Geophysical Research Abstracts
Vol. 19, EGU2017-4090-2, 2017
EGU General Assembly 2017

Inhomogeneous helicity effect in the solar angular-momentum transport

Nobumitsu Yokoi
Institute of Industrial Science, University of Tokyo, Tokyo, Japan (nobyokoi@iis.u-tokyo.ac.jp)

Coupled with mean absolute vorticity $\mathbf{\Omega}_*$ (rotation and mean relative vorticity), inhomogeneous turbulent helicity is expected to contribute to the generation of global flow structure against the linear and angular momentum mixing due to turbulent or eddy viscosity. This inhomogeneous helicity effect was originally derived in Yokoi & Yoshizawa (1993) [1], and recently has been validated by direct numerical simulations (DNSs) of rotating helical turbulence [2].

Turbulence effect enters the mean-vorticity equation through the turbulent vortexmotive force $\langle \mathbf{u}' \times \boldsymbol{\omega}' \rangle$ [$\mathbf{u}'$: velocity fluctuation, $\boldsymbol{\omega}' (= \nabla \times \mathbf{u}')$: vorticity fluctuation], which is the vorticity counterpart of the electromotive force $\langle \mathbf{u}' \times \mathbf{b}' \rangle$ ($\mathbf{b}'$: magnetic fluctuation) in the mean magnetic-field induction. The mean velocity induction $\delta\mathbf{U}$ is proportional to the vortexmotive force. According to the theoretical result [1,2], it is expressed as $\delta\mathbf{U} = -\nu_{\mathrm{T}} \nabla \times \mathbf{\Omega}_* - \eta_{\mathrm{T}} (\nabla^2 H) \mathbf{\Omega}_*$, where η_{T} is the transport coefficient, $H = \langle \mathbf{u}' \cdot \boldsymbol{\omega}' \rangle$ the turbulent helicity, and $\mathbf{\Omega}_*$ the mean absolute vorticity. The first term corresponds to the enhanced diffusion due to turbulent viscosity ν_{T}. The second term expresses the large-scale flow generation due to inhomogeneous helicity.

Since helicity is self-generated in rotating stratified turbulence [3], an inhomogeneous helicity distribution is expected to exist in the solar convection zone. A rising flow with expansion near the surface of the Sun generates a strongly negative helicity there [4]. This spatial distribution of helicity would lead to a positive Laplacian of turbulent helicity ($\nabla^2 H > 0$) in the subsurface layer of the Sun. In the combination with the large-scale vorticity associated with the meridional circulation, the inhomogeneous helicity effect works for accelerating the mean velocity in the azimuthal direction. The relevance of this inhomogeneous helicity effect in the solar convection zone is discussed further.

References

[1] Yokoi, N. and Yoshizawa, A., "Statistical analysis of the effects of helicity in inhomogeneous turbulence," Phys. Fluids A, **5**, 464-477 (1993).

[2] Yokoi, N. and Brandenburg, A., "Large-scale flow generation by inhomogeneous helicity," Phys. Rev. E, **93**, 033125-1-14 (2016).

[3] Marino, R., Mininni, P., Rosenberg, D., and Pouquet, A., "Emergence of helicity in rotating stratified turbulence," Phys. Rev. E, **87**, 033016-1-9 (2013).

[4] Duarte, L. D. V., Wicht, J., Browning, M. K., and Gastine, T., "Helicity inversion in spherical convection as a means for equatorward dynamo wave propagation," Mon. Not. Roy. Astron. Soc. **456**, 1708-1722 (2016).