Waves and Mirror Symmetry in Rotating and Stratified Turbulence

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Invariants of the equations of motion play an essential role in the behavior of turbulent flows. The cascade of energy (a transfer of energy to small scales) in three dimensional hydrodynamic turbulence, associated with the conservation of energy in the ideal case, is a well-known example. Less understood is the role played by the helicity, which embodies the global correlations between the velocity field and the vorticity, and is associated with the break down of mirror symmetry in a flow. In ideal rotating flows, helicity is conserved, and waves in rotating and stratified flows are associated with helical flows, to the point that helical-wave decompositions are often used to study their dynamics. Helicity is also believed to be important in certain atmospheric processes, such as rotating convective (supercell) thunderstorms, and in conducting flows for the generation of large-scale magnetic fields.
We present results from several large direct numerical simulations of rotating and/or stratified turbulent flows. Some of the simulations are the largest in the world, allowing for detailed studies of physical processes with large scale separation. In the case or rotating flows, helicity in the flow affects scaling laws and the mixing of scalar quantities. At sufficiently small scales, the time scale of the eddies becomes of the order of the wave period, and isotropy is recovered with the eddies dominating the dynamics. In stratified and rotating flows, helicity emerges spontaneously from the joint action of eddies and of inertia-gravity waves, and it occurs when the waves are sufficiently strong. Extensions of these results to other systems, and possible experimental measurements will be briefly discussed.

Short bio: Pablo D. Mininni received his diploma in 1999 and his doctoral degree in 2003, both in physics and from the University of Buenos Aires (UBA) in Argentina. From 2004 to 2007 he was a postdoc and later a scientist at National Center for Atmospheric Research (NCAR), in Boulder, Colorado. Now, he is professor and chair of the Physics Department at the University of Buenos Aires, and part-time scientist at National Center for Atmospheric Research. Dr. Mininni works on the numerical and theoretical study of turbulent flows, with applications in geophysics and astrophysics. In the field of fluid dynamics, his expertise includes parallelization methods for computational fluid dynamics, the application of statistical methods for the characterization and analysis of turbulent flows, spectral analysis of multi-scale and multiphysics phenomena, and sub-grid modeling for turbulent flows. Recently, he also became interested in experimental aspects of fluid dynamics and geophysical flows.