is used together with the rotating half-wave plate to detect and compensate wavelength drifts of the interferometer. The vendor selected has failed to meet the delivery date and we may be forced to an alternate supplier. Experiments with a substitute laser showed that a 1mm diameter optical fiber is a fine way of coupling the laser beam to the rest of the optical system and this is now incorporated in the design.

The final major optical system is the camera head. A Reticon 256×256 array camera was selected several months ago after comparison with some alternatives. Preliminary tests of the Reticon camera by Warren Ball and Ken Dowdney suggest that the signal-to-noise ratio performance will be adequate. Furthermore, the design and construction of the commercially-supplied front end of the camera appears to be hard to improve upon. Some changes to the clock drivers will be required but we intend to use the front end as supplied by Reticon with the addition of a cooling system. As the solar image rotates once per day at the final focal plane, a rotator has been designed and the parts obtained by George Streater.

Prototype

The goal of the prototype activity is to construct one *GONG* instrument that will closely resemble the field instruments, including support services and housing. Design studies have been made by Dick Dunn and George Streater that have led to a concept in which the optical system is mounted on an air support table with a vertical optical axis for the majority of the delicate parts. Sunlight is picked up by a two-mirror, sealed turret that is mounted on a strong pier at a ground height of about four feet. The light is directed horizontally within a sealed tube that penetrates one wall of the *GONG* instrument shelter and then into the main instrument. A novel telecentric optical system in which the entrance pupil is located at the focal distance in front of the objective lens was selected.

The prototype studies are proceeding in parallel with the breadboard tests. Items that we believe will not be affected by results of the breadboard tests are candidates for prompt construction or purchase. For example, the prototype turret is under construction. When breadboard tests are completed in 1987, the prototype will be temporarily assembled and tested in the Tucson *GONG* lab pending completion of the prototype instrument shelter. Then our plan is to operate the prototype system as if it were at a remote site in order to streamline operational procedures and to detect and correct any remaining instrumental problems before fielding the final instruments.

Control and Data System

After discussion between NSO staff at Sunspot and Tucson, a decision was made to adopt a VME-bus, 68020 cpu, VRTX real time operating kernel, C language architecture to control the instrument and process the raw observational data. At present the plan is to use separate processors on one bus to execute the control and acquisition functions. This may change with further design study. The control function is in the care of a group at NSO/Sac Peak while the acquisition function is being handled by NSO/Tucson under the guidance of Tom Duvall.

An overall block diagram of the electronic aspects of the *GONG* instrument has been prepared and the details of each block are being explored and defined. A crucial element is what we call a fast image cache whose purpose is to provide a master clock for data acquisition and to accumulate the 5 Mpixel per second stream for a period of about one minute. This buffer is being designed by Steve Colley.

During each integration of about one minute, each image pixel will produce about 48 significant bits of data in 54 bits of dynamic range. Methods for compressing this to between 24 and 36 bits per pixel without loss of accuracy have been designed and tested by Tom Duvall and Kate Rosser using proxy data (see the next section). So far 10-bit reductions have been achieved using techniques that would require about 20 seconds of 68020 processor time. Even at only 36 bits per pixel, a single site may produce nearly 200 Mbytes each day. Therefore we have investigated several data recording technologies. The most promising one appears to be the emerging Rotary Digital Audio Recording Technology (R-DAT) being developed by 81 manufacturers in Japan for consumer use in 1987. The large potential market promises a low media cost which is the main drawback of competing technologies such as laser disks, cartridge tapes, *etc.* When used for storage of digital data instead of music, each R-DAT cassette holds 1.38 Gbyte and measures $73 \times 54 \times 10.5$ mm. (*Jack Harvey*)

Data Compression

The *GONG* preliminary data compression study is two-thirds completed. The purpose of the study is to estimate the feasibility of compressing, at the observing site, the 54-bit-per-pixel intensity samples to 32 bits of velocity, modulation and continuum intensity data, in less than 20 seconds, without loss of information, and with fewer than one percent exceptions. Results for velocity and intensity, based on Kitt Peak Vacuum Telescope $2048 \times$

2048 images, are now complete. Modulation data is currently being studied.

