Kinetic Helicity in the Turbulent Stratified Flows

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A new theoretical approach to describe the spectra of kinetic energy and kinetic helicity under the influence of stratification is developed in this study. The introduction of a new scaling parameter (m) allowed us to consider the effect of stratification rate on the spectra of kinetic energy and kinetic helicity.

Using the scaling analysis, it became possible to identify the features of kinetic helicity and kinetic energy in the spectral properties of turbulent stratified flows. The collective effect of kinetic energy, kinetic helicity, and stratification controls these spectral properties. This study extends the approaches concerning the various time scales[1] relevant to the turbulent flow and a similar consideration for rotating turbulence[2]. Various cascading scenarios reviewed in the present study cover different levels of influence of stratification on the spectrum. In this context, we introduced the scaling parameter (m) to determine the effect of stratification on the distortion of turbulent eddies. In addition to the influence of stratification, we identified various scenarios of either kinetic energy or kinetic helicity domination. Based on this theoretical consideration, it was not only possible to reproduce several forms of the spectra that are already well-known but also to deduce general statements on how an increasing dominance of either kinetic energy or kinetic helicity and different magnitudes of stratification could influence the spectra of kinetic energy and kinetic helicity. The kinetic helicity domination appears to flatten these spectra compared to the dominance of kinetic energy, whereas an increasing influence of stratification steepens both helicity and energy spectra.

The theoretical results of this study are tested against atmospheric balloon-borne observations (see example spectra in the figure below). The hence-developed theory of the spectra of turbulent stratified flows could thus be the foundation for future studies of stratified turbulence and enable us to analyze the dynamics of turbulent stratified flows based on their spectral properties.

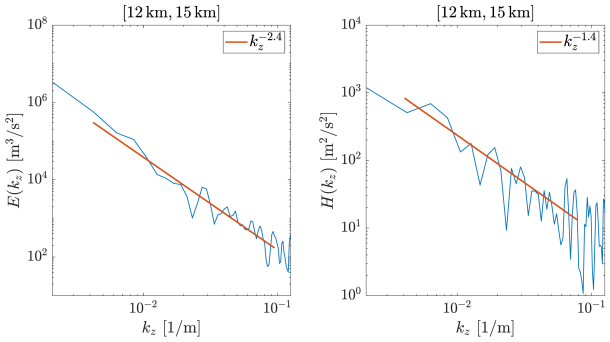

Figure 1: Kinetic energy (left) and helicity (right) spectra with the fit function (orange).

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