The zero phonon line revisited

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As photoluminescence (PL) experiments are a means to infer the quality of a semi-conductor material, it is of practical interest to be able to interpret finite temperature (T) spectra as these could provide for quick and accessible device characterization. We consider a novel Green function based approach built around the fluctuation-dissipation theorem and treating the phonon-exciton coupling as an interaction with a (not necessarily classical) stochastic background. At low-T, one is able to reliably estimate exciton correlation functions using standard perturbation theory; however, our approach serves to extend these calculations to settings where a) thermal populations are large and b) phonon couplings are relatively strong. This is achieved through the use of functional methods (viz. Luttinger-Ward).

As a proof of concept, in these proceedings we specifically apply the method to the computation of the zero phonon linewidth (ZPL) in 2D InAs / GaAs quantum well (QW) geometries at finite temperature (see Fig. 1). In particular, we are able to demonstrate deviations from a Lorentzian profile (not present at low-T but which become more pronounced with increasing T). The study of a 2D QW is motivated as it provides an effective platform for addressing the associated numerical challenges (i.e. frequency *and* momentum dependent phase space integrals subject to kinematic constraints). We show that such a computation is relatively tractable allowing for a simplified treatment of higher order corrections (whenever they might not be small). This diagrammatic approach is geared towards future applications in quantum dots, and especially relaxation processes involving optical / acoustic phonon emission.

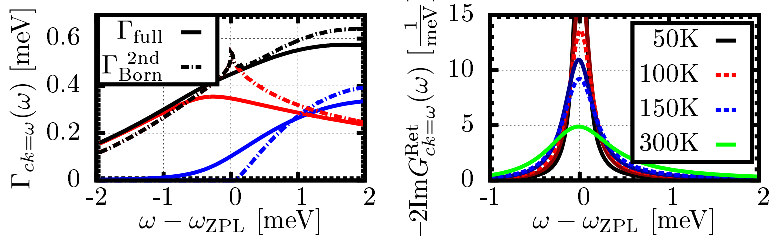

FIG. 1: (L) Linewidth showing gain / loss terms (300K). (R) Spectral density ZPL peak.