The best method for compressing the simulated intensity data seems to be that of fitting a second degree polynomial in $\cos(\theta)$ to each row of the solar disk. The data was reduced by six bits per pixel, with fewer than one percent exceptions, in 15.8 seconds, when implemented in FORTRAN on a SUN-3 workstation. The velocity data was reduced by four bits per pixel with .3 percent exceptions in 3.0 seconds, by the method of first differences.

A compression of ten bits has thus been achieved so far. Alternate methods of compression have also been studied, which may lead to greater compression when applied to the actual data. It should be noted that implementing the algorithms in C or assembly language is expected to significantly increase the speed. (*Kate Rosser*)

Site Survey

The site survey network is now complete! The tenth and final instrument was installed by John Leibacher during November at the Udaipur Solar Observatory in India. The USO is directed by Arvind Bhatnagar, and the instrument is being shepherded by Ashok Ambastha. Rajmal Jain, who spent several months at NSO/Sac Peak, was there to get everything off to a smooth start, and Sudhir Gupta managed to be more resourceful than Indian power was challenging, and he played a critical role in bring the instrument on-line — thus earning himself the affectionate sobriquet of “the Bhagwan of AC”. The instrument was inaugurated at an auspicious moment with a fresh coconut and incense. The weather was perfect throughout the installation, and Udaipur is a fantastic spot — which some of you may recall from the “floating” hotel featured in a James Bond film. The Indian astronomical community is conducting a site survey at a high altitude site in — or even beyond — the Himalayas, at Leh, which might provide an alternative as it should be much less sensitive to the Monsoon. Leh — and the surrounding region of Ladakh — is truly enchanting, and it was shown off to its advantage in the Bill Murray film *The Razor’s Edge*. The whole continent is incredibly photogenic. The installation trip also provided the opportunity to discuss scientific participation and collaboration in *GONG* with the groups at the Indian Institute of Astrophysics in Bangalore, and at the Tata Institute for Fundamental Research in Bombay. It may be possible to hold a major scientific meeting in India on helioseismology, as part of the *GONG* project.

Now that the site survey network is complete, we will be measuring the performance of several alternative networks. While the longitude distribution is basically proscribed by geography, the choice at the longitudes will be made by computing a figure of merit for the sites and the possible networks. The most important figure will of course be the duty cycle of the six station networks, but we will also be measuring instrument downtime, servicing frequency, power outages, fraction of clear time, and statistics of clear time for the individual sites. To effectively utilize the considerable data already collected from the other sites, we have hourly weather observations from Udaipur, so that we have a measure of the full network’s performance for an additional season.

The other instruments in the field continue to work reasonably reliably. The major problems have been the breakage of a wrap-up cable, the failure of a battery, and the continuing, and perplexing, problem of water in the tracker gear case. The software has been upgraded to reduce the cassette usage and to improve the time keeping of the instruments, and the long awaited documentation — *GONG* Report No. 3 — is in the press. It will be distributed to the sites along with the new software, and additional copies are generally available upon request. The installation of the Udaipur instrument meant the return of the Mt. Wilson instrument to serve as a source of spares. It had been run there for several months along side an all-sky monitor to intercompare them, and we would like to thank Larry Webster and Pam Gilman for their support and participation in the tests. Thus, the sites with survey instruments currently are Tucson, Yuma, Big Bear, Haleakala, Mauna Kea, Learmonth, Udaipur, Izaña, Cerro Tololo, and Las Campanas. (*Frank Hill*)

Organization

The New Fiscal Year

The National Science Foundation program for Fiscal Year 1987 (starting October 1, 1986) includes the start of the *GONG* project as a new initiative — the *GONG* is now officially recognized and under way. The Summer and Fall have seen the beginning of the long awaited “ramp-up” to the major activity levels projected for the next several years. This has been reflected by accelerating activity in all areas, including personnel, planning, and, of course, tangible progress in system development.

Personnel

Our project team consists of full-time *GONG* project staff, NSO staff scientists, and support from NOAO Engineering and Technical Services (ETS) and Central Computing Services (CCS) personnel. These include groups located both in Tucson and at Sacramento Peak.

At the time of our June Newsletter, we had a total of 7 FTE personnel working on the project. These included two full-time *GONG* staff, 2 FTE in support from NSO scientific staff, and a total of 3 FTE from NOAO ETS and CCS personnel.

