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Spacetime symmetries, Newton-Cartan geometry and the quantum Hall effect[1]

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Spacetime symmetries place powerful constraints on the physics of quantum Hall states from spacetime symmetries. These symmetries can be seen by putting the quantum Hall system on a curved manifold. By doing so, one discovers that the action is invariant with respect to time-preserving diffeomorphisms. The diffeomorphism invariance remains nontrivial on the lowest Landau level when inter Landau level mixing is negligible. In the talk we will extract physical consequences of the diffeomorphism invariance for physical observables in flat space. In particular, we relate the leading dependence of the Hall conductivity on wavenumber to the shift. We show how the spectral densities of the components of the stress tensor satisfy several sum rules, one of which involves the static projected structure factor and another involves the shift. From the sum rules one can deduce an inequality between the leading k^4 coefficient of the static structure factor and the shift. The inequality is saturated for a large class of trial wavefunctions. The sum rules suggest that if the magneto-roton continues to exist as a sharp resonance at small wavenumber, it should be a "chiral massive graviton," i.e., a particle with spin 2 of one circular polarization. This is demonstrated explicitly in a toy model, where which the sum rules are saturated by one single gapped mode. We argue that the circular polarization of the magneto-roton can be in principle observed by polarized Raman scatterings. The most convenient formalism to write down effective actions satisfying local diffeomorphism invariance turns out to be the Newton-Cartan formalism, introduced by Elie Cartan in 1922-1923 in his attempt to rewrite Newton's gravity in a coordinate-invariant way. We describe the structure of the Newton-Cartan space, including the construction of the connection.

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