Thus in order to obtain better and perhaps more correct results, more observations with a minimum of systematic errors between them are needed.

7. p-mode frequency corrections due to convection (M. Stix)

Convection consists of rising hot and descending cool parcels of gas. In order to assess the effect of such an inhomogeneity on acoustic waves a simple model has been proposed by Zhugzhda and Stix (1994). The model consists of a sequence of alternating vertical layers with temperatures T_1 and T_2 and upward and downward velocities V_1 and V_2. At the interfaces between the layers the horizontal component of the velocity and the pressure are continuous. This model allows to determine the phase velocity of a vertically propagating acoustic wave. The main result is that, with increasing frequency, this phase velocity approaches the sound speed of the *cooler* layers. The reason of such a behavior is that the horizontal structure of the wave is oscillatory in the cool layers, but exponential (evanescent) in the hot layers, so that there is a certain amount of wave trapping in the cool layers. An analogous effect of trapping in a horizontal layer has been described by Kahn (1961) for the temperature minimum of the solar atmosphere. In the present case the consequence is a net decrease of the frequencies of the solar p modes in comparison to a homogeneous model. In the asymptotic approximation the frequency correction is

$$\Delta\nu = n\Big[\Big(\int \frac{dr}{V_{ph+}} + \int \frac{dr}{V_{ph-}}\Big)^{-1} - \Big(2\int \frac{dr}{c}\Big)^{-1}\Big] \, , \tag{6}$$

where n is the overtone number, V_{ph+} and V_{ph-} are the phase velocities of the upward and downward propagating waves, and c is the sound velocity of the homogeneous (mean) model. The two phase velocities differ because of the asymmetry introduced by the streams V_1 and V_2. The result are frequency corrections for three values within the plausible range of the layer widths. The corrections are negative and reach 5 – 15 μHz for oscillation frequencies in the range 3 – 5 mHz. Theoretically calculated frequencies often are too high by a similar amount, so the corrections obtain appear to be welcome.

8. OPAL Equation of State Tables (F.J. Rogers)

The equation of state of astrophysical plasmas is, for a wide range of stars, nearly ideal with only small non-ideal Coulomb corrections. Calculating the equation of state of an ionizing plasma from a ground state ion, ideal gas model is easy, whereas, fundamental methods to include the small Coulomb corrections are difficult. Attempts to include excited bound states are also complicated by many-body effects that weaken and broaden these states.

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Nevertheless, the high quality of current observations, particularly seismic data, dictates that the best possible models should be used. The equation of state used in the OPAL opacity tables is based on many-body quantum statistical methods (Rogers, 1994; 1986; 1981) and is suitable for the modeling of seismic data. Extensive tables of the OPAL equation of state are now available. These tables cover the temperature range 5×10^{-3} to 1×10^{8} K, the density range 10^{-14} to 10^{5} g/cm^{3}, the hydrogen mass fraction (X) range 0.0 to 0.8, and the metallicity (Z) range 0.0 to 0.04.

The OPAL and MHD (Hummer and Mihalas, 1988; Däppen, Anderson, and Mihalas, 1987) equations of state are generally in good agreement (Däppen, 1992; Christensen-Dalsgaard and Däppen, 1992). Nevertheless, the small residual differences are important at the current level of accuracy of the solar seismic data. In a recent paper Dziembowski, Pamyatnykh, and Sienkiewicz (1992) used helioseismology to test the MHD equation of state. They found evidence that the MHD approach is inadequate for conditions that exist in the fractional solar radius range r/R=0.85 to 0.95. In this case the OPAL EOS fares somewhat better (Rogers, 1994); whereas Christensen-Dalsgaard (section 3) has presented a case that samples a different r/R region, where the MHD equation of state seems to be satisfactory. At higher densities, where the Coulomb coupling is outside the range of validity of the Debye-Hückel theory, discrepancies between MHD and OPAL increase. This is because the OPAL equation of state has systematic corrections for stronger coupling, while MHD does not. These differences could affect the modeling of low mass stars.

9. Helioseismology, solar evolution and other physics (P. Demarque, B. Chaboyer, D.B. Guenther, M.H. Pinsonneault)

The last few years have seen rapid progress in solar interior modeling, and standard solar models (SSM) now predict a p-mode oscillation spectrum which agrees, within the estimated uncertainties in the physical input, with the observed oscillation spectrum of the Sun (Guenther *et al.*, 1992a, 1992b; Guzik & Cox, 1993). This is the result of a number of improvements in the input physics, most notably the advances in opacities for the solar interior (Rogers & Iglesias, 1994) and the low temperature regions of the Sun (Kurucz, 1991). The agreement between the observed solar p-mode frequencies and the frequencies predicted by the SSM is not yet perfect, however, and understanding these discrepancies has become a focus of our research.

The importance of diffusion processes, not normally included in the SSM, has been explored and found to be significant (Proffitt & Michaud, 1991; Bahcall & Pinsonneault, 1992a,b; Guenther *et al.*, 1993; Guzik &