At this writing our full-time project staff has more than doubled to five, with another four positions currently being advertised. We expect to have all nine full-timers on board by February. Our NSO Scientific staff support has increased to 3 FTE, while our commitment from ETS and CCS has grown to 6 FTE. By the end of FY 87 the overall effort will have grown to a total of 15 FTE.

These efforts have led to several new faces. Jim Kennedy joined us in September as the new Project Manager. Jim has a Ph.D. in physics from the University of Florida, where he worked on solar wind problems, and since, he has spent a number of years in both industrial and academic management. Warren Ball, from NOAO ETS, is now our Project Engineer. Warren is an old hand with the Tucson group and a lucky catch for the project. At Sacramento Peak, George Streander has been making major design contributions to the light-feed system.

Kate Rosser came on board in August as a scientific programmer and has played a significant role in the primary data compaction and data analysis system design work. Steve Colley, the ETS Manager at Sac Peak, is leading the effort to develop a critical high-speed accumulating image cache memory system.

Planning and Organization

The beginning of the new fiscal year was preceded by the institution of a major planning effort. An intensive review of all aspects of the project was undertaken in September which involved the participation of the entire project team. This process has provided a clarified view of the project, as it presently stands, and has led to a more detailed organizational structure to meet the needs of the current phase of the project and the development of a set of targets for the coming years.

One of the specific products of the planning activity was the definition of the various new positions required in the coming year. Significant among them was the creation of a Data Systems Specialist to play a leading role in the development of the hardware and software systems for the end-user *GONG* data reduction, distribution, and analysis facility. A national search is currently under way to fill this important slot. Other positions defined and created included an electrical engineer, a real-time programmer, an machinist, a drafter, and an electronics technician.

Overall the project has been organized into five major working groups:

1. Doppler Imager – Jack Harvey
 - a. Doppler analyzer
 - b. Data acquisition
2. Light Feed – Dick Dunn
3. Image Cache – Steve Colley
4. Data Analysis – Jim Kennedy (temporarily)
5. Site Survey – Frank Hill

The light feed and image cache efforts are being carried out at NSO/Sac Peak and constitute about one-third of the effort this year, while the balance of the effort is located at NSO/Tucson. Management has been greatly facilitated by the opening of “*GONG* Airlines” under the steady hands of pilots Jim Kennedy, Warren Ball, and John Leibacher (go east and sorta turn left at El Paso...).

Goals and Objectives

The development plan for the doppler imager calls for conducting a final proof of concept analysis of the device employing a breadboard version of the instrument. This will be followed by the construction and evaluation of a prototype version of the instrument which is intended to resemble the final fielded instrument as much as possible. Following these lab tests, the imager will be integrated with the prototype of the light feed and the various computer control systems

to form a fully operational prototype of the field unit, including the external shelter building.

While contingent on continued funding at projected levels and a myriad of other unknowns, we look forward to meeting the following major milestones:

- Spring 1987 Begin Breadboard Image Tests
- Fall 1987 Begin Prototype Lab Tests
- Spring 1988 First Light Integrated Prototype System
- Spring 1989 Begin Integration of First Field System
- Spring 1990 Begin Field Site Installation
- Fall 1990 GONG Network Operational

(*Jim Kennedy*)

A Test of a Modified Algorithm for Computing Spherical Harmonic Coefficients Using an FFT

Mark Elowitz (a Summer Student from the University of Arizona), Frank Hill and Tom Duvall have modified and evaluated the Dilts (*J. Comput. Phys.* **57**, 1985, 439) algorithm for spherical harmonic transforms as applied to helioseismology. This algorithm performs a spherical harmonic transform by first using a recursion relation to generate the Fourier coefficients of the harmonics. The transform is then accomplished by evaluating a double sum involving the coefficients and the two-dimensional FFT of an image that has been interpolated onto an evenly spaced grid in latitude and longitude.

In its original form, the Dilts algorithm computed the coefficients once and then stored them, reading them in as needed. For high this is not practical, since 5.3 Mbytes would be needed for a maximum degree = 250, requiring a high i/o rate. Thus the coefficients were computed as needed, using new recursion relations to cope with the overflows generated by the factorial terms in the spherical harmonic normalization.

