MAR15-2014-020366

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Hall viscosity[1]

NICHOLAS READ, Yale University

Viscosity is a transport coefficient relating to transport of momentum, and usually thought of as the analog of friction that occurs in fluids and solids. More formally, it is the response of the stress to the gradients of the fluid velocity field, or to the rate of change of strain (derivatives of displacement from a reference state). In general, viscosity is described by a fourth-rank tensor. Invoking rotation invariance, it reduces to familiar shear and bulk viscosity parts, which describe dissipation, but it can also contain an antisymmetric part, analogous to the Hall conductivity part of the conductivity tensor. In two dimensions this part is a single number, the Hall viscosity. Symmetry of the system under time reversal (or, in two dimensions, reflections) forces it to vanish. In quantum fluids with a gap in the bulk energy spectrum and which lack both time reversal and reflection symmetries the Hall viscosity can be nonzero even at zero temperature. For integer quantum Hall states, it was first calculated by Avron, Seiler, and Zograf, using a Berry curvature approach, analogous to the Chern number for Hall conductivity. In 2008 this was extended by the present author to fractional quantum Hall states and to BCS states in two dimensions. I found that the general result is given by a simple formula $ns/2$, where n is the particle number density, and s is the "orbital spin" per particle. The spin s is also related to the shift S, which enters the relation between particle number and magnetic flux needed to put the ground state on a surface of non-trivial topology with introducing defect excitations, by $S = 2s$; the connection was made by Wen and Zee. The values of s and S are rational numbers, and are robust—unchanged under perturbations that do not cause the bulk energy gap to collapse—provided rotation as well as translation symmetry are maintained. Hall viscosity can be measured in principle, though a simple way to do so is lacking. It enters various theoretical calculations of other properties, and can be used as a diagnostic tool to distinguish phases. The talk will review these results, describing different microscopic approaches to calculating Hall viscosity, robustness, and the relation with effective field theories.

[1]Research supported by NSF DMR