ANOTHER REASON TO SEARCH FOR SOLAR $g$-MODES AND NEW LIMITS FROM SOLAR ELLIPTICITY MEASUREMENTS

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ABSTRACT. Observations of solar $g$-modes will teach us some gravitational physics. The present sensitivity of the Princeton Solar Distortion Telescope and other recent claims of solar $g$-modes suggest that these low frequency modes should be observable in shape measurements. From about 250 days and nearly 1000 hours of observations we find no evidence for significant spectral power that can be associated with $g$-modes and no sign of the elusive 160.01 min period solar oscillation.

1. NEW GRAVITATIONAL PHYSICS INTERESTS

We will undoubtedly learn a great deal about the solar interior from the long period $g$-modes if they are reliably observed, but there's another perspective from which their observation is interesting. I'm impressed that we (almost!) understand the sun to the extent that as we learn more about the oscillations we can treat the sun as a "detector." In particular, a good example of this are potential observations of low degree modes with periods near one hour. Such observations may yield interesting limits to a stochastic gravitational wave background (Boughn and Kuhn, 1984). It's also interesting that the low degree modes with periods of order an hour have a relatively large gravitational energy associated with their oscillation. In light of recent geophysical evidence (Holding and Tuck, 1984) that the effective gravitational constant may be larger on distance scales much larger than laboratory scales, a solar determination of $G$ becomes interesting. Some hope that such a measurement can be disentangled from the mass uncertainty of the sun is gained by noting how the eigenfrequencies of the low order modes are affected by perturbations in the gravitational constant. Figure 1 shows the relative frequency shift, in terms of the fractional perturbation in $G$, expected for some low order $\ell = 2$ and $\ell = 3$ $g$- and $p$-modes. The figure suggests that a possible 1-percent effect seen in the geophysical data might be detected from the solar oscillation spectrum. At present such predictions are premature and more work must be done to constrain the density-gravitational constant product from other solar observational constraints.

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Figure 1. Modal frequency shifts due to gravitation constant perturbations.

2. LONG PERIOD SOLAR OSCILLATIONS

Several claims for detection of solar g-modes with periods between 2 and 10 hours have been made (e.g. Scherrer, 1984; Isaak, et al. 1984; Frohlich and Delache, 1984). The surface velocity amplitudes of these modes appear to be between 0.1 and 1 m/s but there is poor agreement on the excitation spectrum between different observers. On the other hand several groups have consistently claimed detection of a 160.01 min period solar oscillation (cf. Kotov, et al., 1984) also with a velocity amplitude near 1 m/s. All of these modes have been observed with low spatial resolution and are most likely of low spherical harmonic degree ($\ell \leq 2$).

It's notable that the surface amplitudes of these oscillations are comparable to 5-min p-mode amplitudes of about 15 cm/s (cf. Kuhn, 1984a). If the observations are correct then the energy per g-mode is roughly $10^8$ times larger than typical p-mode energies and of considerable curiosity.

3. SHAPE OBSERVATIONS

Except for the ACRIM data (cf. Frohlich and Delache, 1984) and