After solving these problems, timing tests of the program were performed on a VAX 8600. The results showed that the CPU time required to compute all of the Fourier coefficients of the spherical harmonics up to a maximum degree was proportional to N^3 . When the program was run for an of 250, the CPU time required for this step alone was approximately 500 seconds. This time does not include the time required for the two-dimensional image interpolation and FFT, nor does it include the time required to evaluate the double sum. The slow execution time of this part of the algorithm lies in the large number of operations required to evaluate the recursion relations for high . For this step, the number of operations required is approximately $75 N^3$.

Of even more consequence is the number of operations involved in evaluating the double sum, given by Dilts as $40 N^2$, where N is the number of pixels along one edge of the

(square) image. Note, however, that this number of operations is required to evaluate the sum for a *single* mode with a particular choice of l and m . If one desires to compute the transform for all available modes in the image, then $11 \approx N$ and, since there are a total of $11(2l+1)(2l+1) = 8011$ modes, the operation count to evaluate the sum alone becomes

40 number of operations in the Dilts algorithm to compute the spherical harmonic transform for every mode up to l using an $N \times N$ image is

$$n_f N^2 + n_{FFT} N^2 \log N + 80 11^3 N + 40 11^2 N + 75 11^3$$

where n_f is the number of operations required to interpolate the data f onto an evenly spaced grid, and n_{FFT} is a constant reflecting the number of operations in the FFT. Typically $n_f \approx 20$ and $n_{FFT} \approx 25$. If all of the modes available in the image are desired, then the number of operations will be dominated by the $80 11^4$ term. When the double sum was evaluated for l of 250, the CPU time required was about 10 hours. This renders the procedure impractical for helioseismology, but it still remains viable for applications where only low values of l need be computed.

The current best method appears still to be that first implemented by Brown (*Nature* **317**, 1985, 591). With this method as currently in use at NSO, we can perform a spherical harmonic transform, including the interpolation and FFT for all l values and every other m value up to 250 on an 244×244 image in 50 CPU seconds on the VAX 8600. This is much more acceptable than the 10 CPU hours per image that would be spent using the Dilts algorithm, and allows the inference of internal solar structure to be accomplished much more efficiently.

An article discussing the results of this study has been submitted to the *Journal of Computational Physics* after discussion with Dilts. Copies of a preprint are available upon request. (Frank Hill)

Shared Software — *caveat emptor*

It was suggested at the *GONG* Workshop, that *GONG* provide for the distribution of shared software — essentially provide a “users group” for contributed software and documentation — and the most widely desired capability was the calculation of eigenvalues from a given solar model, as well as the associated eigenfunction and the kernels for sensitivity to rotation and other parameters. Roger Ulrich has provided one such code which we are happy to distribute, and John Leibacher has thrown in a mailing list and bibliography handler. The intent is to help the casual user, or person interested in getting started in a new area, with the tools to do so. At the same time, we will attempt to off-load the burden of providing minimal support from the contributor.

Eigenvalues

The solar oscillation eigenfrequency, eigenmode and kernel function calculating code, *KWAVES*, is now available through the *GONG* project. This code is a single main program with no subroutines. It requires as input a solar model in a standard format and calculates three kernel functions for each frequency. A solar model in the required format incorporating the latest improvements by Bahcall and Ulrich is provided as part of this release. A set of standard input and output is also included in the release so that investigators can verify that they have the code working the same way as it works at UCLA. Future releases will make available the two additional codes that are needed to produce solar models in the standard format. These two additional codes are named *SUNEV* and *CATMOS*. Each is much more complex than *KWAVES* both in length and in convoluted logic. At this time I have made one pass through *CATMOS* and it is close to being ready. I have started to look at *SUNEV* but have not made too much progress. *SUNEV* calculates the detailed nuclear abundances and produces the predictions of neutrino fluxes that I believe. *CATMOS* has a detailed treatment of the equation of state and surface layers and uses the output from *SUNEV* to calculate the standard solar model data sets. At this time I do not wish to make a firm prediction about availability of these two additional codes. (*Roger Ulrich*)

