Photoluminescence of charged excitons in fractional quantum Hall systems

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Photoluminescence (PL) of a two-dimensional electron gas (2DEG) in the lowest Landau level (LL) can often be explained in terms of dynamics and recombination of the relevant quasiparticles: bound states of a valence hole (*h*) and one or more electrons (*e*) or other negatively charged excitations such as Laughlin quasielectrons (QE), Rezayi reversed-spin quasielectrons (QE_R), composite fermions (CF), or skyrmions. The talk covers (mostly ours) theoretical predictions and reviews some of the related experiments.

In the dilute regime (small LL filling factor ν), PL occurs from neutral or charged excitons, $X=e+h$ or $X^-=2e+h$. Three bound X^- states can occur, different by orbital quantum numbers such as angular momentum [1,2]: two spin-triplets (the lower-energy dark X^-_{td} and a higher-energy bright X^-_{tb}) and one spin-singlet (bright X^-_s). The two kinds of optical selection rules that apply to the X^- recombination result from the geometrical (translational) symmetry and a "dynamical" particle-hole symmetry (both conserved to varying degree in different experimental systems). The pseudopotentials describing repulsion between an X^- and the surrounding charges are all shown to have short range. From the general theory of the fractional quantum Hall effect, such short-range repulsion is known to yield Laughlin e-X^- and X^--X^- correlations and hence the spatial isolation of the X^- [3]. Such isolation seemed to be consistent with the weak sensitivity of the energy and intensity of the X^- recombination to the presence or density of the surrounding electrons [1,2]. However, our most recent calculations do not quite support such a simple "independent X^-" picture for the PL of a 2DEG.

At higher density, near the Laughlin filling $\nu=1/3$, valence holes may prefer to bind fractionally charged QE's or QE_R's rather than the "whole" electrons, if the strength and resolution of e-h attraction is sufficiently reduced due to a finite separation between the *e* and *h* layers. The stability and recombination of possible "fractionally charged exciton" (FCX) states hQE_n or $h(QE_R)_n$ is discussed [4]. The occurrence of bright states hQE_2 and hQE_R only in the presence of free QE's or QE_R's causes discontinuity of PL at $\nu=1/3$.

At yet higher density, near $\nu=1$, the excess electrons in the reversed-spin LL (e^*) or the spin-holes (*s*) in the lowest LL are unstable and may induce and bind additional s-e^* pairs (spin waves) to form skyrmions (S^-). The optically active h-s-e^* bound states resulting from attraction between valence holes *h* and either e^* or S^- are mentioned.

References:

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