THE STUDY OF STELLAR GLOBAL OSCILLATIONS BY CA II
H AND K VARIATIONS.

(Extended Abstract)

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The search for stellar analogues of the solar "5-minute" oscillations is one of great excitement, in large part due to the extraordinary success of the study of global solar oscillations. Much of this success builds on observations obtained in unimaged sunlight--that is observations of the Sun as a star. These observations reveal the frequencies and amplitudes of p-modes of low degree \((l < 4)\), and probably also some g-modes. Similar observations are capable of yielding changes over time of these frequencies and amplitudes. From such data one can learn a great deal about the structure and dynamics of the solar interior, and perhaps their relation to solar activity phenomena. The same techniques used for integrated-light solar oscillation studies should be equally applicable to other stars; the only problem is one of signal-to-noise ratio.

The observed amplitude per mode of disk-integrated solar velocity oscillations is less than about 30 cm s\(^{-1}\), which is beyond the range of conventional stellar radial velocity measuring capabilities, although specialized techniques may have succeeded in detecting them (Fossat, these proceedings). Solar "5-minute" oscillations are also visible in the intensities of the Ca II H and K lines (cf. Kneer and van Ückel 1983). There the amplitude per mode of the spatially-integrated fluctuations in the H and K line cores, relative to the nearby continuum, is expected to be only a few times \(10^{-5}\)--again, near the limits of detection, but by no means impossible to detect. Chopping from line to continuum should eliminate most of the atmospheric noise, and if the coherence time of the oscillations is like that in the Sun, there is ample integration time available over an entire night or over several nights of observation to build up the signal to (photon) noise ratio in the data, for stars brighter than say 5th magnitude, with a moderate-sized telescope.
In "active chromosphere" stars the H and K line emission cores are very much stronger than in the Sun, and it is possible that the relative chromospheric response to the global p-mode oscillations is enhanced as well. Although no theoretical work has been done to justify such an assumption, there are observational indications that this might be the case (e.g. Baliunas et al. 1981). In the course of nightly monitoring of the star $\epsilon$ Eridani (a young K2V dwarf with strong chromospheric emission) for the Mt. Wilson H-K program, we detected variability from moment to moment considerably above the level expected from photon and instrumental noise, so this star was a good candidate for a search for p-mode oscillations in the H and K lines.

Observations of this star did indeed reveal suggestive, if not definitive, evidence for p-mode oscillations in the H and K lines. The detailed results are reported by Noyes et al. (1984). Summarizing, two six-hour data sets obtained at widely spaced intervals each revealed spikes of power in the power spectra of the H and K fluctuations, located near 1700 $\mu$Hz and separated by about 86 $\mu$Hz. If these peaks are identified with p-modes, then the spacing between modes of successive order $n$ would be twice as large, or 172 $\mu$Hz. The peaks occurred at the same frequency for each data set, to within less than 10 $\mu$Hz. The 172 $\mu$Hz spacing of the peaks is intriguing, for the predicted peak spacing between modes of successive degree for a star of the known radius (0.81$R_\odot$) of $\epsilon$ Eri should lie between about 169 and 179 $\mu$Hz (Christensen-Dalsgaard, private communication). This is in contrast to the spacing of about 135 $\mu$Hz predicted and observed for solar p-mode oscillations of successive order.

The signal-to-noise ratio of the present observations is marginal, so that the detection needs to be confirmed, and if possible verified by observing other stars with different characteristic p-mode spacings, before being considered definitive. Nevertheless, we note that if this technique is verified, its use to measure p-mode spectra in a host of active chromosphere stars should not be too difficult.
If the detection is valid, we note some inconsistency with expectations. First, for the strongest modes the amplitude $\Delta I/I$ in the cores of the H and K lines is $6 \times 10^{-3}$. This is a factor of 100 greater than in the Sun. It would imply either a 100-fold increase in the amplitude of photospheric velocity observations (considered unlikely) or a 100-fold increase in the fractional response of the disk-integrated chromosphere to photospheric velocity oscillations, in this chromospherically active K dwarf. Second, the peak power is observed to occur at $P \sim 10$ minutes, whereas theoretical expectations (e.g. Christensen-Dalsgaard and Frandsen 1983) suggest that peak power occurs near 4 minutes for a K dwarf.

Whether this suggestive result stands the test of time or not, it remains clear from solar data that study of global stellar oscillations from the emission fluctuations in the cores of strong chromospheric lines is in principle feasible. The ability to ratio against the nearby continuum allows rejection of most of the atmosphere-induced noise. There is no reason in principle why intensity oscillations with amplitude as low as those seen in the Sun cannot be detected in this way, such as we might expect in other quiet-chromospheric stars.

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References
Christensen-Dalsgaard, J., and Frandsen, S. 1983, Solar Phys. 82, 469.