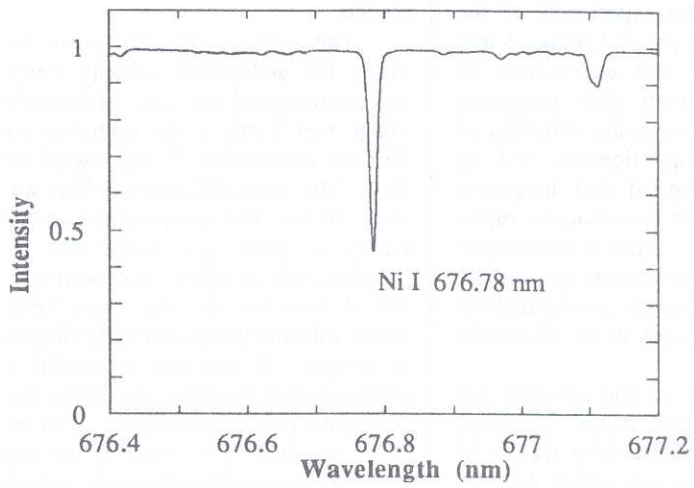
Formation of Fourier Phase Shifts in the Solar Ni I 6768 Å Line

A formalism has been developed to understand better how Doppler shifts of spectrum lines, as inferred from phase shifts in the Fourier transforms of line profiles, are related to the underlying velocity structures which they are intended to measure. With a standard model atmosphere and a simplified, quasi-LTE treatment of line formation, the formalism has been applied to the Ni I 6768 Å line. Fourier phase shifts are found to be a remarkably linear measure of velocity even in the presence of gradients and unresolved lateral variations in the assumed velocity field. An assumed outward increase in amplitude of a model oscillatory velocity is noticeably reflected in the center-to-limb behavior of the simulated velocity measure, and a sample model of solar granulation is found to have a strong influence on the formation of the Fourier phase. A detailed discussion of these results will be appearing in a forthcoming issue of *Solar Physics*.

Harrison P. Jones



The solar absorption line which was selected as the velocity indicator for the GONG Doppler analyzer is the Nickel I line at 676.78 nm. It was chosen because of its relative isolation from other nearby solar features, its freedom from atmospheric contamination, and the profile's well behaved variation as a function of magnetic field strength and center-to-limb position. Two recent studies of the details of the formation of this nickel line in the sun's atmosphere and the resulting effects on oscillations measurements are outlined here.

Description of NLTE analysis Ni 676.78 nm line

At Utrecht, we are currently working on a Non-LTE (NLTE) analysis of the formation in the solar photosphere of the Ni I line at 676.78 nm, which is the proposed Doppler shift measuring line for GONG and also for the SOI experiment on SOHO. In addition, we are investigating the formation of the solar Na I and K I resonance lines which are used in resonance cell helioseismology, in cooperation with M.T. Gomez and G. Severino of the Capodimonte Observatory at Naples and N.G. Stchukina of the Main Astronomical Observatory at Kiev. A preliminary report is given in the proceedings of the recent ESA IAC Tenerife conference on helioseismology.

There are three NLTE phenomena of interest that affect the GONG line. The first one is the standard effect of photon loss which uncouples the line source function from the Planck function and therefore the line core behavior from the local thermal structure of the upper photosphere where it is formed. The second effect is the presence of radiative overionization which occurs in Ni I similar to Fe I because there are many bound free transitions in the near ultraviolet. They mainly affect the opacity of the GONG line. The third effect is the presence of optical pumping of the upper level of the GONG line by ultraviolet transitions from the lowest Ni I levels, which affects the line source function.

The first effect tends to uncouple the GONG line from the temperature structure of the upper photosphere, *i.e.* from the temperature contrast of the granulation where it overshoots. The other effects tend to couple the GONG line formation in the upper photosphere to the thermal structure of the deep photosphere where the ultraviolet radiation escapes, *i.e.* to the temperature contrast of the granulation where it is very vigorous. Thus, the GONG line feels the thermal structure of the upper photosphere less than an LTE computation would indicate, but instead it has NLTE response to the granulation in the deep photosphere even though it is formed much higher. This non local sensitivity is enhanced because it obeys the ultraviolet sensitivity of the Planck function to temperature fluctuations rather than the red sensitivity at the line wavelength.

How large are these effects? This question requires detailed computer modeling which we are doing now. We find that the resulting line cores are sensitive to the details of the granulation model used as input and to the details of the computation of the ultraviolet radiation fields, and so we will bracket the effects on the line rather than specify them precisely. For example, Steffen's granulation simulation

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predicts a temperature reversal in the middle photosphere (granules cooler than intergranular lanes) in accordance with observations; whether or not this reversal is present in the computed line core depends on the details of the ultraviolet overionization. Our preliminary results indicate that the granular contrast in the line core is quite small; there is a fortuitous cancellation between the ultraviolet effects on the source function and on the opacity.