Lister

This package provides manipulation of bibliographies and mailing lists, generating labels, *etc...* It currently runs on a *UNIX-VAX*, and optionally provides output compatible with the "roff" family of *UNIX* text processing utilities. The *GONG* bibliography (*GONG* Report No. 2) was produced with this package, and Frank Hill's updated version of that data file is included, as is an extensive mailing list used at NSO. The preferred medium for distribution is a *UNIX* "tar" tape. (*John Leibacher*)

Workshops

Solar Model Workshop

This will be a 2^{1/2} day working meeting to compare the results of different stellar structure codes, which will be sponsored by the *GONG* project and held in Tucson in mid-June, 1987. Present published results are difficult to reconcile in all regards, and we need to bring together enough detailed numerical output so that the causes of the discrepancies can be isolated. The plan is to specify an archetypal solar model for different codes to use as input, and to compare their output. Detailed specifications of a simplified solar model will be provided in a subsequent memo to those investigators who express interest in participating in the workshop. Key aspects of the simplified model will include a reduced nuclear reaction network, an equation of state with hydrogen, helium and one metal with a Saha equation for ionization equilibrium and an assumption of full ionization above one million K, a standard opacity table throughout the model, and a standard outer boundary condition both for the model and for the oscillations. Investigators will be asked to calculate frequencies for a standard set of modes.

Attendance is aimed at those actively involved in the computation of solar models, and the development of the required equations of state, opacities, nuclear reaction rates, *etc.*., as evidenced by past work or by submission of a contribution. In addition to the usual meeting amenities, the *GONG* will provide access to VAX 750's running VMS and UNIX for the purpose of comparing solar models computed by different investigators using different codes. In the spirit of the *GONG* project each investigator is expected to cover his or her travel and per diem costs.

If you wish to be included in future announcements about this workshop please write to R.K. Ulrich at the Department of Astronomy, UCLA, Los Angeles, CA. 90024 or send a E-Mail message to EBQ3RKU@UCLAMVS over BITNET or to rulrich if you can get messages to the Stanford E-Mail forwarder courtesy of Rick Bogart. (*Roger Ulrich, Organizer*)

Preliminary Announcement of Inversion Meeting

The Harvard-Smithsonian Center for Astrophysics will sponsor an informal 2 1/2 day workshop on the solar inverse problem in the late spring (*e.g.*, last week of May, or first week of June) of 1987. The planned format will consist of invited talks, focussing on current methodology, and highlighting numerical techniques in current use, and their specific implementations; contributed poster papers; and extensive discussion periods. We intend to have all contributed papers presented as poster papers; and to provide specific times for discussions of these papers. The enrollment will be limited to those actively involved in inverse problems, as evidenced by past work or by submission of a contribution. The aim is to have a working meeting in the Gordon Conference style. If you are interested in attending this meeting, please contact R. Rosner within a month of this announcement at CfA (60 Garden St., Cambridge, MA 02138, telephone 617-495-5879; via BITNET, contact rosner@CFA2; the Stanford mailer name is rrosner). A second announcement will be sent out around the first of the new year.

Annual GONG Workshop

The annual GONG Workshop will be held in Tucson, for 2 1/2 days, April 8 through 10, breaking at noon on the 10th so that east-bound departures can catch afternoon flights home. This will be an extremely important meeting as it will provide the first meeting for the Teams (see below), and we urge you all to attend if at all possible. We apologize in advance to those of you who find these dates inconvenient. Our past experience has shown that it is virtually impossible to accomodate the enormous variety of university Spring break schedules.

Invitation to Participate

You will find in the next section a "Membership Plan". It has been apparent from the outset of the *GONG* project that we needed some mechanism for encouraging and formally recognizing participation. *GONG* is a collaborative project which is based upon the active participation of a broad and diverse group of scientists, contributing their special skills to the success of this community-wide effort in an organized way, while still pursuing their own individual avenues of research. The intent of the Membership Plan and this Invitation is to encourage

active contributors, rather than to limit or exclude participation.

This Plan results from the discussion at the Workshop in April, 1986, as well as further comments at the IAU Colloquium in Aarhus, and considerable help from the Scientific Advisory Committee.

We very strongly encourage you to respond to this Invitation. While the opportunity to join will be re-opened periodically throughout the life of *GONG*, the most significant contribution to its success will be made by the “charter” Members, responding to this initial invitation. In order that the Teams can be established before the April *GONG* Workshop, the deadline for responses — a form is attached — is March 1, 1987. If you have any questions, please call or write John Leibacher.

