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### 3.23 Electrical, Optical, and Magnetic Properties of Materials

Fall 2007

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## 3.23 Fall 2007 – Lecture 24

# LUMINESCENCE

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## Last time

- Optical processes, optical materials
- Complex dielectric constant, Kramers-Kronig relations
- Interband absorption, direct and indirect transitions
- Fermi's golden rule, perturbing Hamiltonian

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# Study

- Fox, Optical Properties of Solids: Chapter 5

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## Direct and indirect transitions

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Please see: Fig. 3.2 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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## Transition rates: perturbing Hamiltonian

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## Transition rate for direct absorption

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# Transition rate for direct absorption

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Please see: Fig. 3.5 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

Please also see any diagram of GaAs energy bands, such as [http://ecee.colorado.edu/~bart/book/book/chapter2/gif/fig2\\_3\\_6.gif](http://ecee.colorado.edu/~bart/book/book/chapter2/gif/fig2_3_6.gif).

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## Dipole-allowed selection rules

These are for atoms...

- Parity of initial and final state are opposite
- $\Delta m = -1, 0$  or  $1$
- $\Delta l = -1$  or  $1$
- $\Delta m_s$

E.g. phosphorence involves dipole-forbidden transitions that are mediated by higher order terms (magnetic dipole, electronic quadrupole)

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# Joint Density of States

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## Frequency dependence of band edge absorption

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Please see: Fig. 3.6 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Indirect gap semiconductors

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# Indirect gap semiconductors

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Please see: Fig. 3.10 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Absorption above the band edge

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Please see: Fig. 3.11 and 3.12 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Excitons

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Please see; Fig. 4.1 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Excitons

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## Excitons absorption

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Please see: Fig. 4.4 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Light emission in solids

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Please see: Fig. 5.1 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Interband luminescence

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Please see: Fig. 5.2 and 5.3 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Indirect band gap materials

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Please see: Fig. 5.4 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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# Photoluminescence: excitation, relaxation

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Please see Fig. 5.5 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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## Low-carrier density case

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Please see: Fig. 5.6 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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## Degeneracy

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Please see: Fig. 5.7 and 5.8 in Fox, Mark. *Optical Properties of Solids*. Oxford, England: Oxford University Press, 2001.

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