Do these NLTE effects make the GONG line a bad diagnostic for helioseismology? We don't think so. Ultraviolet overionization and overexcitation occur in most neutral metal spectra, so for example any Fe I line is bound to have similar NLTE effects in its formation; The granulation signature may be smaller in lines from ionized spectra such as Fe II, but these offer far fewer candidates and none with the clear continuum window that GONG requires.

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South Pole Helioseismology - 1988

At the end of October 1988, a team consisting of S. Jefferies and M. Pomerantz (Bartol Research Institute), T. Duvall (NASA), J. Harvey (NSO) and R. Aikens (Photometrics, Ltd.) went to Antarctica to conduct helioseismology observations. We arrived at South Pole on November 2 and were ready to observe by November 10. The equipment consisted of a simple telescope equipped with a 0.6 nm passband filter centered on the calcium K line at 393 nm which formed full disk images on a CCD camera. The CCD has 1024 pixels on a side but we elected to use an area of 512 by 512 principally to reduce the amount of data. Images were collected every 3 seconds and integrated for 1 minute before digital recording on 8-mm video tape. The telescope and camera were mounted on a tracking platform which followed the sun to better than 1 arc second on average.

Weather cleared at 01:00 UT on November 14 and the equipment was operated for 329 of the following 399 hours for a duty cycle of 82%. In this interval, we estimate that 261 hours consist of high quality data so the ratio of good data to 399 hours is 65%. Observations ceased at 16:30 on November 30. A period of good weather started on November 18 at 05:00. Good data were collected for 92% of the following 123 hours and 79% of 253 hours. In all, we collected about 10 Gbytes of data which are now in Tucson. The major technical problem we encountered was unreliable operation of the 8-mm digital tape recorder at the telescope even though it had performed acceptably in laboratory tests. The cause of this problem is being investigated.

The observations will be used to explore the characteristics of *p*-mode oscillations at degrees above 100 in addition to traditional studies of lower degrees. We also plan to do local tomographic studies of various kinds of activity such as sunspots, plages, flares and supergranules. The evolution of the network and active regions will be investigated. A more-or-less continuous movie of the solar disk will be prepared. Collaborators in the reduction include D. Braun, F. Hill, and J. Leibacher. We plan on eventually adding the data to the GONG database for general use by the community.

Jack Harvey

Tenerife Summary

From September 26 to October 1 the IAC (Institute of Astrophysics of the Canaries), particularly the Local Organizing Committee, was honored to host the Symposium on "Seismology of the Sun and Sun-like stars", in Puerto de la Cruz (Tenerife) jointly organized by IAC and ESA. The aim of the meeting was to bring together the experimenters which have been and still are preparing instrumentation for ground based networks and for space, as well as the rest of the helio and asteroseismology community to exchange ideas and results. The participation in terms of scientists was unexpectedly high (140) and the contributions, a total of 123 (8 invited, 51 oral and 64 posters) were of high quality.

The first 6 sessions were devoted to helioseismology. We learned about progress on lifetime measurements, understanding mechanisms for excitation and damping of the oscillations, new data and inversions on the rotation rate of the solar interior (including bets). Further, we heard about the status of the different ground-based networks (IRIS, GONG, Birmingham and others), intensity data from two stations and other ways of looking at solar oscillations. The state of the art on instrumentation of these projects were also presented. Oscillations in the presence of magnetic fields was discussed and new data on the solar cycle dependence of the *p*-mode frequencies was presented.

The difficulties in identifying solar *g* modes were put forward and even lower frequency signals (related to surface inhomogeneities) were shown; methods of search and theoretical predictions on *g* modes were announced. These are the main goals for space experiments which will fly on SOHO (GOLF, VIRGO, MDI) and whose concept and state of the art were presented by their PI's. Results and questions from solar modeling techniques (direct and inverse methods) were presented and discussed. Finally we also heard about the Ga solar neutrino experiment.

Only two sessions were left for asteroseismology, both technological and observational, of sun-like stars and others. In these we learned about the efforts being made to detect the *p*-mode spectrum on other stars via spectrometric methods (using the MOF mainly). Models for stellar pulsations and ways to know the evolutionary stage of the star itself were also presented.

The Local Organizing Committee wishes to thank specially all of the Chairmen of the sessions who did their job very well indeed, providing the tight scheduling of the scientific sessions. The LOC also hopes that scheduled and nonscheduled social events provided the necessary personal contacts amongst all participants, which will no doubt result in a increased fa-

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