Global Oscillations Network Group

Membership Plan

0) Preamble:

The *GONG* is a collaborative project to study the interior structure and dynamics of the Sun. To accomplish this, *GONG* will develop and operate a world-wide network of complex instruments as well as reduce, analyze and communicate the results. Achieving the full potential of such a project requires major and sustained contributions from a diverse group of scientists, bringing together skills in instrumentation and observational techniques, in computational methods, as well as a broad range of theoretical and interpretative disciplines.

The *GONG* project team within the National Solar Observatory (*NSO*) of the National Optical Astronomy Observatories (*NOAO*) bears the responsibility for the instrumentation, and for the primary reduction and analysis system. The project team will carry out its work in close consultation with the Members of *GONG*. The intricacies of helioseismology require substantial research on data analysis and theoretical aspects to proceed apace with the instrumental development. The conduct of this work (whether on the combination of data from different sites, mode analysis, inversion methods or the forward problem, equations of state, or interior dynamics,...) will be carried out by the Members of *GONG*, coordinated in Teams. It is the purpose of this Membership Plan to describe the envisaged mode of participation in *GONG*, and to encourage active collaborations by extending an invitation to Membership in *GONG* at the very outset of the project. It is the intent of this Plan to encourage participation by a broad community.

Realizing the scientific potential of *GONG* requires the efforts of researchers at a number of institutions, the support of various observatories, in addition to the work of the *NSO/NOAO* project team. *GONG* must coordinate these activities, to ensure that all participants have a real stake in *GONG*, and to permit all to be able to contribute to the success of *GONG*.

While the Members will provide their own individual research support, the *GONG* project will provide the facility for the primary data reduction as well as for the principal data analysis tasks developed by the Teams. In addition to Members' on-site use of this facility, a distributed data analysis system based on transportable software and data products for use at the Member's home institution, as well as remote access to shared facilities, will be central aspects of *GONG*.

1) Objectives of this Plan:

a) Encourage active participation during instrument development as well as during data reduction and analysis. The scope of the data analysis effort requires substantial contributions from members of the interested community prior to the acquisition of the full data set including: *i*) participation in instrument trade-off discussions to optimize the scientific return within the inevitable constraints, *ii*) development of data reduction algorithms as well as specialized processing, *iii*) providing data analysis and interpretation programs for collaborative studies of identified problems. Coordination of the efforts is a major requirement for the successful attainment of this objective.

b) Establish Membership in *GONG* as the specific vehicle for participation. There is a need for formal identification of Members to assure that their rights are maintained and responsibilities are met, as well as to demonstrate Member's participation to institutions and funding agencies in order that they may obtain support for their *GONG* activities.

c) Provide for equitable access to the data as well as recognition of individual contributions. As with § 1a, coordination of the efforts is a major requirement for the successful attainment of this objective.

d) Lay out simple and clearly enunciated procedures to achieve these objectives, which are practical to implement — *e.g.* that are not based upon unrealistic levels of dedication or unrealistic levels of support.

2) Membership:

It is the intent of this Plan to encourage Membership by a broad community. It is assumed that scientists will wish to become members of *GONG* in order to contribute to the success of the effort, and in order to partake in its scientific fruits. Because of their participation in the development of the tools to achieve the overall success of *GONG*, Members will quite naturally have access to the data and the shared analysis and interpretation tools from the outset.

Membership will only be through active and continuing participation in Teams (see §3 below), which will coordinate the overall contribution to *GONG*. It is recognized that a given scientist may work on a variety of problems contributing to helioseismology during the lifetime of *GONG*. Thus a scientist's participation on the Teams will evolve, as will the Teams themselves. Continued Membership in *GONG* requires active work on at least one of the Teams.

Applications for Membership in *GONG* should contain the following information: name, institution and title, a brief description of the scientific objectives of the proposal, a brief description of the activity to be contributed, the level of effort that would be committed and what resources are available or would be sought, potential collaborators, and a brief bibliography of relevant publications. A committee consisting of a member of the *Scientific Advisory Committee*, a representative of the *Coordinating Committee*^{*} and the *Project Scientist* will review the responses on the basis of their scientific merit, the suitability of the *GONG* data set, and the degree of commitment and ability to contribute to *GONG*, and assign the Members to appropriate Teams.

