assumption can be seismically tested. The ingredients of this model are the measured values of mass, radius and photospheric abundance of heavy elements.

Our seismic model does not yield the temperature or the hydrogen abundance in the core; and, therefore, it does not enable us to evaluate the neutrino flux. To do this, one has to assume thermal equilibrium and make use of opacity and nuclear reaction rate data. Still, the closer agreement between the speed of sound in the most up-to-date seismic model and the best reference model is a powerful argument in favor of the standard modeling of the solar interior. Therefore, these latest results provide greater support for a non-astrophysical solution of the solar neutrino problem. We emphasize that except for the $^7B + p$ reaction rate, all other known modifications in solar models affecting prediction of the neutrino flux leave signatures in the speed of sound that can be detected with existing data.

We are clearly on the road to achieving good resolution in probing the solar core. We feel that it is more important to extend the number of low-l modes rather than obtaining more accurate frequencies of the modes we have. The broader frequency range is critical to obtaining greater spatial resolution in the core. Our experience shows that adding even a single $l = 0$ mode at higher frequency leaves a visible trace in the speed of sound in the inner core.

5. Internal dynamics and magnetism of the Sun (L. Paternò)

The present internal dynamics and magnetism of the Sun have been determined by the initial conditions in the pre-main sequence age, by the angular momentum loss and its redistribution in the interior, and the interaction of motion with magnetic field.

The history of the Sun rotation is traced back by observing the present rotation of stars with the same mass as the Sun at earlier evolutionary stages. The present angular momentum of the Sun, as deduced from its internal rotational behavior derived from helioseismological data, appears to be a small percentage of the original one contained in similar mass stars (T Tauri and α Persei). It is not easy to reconcile the sharp decrease in the surface angular velocity, which follows the α Persei phase, with the subsequent soft decrease, taking place after Pleiades phase, unless some very effective mechanism transfers angular momentum from inner to outer regions, where is lost in the solar wind. Such a mechanism is probably magnetic in origin, since purely hydrodynamic instabilities fail to transfer angular momentum at a rate sufficient to determine the presently observed flat radial gradient of the internal angular velocity.

In the pre-helioseismological era, any inference about the internal dynamics and magnetism was mostly based on theoretical efforts in modeling motions and magnetic fields in the convection zone. Many mechanisms able to transport angular momentum from the poles to the equator against the viscous dissipation to produce the observed differential rotation were explored, essentially based on the interaction of rotation with convection. At the same time, α-ω dynamo models of solar cycle, operating in the whole convection zone, were worked out, which reproduced the correct migration of the surface magnetic fields only if isorotation surfaces were shaped in such a way that angular velocity had to increase inwards. This requirement created a conflict with hydrodynamical calculations which tended to produce isorotation surfaces aligned on cylinders, which imply an angular velocity increasing outwards. Even the more recent hydromagnetic dynamo models, which solve the whole set of the magnetohydrodynamic equations at once, did not succeed in reproducing all the features of the solar cycle.

The advent of the helioseismology with almost 4000 p-mode eigenfrequencies up to now identified, opened a new window on the knowledge of internal dynamics and magnetism of the Sun, discovering unexpected features of the rotational behavior and distribution of magnetic field.

Rotation removes mode degeneracy in the azimuthal order m and the eigenfrequencies split in multiplets whose separation in frequency depends on the rotational speed. The frequency splittings can be expressed as expansions, generally truncated at 5th term, in terms of Legendre polynomials in $m/\sqrt{\ell(\ell+1)}$, where ℓ is the harmonic degree of the mode. The odd coefficients of the expansions are a measure of the rotational field, while the even coefficients are a measure of the Sun's asphericity. These latter, once the dominant effects of rotation are eliminated, are a measure of the magnetic field strength.

Modes with different ℓ's are trapped in resonant cavities whose walls extend from the surface to a depth which depends mainly on the value of ℓ, low ℓ's penetrating more deeply than the high ones. Therefore the splittings of the modes with different ℓ's trace the rotation at different levels below the Sun's surface, the 1st coefficients of the expansions giving the radial dependence and the 3rd and 5th coefficients the latitudinal dependence. Thus, the isorotation surfaces can be obtained from an inversion for the expansion coefficients.

The inversion analysis gave a surprising result which contradicted all the numerical models of internal dynamics already constructed, showing that isorotation surfaces in the solar convection zone are mainly radial, with the surface latitudinal differential rotation persisting at all depths. Below the convection zone to a depth of about $0.3R_\odot$, corresponding to splittings of modes with $\ell = 5$, the rotation appears to be rigid at a rate corresponding to the surface rotation observed at a latitude of about 30°. There is a

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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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