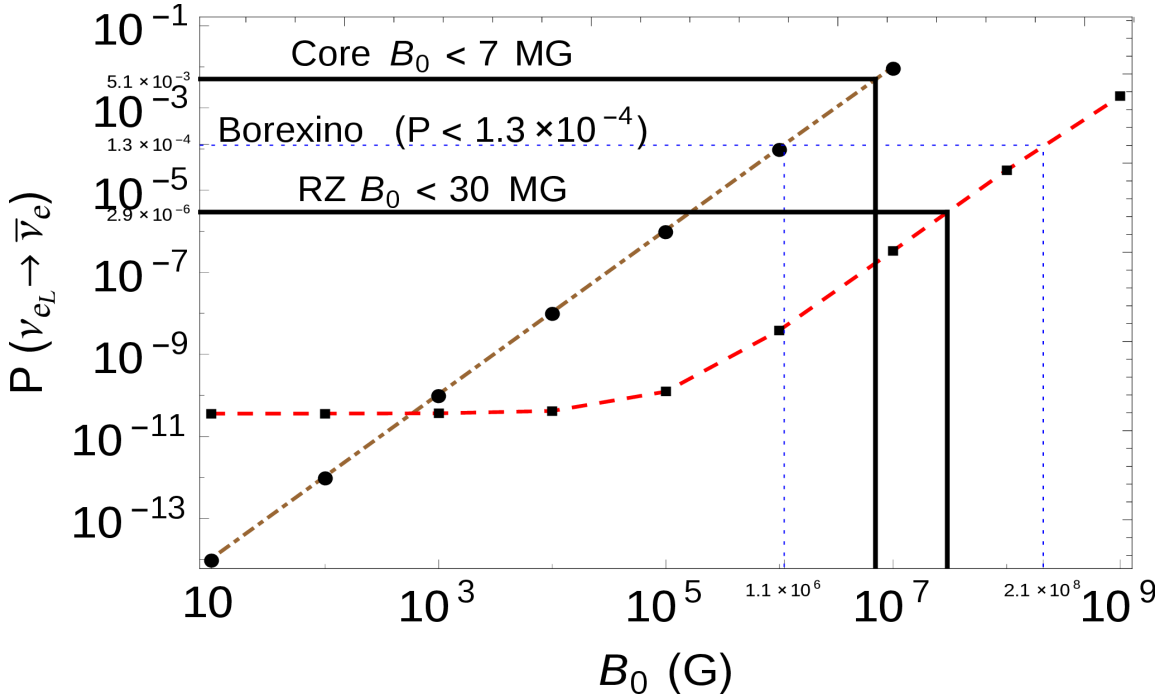
Neutrino spin-flavor oscillations in solar environment

In this paper, we have studied the phenomenon of neutrino spin-flavor oscillations in the Sun for neutrinos having sufficiently large magnetic moments ~ $10^{-11}\mu_B$. We have constructed two models for solar magnetic field based on the current bounds on the magnetic field in different regions of the Sun. In the first model, one can have large magnetic field in the solar core and it tapers off with distance from the center. In the second model, we have a large magnetic field in the RZ which becomes negligible in the core region and in addition there is a CZ magnetic field. We have also obtained a novel parametrization for the electron density profile in the Sun, which provides a better approximation compared to the usual exponential parametrization.

For the case of zero vacuum mixing and large magnetic field in the solar core, we obtain analytically exact solutions. This allows us to put strong bounds on the magnetic field in the solar core using results from the Borexino experiment. Also, the difference between the Dirac and Majorana neutrinos is significant only for magnetic fields ~ 10^5 G or more. We then examined the effects for the realistic case of large vacuum mixing angle and found that it has an effect in suppressing the $\nu_e \rightarrow \bar{\nu}_\mu$ transitions. The energy level diagrams distinctly demonstrate the difference between the two cases. Whereas in the case of small mixing angle we get enhanced transitions due to adiabatic level crossings. For the latter case of large vacuum mixing, the eigenstates of the Hamiltonian in the mass eigenbasis do not exhibit such crossing phenomenon. Thus the dominant terms are the diagonal terms and small transitions take place only in the RZ where the ratio of the two terms is ~ 0.1. Furthermore, the CZ fields do not affect the neutrino transitions. The Borexino results are then utilized to place appropriate bounds on the two models of solar magnetic field. It is found that whereas the Borexino bounds are too weak to place any upper limit on the RZ magnetic field, for the solar core magnetic field we are able to place an upper bound $B_0 < 1.1 \times 10^6$ G. This is significant improvement over the existing bounds coming from helioseismology results.

REFERENCE:



Sandeep Joshi and Sudhir R. Jain, Res. Astron. Astrophys. 2020 Vol. 20 No. 8, 123