To facilitate the review process, applications will be considered periodically at dates to be announced in the *GONG* Newsletter[□].

3) Teams:

The Teams will be organized to address broadly defined scientific and technical objectives, with goals consisting of the development of the tools necessary for the reduction and analysis of data as well as the publication of the results. The Teams will sort out in detail how the work will be accomplished, so as to minimize duplication of effort, and assess what other efforts may be needed. The actual work to be carried out may be by collaboration or by individual effort as is appropriate. Activity on a Team is not intended to replace individual scholarship or creativity with group discipline, rather to facilitate those aspects of *GONG* that require concerted efforts by many participants.

The Teams, and their Memberships, shall be dynamic. It is expected that Teams will evolve, and possibly even be reconstituted within the duration of *GONG*. Making a substantial contribution to the Team's progress constitutes Membership on the Team, and it is anticipated that Members who are unable to make such contributions will resign. The Team's activities will be coordinated by a Team Leader, elected by the Team's members. It is expected that Members must attend at least half of the Team meetings, and carry out those tasks outside the meeting that contribute substantially to the work of the Team and which they and the rest of the Team shall mutually decide.

The Teams require ongoing coordination and a forum for communication. This will be achieved by forming a *Coordinating Committee* consisting of the Team Leaders and the members of the *Scientific Advisory Committee*.

On the basis of the initial expressions of interest by participants at the second *GONG* Workshop, held in Tucson in April 1986, it appears that roughly a half dozen major teams, each of which would be responsible for several different tasks are appropriate. It would seem that the

^{*}As the *Coordinating Committee* will not come into existence until after this first invitation, this member will be appointed by the Director of the *NSO*.

[□] March 1, 1987 for this first Invitation.

following Teams are likely to be established in response to the initial *Invitation to Participate* in *GONG*, and we indicate here, in outline form, some of the sorts of tasks that they might concern themselves with: *Data Analysis* (Spherical Harmonic Decomposition, Other Spatial Filters, Modal Analysis, Gap Filling, Image Interpolation, Data Stream Merging), *Internal Structure and Rotation* (Opacity and Equation of State, Internal Models, Convection), *Physics of the Oscillation Modes* (Excitation and Damping, Mode Interaction, Solar Atmospheric Effects, *g*-modes, Non-Oscillatory Effects), *Dynamics and Time Varying Effects* (Rotation, Giant Cells), *Magnetic Effects* (Fibrils, Sunspots and Active Regions, Solar Core), *Inversions* (Comparison of Existing Techniques, Development of New Methodologies, Provision of “Standard” Packages), *Models of Observations* (Solar “Noise”, Spectral Line Formation, Solar Activity), *Computational Tools* (Electronic Mail, Networking, Workstations, Supercomputers). The intent of this task breakdown is to give some idea of the sorts of things, or the level of specificity in the Application, without being restrictive. The Coordinating Committee will periodically review the functioning of the Teams, and other Teams, or ones with a modified emphasis from the ones listed here, will be formed as the need arises.

4) Publication and Data Access:

The initial publication of the papers presenting the data, the methods by which they were acquired and processed, and the immediate scientific implications shall be authored by the Members of that Team directly responsible for the contents of the paper. The data shall be available solely to the Teams until these assessments are made within the first year, and thereafter the data shall be made available to any qualified scientist. The broad contents of the papers shall be determined by mutual agreement between the Teams to avoid unnecessary duplication.

GONG Membership Application

As stated in the Membership Plan, *GONG* is a collaborative project which seeks the active participation of a broad and diverse group of scientists to contribute their special skills to the success of this community-wide effort in an organized way, while still pursuing their own individual avenues of research. The intention is to include active contributors, rather than to limit or exclude participation.

Name	Title	Institution
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Work Address	City	State	Postal Code	Country
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Telephone	Electronic Mail Network / Path	TELEX
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Home Address (<i>Optional</i>)	City	State	Postal Code	Telephone
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Scientific Objectives of Proposed Work:

Activity to be Contributed to *GONG*:

Level of Effort and Source of Support:

Potential Collaborators:

Relevant Publications:

Signature

/ /1987

Date

Return to:

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