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TORSIONAL MHD OSCILLATIONS OF THE SUN

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ABSTRACT

Assuming that the solar activity and the solar cycle phenomena may be manifestations of global torsional MHD oscillations, we compute the Alfven wave travel times along the field lines in the five models of magnetic field described in the following text. For all these models, we compute standard deviation and it's ratio to mean Alfvenic wave travel times. The last two models yield the smallest relative bandwidth for the frequencies of the MHD oscillations. However, the last model is the only admissible one which can sustain global Alfvenic oscillations with well defined frequency for the fundamental mode

Key Words : Solar cycle, Solar magnetic field

I. INTRODUCTION

The well known solar activity and solar cycle phenomena have been modeled earlier in terms of the dynamo mechanism which may supposed to be operating just beneath the solar convection zone. Until the advent of helioseismology, it was believed that the turbulent dynamo could reproduce the observed characteristics of solar activity and the solar cycle phenomena. However, heliosismologically inferred rotational gradients are contradictory to what dynamo theories require. Moreover, recent spherical harmonic fourier analysis of Sun's magnetic field (Stenflo and Vogel 1986) and of inferred magnetic field from sunspot data (Gokhale *et.al* 1992) brought out new global properties of the solar activity and solar cycle phenomena. These results show that all the axisymmetric Legendre terms with odd degree 'l ' have nearly the same dominant periodicity ($\sim 22 \quad yr$). Also, superposition of Legendre-Fourier terms computed from the sunspot data in latitudes $\leq 35^o$ could predict the global behaviour of magnetic field at *all* latitudes including poleward migrations of weak fields and polar reversals. This suggests the possibility that solar activity originates in global MHD oscillations of forced periodicity $\sim$ 22 yr. Such oscillations are originally proposed by Alfven (1943), Plumpton and Ferraro (1955) and, Layzer *et.al* (1979). In the oscillatory theory, solar cycle and solar activity phenomena are viewed to be the manifestations of global torsional magnetohydrodynamic (MHD) oscillations superposed on the background steady part of the magnetic field. The aim of the paper is to determine whether the axisymmetric terms of long period global magnetic oscillations with nearly the same periodicity are admitted by the Sun's steady field, assuming Sun has such a field. For the steady field to admit such oscillations, the Alfven wave travel time along different field lines of the steady part of the field should be independent of the latitudes of the photospheric intersections. In order to get an idea as to what type of steady part of the field structure can satisfy this condition, we have computed the Alfven wave travel times along the field lines in the following five models of magnetic field. The first three of these models are adhoc. In the first model, the field is taken to be uniform and in the second it is assumed to be a dipole field. In the third model, the field is taken to be a combination of a uniform field and a dipole field. The fourth and the fifth models are the models of 'steady' part of the magnetic field (Gokhale and Hiremath 1993, Hiremath 1994, Hiremath and Gokhale 1995) satisfying the law of isorotation with the the helioseismologically inferred internal rotation (Dziembowski *et.al* 1989).

II. RESULTS AND CONCLUSION

Using the density values from the standard solar model (Bachal's (1989) model in the radiative core, and Spruit's (1977) model in the convective envelope), we have computed the travel times of Alfven waves along different field lines in the afore mentioned five models. The magnetic fields in these models are scaled to the asymptotic external uniform field. For the sake of comparison, all the models are assumed to have the same amount of the steady part of the photospheric magnetic flux with a nominal value 1.5x10^{22} Mx corresponding to a uniform field of $\sim$ 1 G. In Table 1., we give for each model , the average $\overline{\tau}$ of the travel times, their standard deviation (σ_τ) from the mean, and the ratio $\frac{\sigma_\tau}{\overline{\tau}}$ which represents the spread in the oscillatory periods. The least spread in the oscillatory periods give nearly the same periodicity along the different field lines. Model numbers 2, 4 and 5 give the values of $\sigma_\tau/\overline{\tau}$ < 0.1. However, the smallness of $\sigma_\tau/\overline{\tau}$ in models 2 and 4 is due to the fact that all the field lines enter the radiative core with similar arcs of field lines passing through similar density structure. This is mainly due to the presence of central singularity in these models. However, in the model 5, there is no singularity and the field is regular at the center. Hence, we conclude that among models 1 to 5, model 5 is the only physically admissible model which can sustain global Alfvenic mode

Table 1. The mean Alfven wave travel times and their spread in the five models of the magentic field structure

Model:	1	2	3	4	5
Mean$\overline{\tau}$	1572	34.3	22.85	23.90	284.0
σ_{τ}	2395	2.81	2.72	0.70	12.0
$\frac{\sigma_{tau}}{\overline{\tau}}$	1.52	0.08	0.12	0.03	0.04

of oscillations with well defined period (frequency) for the fundamental mode. In order that the solar cycle period be $\sim 22 \quad yr$, we get the intensity of the steady part of the solar magnetic field to be ~ 1 G.

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