



## New Exact Relations for Helicities in Hall Magnetohydrodynamic Turbulence

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Hall magnetohydrodynamics is a mono-fluid plasma model appropriate for probing some of the physical processes (other than pure kinetic effects) at length scales smaller than the scales of standard MHD. In sub-ionic space plasma turbulence (e.g. the solar wind) this fluid model has been proved to be useful. Three-dimensional incompressible Hall magnetohydrodynamics (MHD) possesses three inviscid invariants which are the total energy, the magnetic helicity and the generalized helicity. In this presentation, we would like to discuss new exact relations for helicities (magnetic helicities and generalized helicities) which are derived for homogeneous stationary (not necessarily isotropic) Hall MHD turbulence (and also for its inertialess electron MHD limit) in the asymptotic limit of large Reynolds numbers. The universal laws are written only in terms of mixed second-order structure functions, i.e. the scalar product of two different increments and are written simply as  $\eta_M = d_i \langle \delta(b \times j) \cdot \delta b \rangle$ , with  $\eta_M$  the average magnetic helicity flux rate,  $\mathbf{b}$  the magnetic field,  $\mathbf{j}$  the current and

$$\pm \eta_G = \langle \delta(\mathbf{v} \times \Omega) \cdot \delta \Omega \rangle,$$

with  $\eta_M$  the average generalized helicity flux rate,  $\mathbf{v}$  the fluid velocity and  $\Omega = \mathbf{b} + d_I \omega$  being the generalized helicity where  $\omega$  is simply the fluid vorticity ( $= \nabla \times \mathbf{v}$ ). It provides, therefore, a direct measurement of the dissipation rates for the corresponding helicities even in case of an anisotropic plasma turbulence. This study shows that the generalized helicity cascade is strongly linked to the left polarized fluctuations while the magnetic helicity cascade is linked to the right polarized fluctuations. The newly derived relations also show that like energy, a non-zero helicity flux can only be associated to a departure of Beltrami flow state.

## Reference

S. Banerjee & S. Galtier, **Chiral Exact Relations for Helicities in Hall Magnetohydrodynamic Turbulence** (submitted).