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Bound exciton model for "shallow" impurities in semiconductors[1]

YONG ZHANG, JIANWEI WANG, Univ of NC - Charlotte — Most impurities can be described by a unified bound exciton model [1] that includes impurity binding energy E_I, exciton binding energy E_{XB}, and excitonic transition energy E_X =E_I-E_{XB}. E_{XB} corresponds to the commonly known acceptor binding energy E_A or donor binding E_D for the respective case. Analogous to the free exciton problem, E_g or E_I is the single particle transition energy, E_{XB} is due to many-body effect that can sometimes be simplified as an effective mass (EM) equation with a screened Coulomb interaction between the electron and hole. Although E_{XB} typically represents a small modification to the inter-band transition energy (e.g., E_g = 1.519 eV and E_{BX} = 4 meV for GaAs), the excitonic effect is responsible for the strong absorption at E_X and other discrete excitonic transition peaks. The same phenomenon occurs in impurities either known as "deep" or "shallow." The standard theory for "shallow" impurities overlooks an important aspect of the problem, the E_I part associated with a short-range potential. The attempt to consolidate the discrepancy between the EM model and experimental data by introducing a "core correction" into the EM equation is conceptually problematic, equivalent to "correcting" E_{BX} to match the E_g value for a free exciton.

[1] Zhang and Wang, PRB (in press).

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