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Impacts of Magnetorotational Instability on Dynamo and Angular Momentum Transport in the Sun

Youhei Masada[1*]

[1]NAOJ, HInode Science Project

Two important unsolved issues in the solar physics are the mechanisms of magnetic dynamo and angular momentum transport in the solar interior. These physical processes are inevitably related to the operation mechanism of the solar internal rotation.
It is thus essential to elucidate the driving and sustaining mechanism of the solar internal rotation for settling these unsolved issues.

The thermal wind balance is retained in the solar interior with small Rossby number by balancing between Coriolis and entropy gradient forces (Pedlosky 1987; Kitchatinov & Rudiger 1995). This causes the deviation from Taylor-Proudman state and drives the differential rotation along the rotation axis as is observed in the convective zone by the helioseismic inversion (Thompson 2003). This strongly suggests that the entropy gradient force in the latitudinal direction plays a crucial role for sustaining the observed internal rotation profile of the Sun (Balbus 2009). Here we reveal the impacts of MHD turbulence driven by the magneto-rotational instability (MRI) on the the thermal wind balance in the solar interior.

From our analysis on the basis of linear theory coupling with the observed rotation profile and the standard solar model (Christensen-Dalsgaard 1996), we find that the MRI venue is confined to the higher-latitude tachocline and the lower-latitude near-surface shear layer. It is especially interesting that the MRI active tachocline region closely overlaps with the area indicating the steep entropy rise which is required from the thermal wind balance in the solar interior.

These suggest that the MRI-driven turbulence plays a central role in realizing the thermal wind balance of the sun by sustaining the exceptional heating and equatorward angular momentum transport. The warm pole existing in the tachocline would be a natural outcome of the turbulent activities energized by the MRI.

Keywords: Sun, Rotation, Magnetic Field, Instability, MHD