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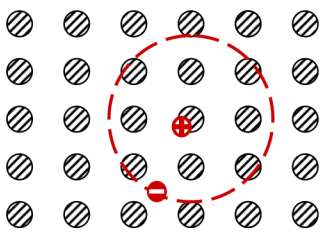
Postdoc Berkeley

Faculty RPI (Chem. & Bio. Engineering) 2015 -

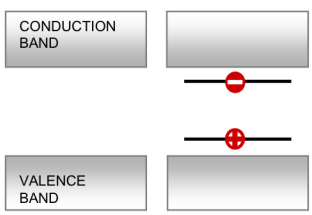
Light-matter interactions

Excitons
(bound electron-hole pairs)

Wannier exciton
(typical of inorganic semiconductors)



SEMICONDUCTOR PICTURE



GROUND STATE WANNIER EXCITON

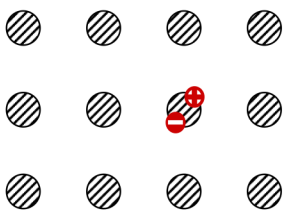
binding energy ~10meV
radius ~100Å

treat excitons as chargeless particles capable of diffusion,

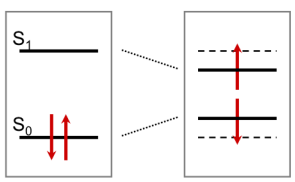
also view them as excited states of the molecule

Charge Transfer (CT) Exciton
(typical of organic materials)

Frenkel exciton
(typical of organic materials)



MOLECULAR PICTURE



GROUND STATE FRENKEL EXCITON

binding energy ~1eV
radius ~10Å

Electronic Processes in Organic Crystals and Polymers by M. Pope and C.E. Swenberg 3

Hydrogenic energy levels of bound e-h pair:

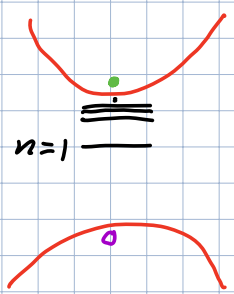
$$E_{ns} = -\left(\frac{13.6\ eV}{n^2}\right)\cdot\left(\frac{\mu}{m_0}\right)\div \epsilon$$

ϵ: dielectric

μ: reduced mass

$n^2 \rightarrow (n-\frac{1}{2})^2$ in 2D

$$\mu = \frac{m_e m_h}{m_e + m_h}$$



electron in CB
m_e

hole in VB
m_h

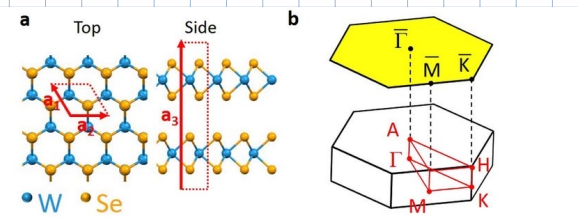
K/K′ ↓

Radius ~ n^2 reaches 214 nm for n = 11 ↓

Giant Valley-Polarized Rydberg Excitons in Monolayer WSe_2 Revealed by Magneto-photocurrent Spectroscopy

↑ Conductance in presence of illumination μA/W

↑

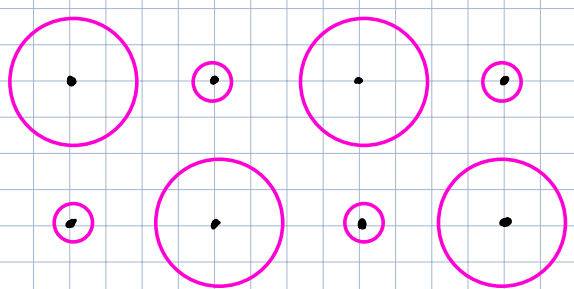


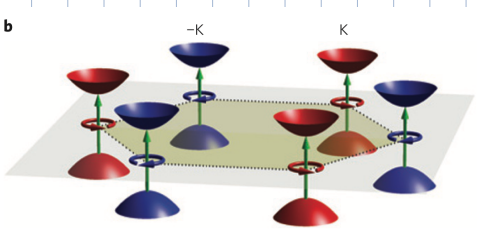
↑ Broken inversion symmetry in monolayer

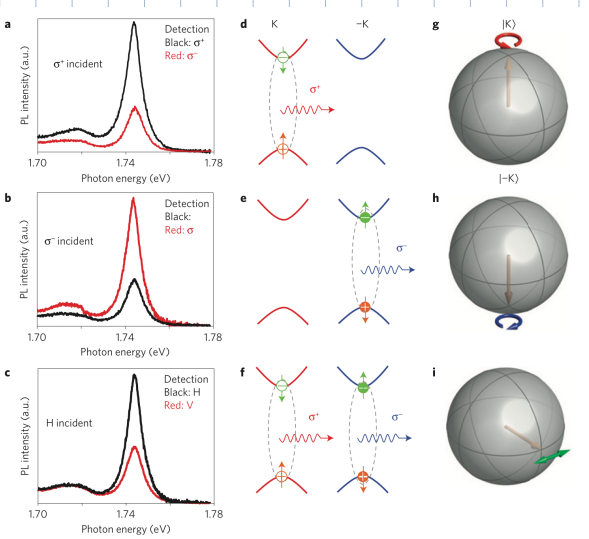
Rydberg qubit: n=1 n=2

Rydberg blockade:

Quantum simulator:







Valley-dependent selection rules

Xu Yao Xiao Heinz 2014

$K \xleftrightarrow{\mathcal{T}} K' = -K$

Low magnetic fields: $E_{ns} = E_{ns}^{0} + \frac{1}{2}\tilde{\sigma} g \mu_B B + E_{diamag}$

$\tilde{\sigma}$: ± 1 in K/K'

E_{diamag}: $\frac{e^2}{8\mu}\langle r^2 \rangle_{ns} B^2$

Strong fields: Landau quantization