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Anyonic molecules in atomic fractional quantum Hall liquids: a quantitative probe of fractional charge and anyonic statistics

We study the quantum dynamics of massive impurities embedded in a strongly interacting two-dimensional atomic gas driven into the fractional quantum Hall (FQH) regime under the effect of a synthetic magnetic field. For suitable values of the atom-impurity interaction strength, each impurity can capture one or more quasi-hole excitations of the FQH liquid, forming a bound molecular state with novel physical properties. An effective Hamiltonian for such molecules is derived within the Born-Oppenheimer approximation, which provides renormalized values for the effective mass, charge and statistics of such anyonic molecules by combining the finite mass of the impurity and the fractional charge and anyonic statistics of the quasi-holes. The anyonic statistics is shown to provide a long-range Aharonov-Bohm-like interaction between molecules. The resulting relative phase of the direct and exchange scattering channels can be thus extracted from the angular position of the interference fringes in the scattering cross section of a pair of colliding molecules. Different configurations providing direct and quantitative insight on the fractional charge and the anyonic statistics of quasi-hole excitations in FQH liquids are highlighted for both cold atoms and photonic systems.

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