shallow transition layer located at the base of the convection zone in which the radial and latitudinal rotational stresses are mostly concentrated. In this layer, at low latitudes, the isorotation surfaces are aligned on cylinders giving an angular velocity increasing outwards.

This new scenario precludes that a dynamo can operate in the whole convection zone because there is no radial stress, and indicates the boundary layer between the base of the convection zone and the underlying radiative envelope as the possible dynamo location. In this overshooting layer, contrarily to what happens in the convection zone, convective motions are mainly directed downwards, so that α-effect changes sign to produce the correct migration of the magnetic field in the presence of rotation in cylinders. In this weak buoyancy layer, the dynamo field can be intensified to largely exceed the equipartition energy and persist long enough, before emerging, to give the correct cycle period. The inversion of the even coefficients of splitting expansions indicates indeed the presence of an intense magnetic field of the order of 1 MGauss in this layer.

The rotation of solar core below $0.3R_\odot$ can be inferred from the splittings of p-modes with $\ell = 1, 2, 3$. However the information one can obtain from the analysis of these splittings is coarse, essentially because the noise is large and the eigenfunctions of these modes reflect average, more than detailed properties of the layers sounded. Nevertheless, three sets of very recent results, two of them coming from ground-based observation networks and the third from space measurements, are consistent with a core rotation not much larger than the surface rotation, at most three times faster. These splitting results are in turn consistent with the completely independent results obtained from the also very recent oblateness measurements outside the atmosphere by means of stratospheric balloons. Nothing can be inferred from these splitting data about the core magnetism since the asphericity second order effect cannot be extracted from noise. To gain a deeper knowledge of the core dynamics and magnetism is necessary to detect the long period g-modes, if they are excited and have sufficient amplitude at the Sun's surface.

6. Determining the solar structure from oscillation frequencies (S. Basu)

The inverse problem of finding the structure of the solar interior from the observed frequencies can be written as

$$E_i \frac{\delta\omega_i}{\omega_i} = \int \left[K_i^{(1)}(r) \frac{\delta f_1(r)}{f_1(r)} + K_i^{(2)}(r) \frac{\delta f_2(r)}{f_2(r)} \right] dr + F(\omega_i), \qquad (5)$$

where, $\delta\omega_i$ is the difference in frequency of the i^{th} mode between the solar data and the reference model, f_1 and f_2 are an appropriate pair of model

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parameters (*e.g.* sound speed squared c^2, and density ρ), E_i is the mode kinetic energy, $K^{(1)}$ and $K^{(2)}$ are known functions of the reference model, and $F(\omega)$ is the unknown function added to account for uncertainties associated with the physics of the surface layers.

By representing the unknown difference in sound-speed and density between the Sun and a solar model in terms of B-splines in radius, and the function $F(\omega)$ in terms of B-splines in frequency and doing a regularized least squares (RLS) fit to the frequency differences, Antia & Basu (1994) found that the sound speed and density in a solar model with gravitational settling of helium and heavy elements is very close to that in the Sun, the maximum difference being 0.5% in sound speed and 1.5% in density. The results indicate a possible difference in the equation of state inside the Sun and that used in the model in this region. To see if this is indeed the case, the inverted sound-speed and density profiles can be used to find the adiabatic index Γ_1 inside the Sun, which can be used to detect differences in the equation of state (*cf.* Dziembowski *et al.*, 1992).

The sound speed and density thus obtained along with the energy equation was used by Antia & Chitre (1995) to estimate the central temperature of the Sun as $T_c = (15.6 \pm 0.4) \times 10^6$ K for currently accepted uncertainties in the values of opacity, nuclear energy generation rates, metal abundance and inverted profiles.

The inversion results do not merely give us information about the structure of the Sun, but also about the physical processes that go on inside. From the sound speed inversion results it has been possible to show clearly that gravitational settling of heavy elements occurs below the solar convective zone (Guzik & Cox, 1993, Christensen-Dalsgaard *et al.*, 1993, Basu & Antia, 1994 a,b). This conclusion can be drawn by looking at the sound speed difference between the Sun and solar envelope models which have the correct depth of the convection zone. The smallest sound speed differences are obtained for models which have diffusion. Using a similar method, we have shown that models which use the Canuto & Mazzitelli (1991) prescription for convection are closer to the Sun than those which use the mixing length formulation (Basu & Antia, 1994a). This is also borne out by the frequency differences between the Sun and these models.

Thus inversion of solar frequencies has given us a wealth of information about the Sun. However, the problem of differences in results obtained from different inversion techniques, particularly in the core, remains. Another problem that we encounter is that the sound-speed and density obtained from inversion do not reproduce the solar frequencies to within their observational errors. Our investigations suggest that systematic errors in observed frequencies, particularly between frequencies determined by different observation techniques can account for this (Basu & Thompson, 1994).

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

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

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.