PH682 Day 6

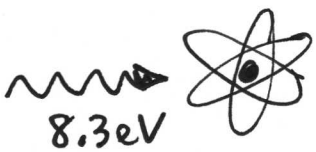
TIGHTLY BOUND EXCITONS

For p 86

(Also called Frenkel Excitons)

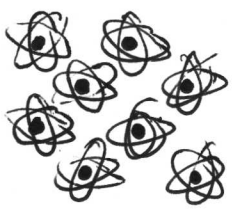
Consider Xenon crystal — an extreme case of a tightly bound exciton.

Absorption spectroscopy of dilute Xe gas



$5p^6 \rightarrow 5p^5 6s$ First absorption line.

When Xe is crystalized ($T < 160°K$)



Insulator with $E_g = 9.3\,eV$ and strong exciton absorption peak at 8.3 eV. i.e. $E_g - 1eV$ ← Exciton binding energy.

- The atomic levels are only weakly perturbed when Xe condenses into a solid. ← held by van der Waals interactions.
- The tightly bound exciton is localized on one Xe atom.

Note: The E_g is measured by adding an e^- to the cond. band without removing an e^- from the val. band.

The atomic transition is measured when the e^- is removed from a lower level and added to a higher level.

Molecular crystals exist at room temp and have similarities with the Xe crystal.

- Held together by van der Waals forces.
- The exciton absorption almost matches molecular levels.

Figure from Fox.

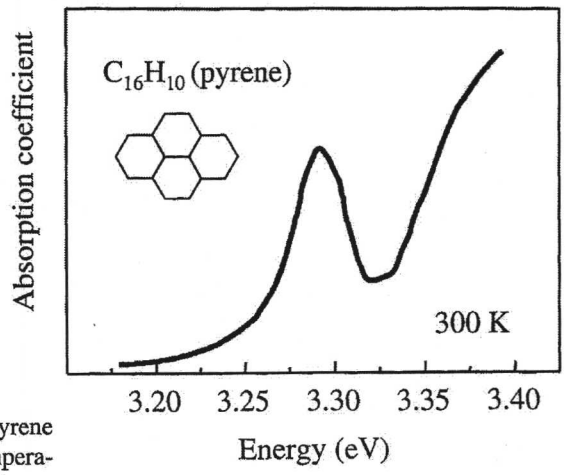
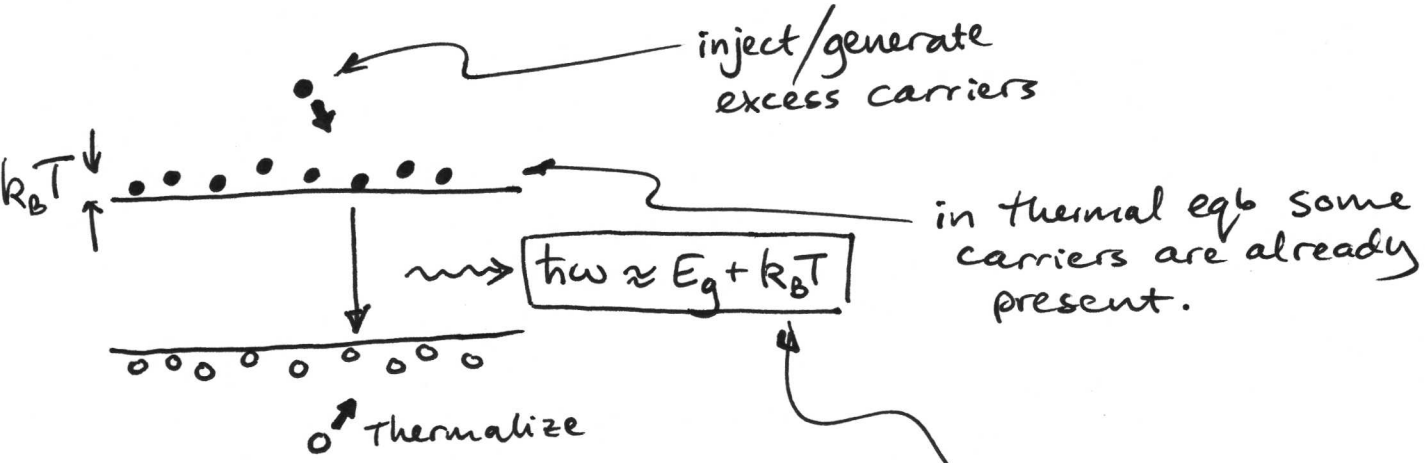


Fig. 4.9 Absorption spectrum of pyrene ($C_{16}H_{10}$) single crystals at room temperature. After [5], reprinted with permission.

Similar crystals are studied in Dr. Ostroverkhovas lab.

LIGHT EMISSION PROCESSES



Radiative decay:

- Time reverse process of absorption.
- Will the e-h pairs first become excitons?
- How long will it take for e⁻ & h⁺s to find each other?

All these points contribute to τ_R,
the "excess carrier radiative recombination lifetime"

It is impossible to create a sample where 100% of carrier recombination is radiative.
Another important parameter is τ_{NR},
the "excess carrier non-radiative recombination lifetime"

↖ more on Day 7.