Dissipationless "Hall viscosity" and its relation to incompressibility of quantum Hall fluids

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Abstract

A non-uniform drift-velocity field in an incompressible 2D quantum Hall fluid sets up a stress field that is related to the velocity field by a dissipationless viscosity ("Hall viscosity") tensor. If the 2D fluid is isotropic, the Hall viscosity is proportional to the (quantized) intrinsic spin of the "elementary droplet" of the fluid. The Hall viscosity can also be related to an intrinsic electric dipole moment on the boundary of an incompressible fluid droplet which balances a discontinuity in the stress field. In the high-magnetic-field limit, it can be separated into distinct contributions from the Landau-level (cyclotron motion) and the guiding-center degrees of freedom. An apparently-unrelated fundamental property of (fractional) QHE states is that their "guiding center structure factor" $S_0(Q)$ vanishes as Q^4 in the limit $Q \to 0$. A surprising new relation shows that the coefficient of the Q^4 term has a lower bound proportional to the absolute value of the (guiding-center part of the) Hall viscosity. This bound is saturated in the case of the famous FQHE "model wavefunctions" (Laughlin, Moore-Read, *etc.*) that can be obtained from conformal field theory.