Applied quantum mechanics- session 1

Note Title 12/25/2007

Why do we need to learn QM ?

because we live in the Quantum World!

Engineers : electronics, OE, optical devices → atomic scale

Biology : molecules & cells → modify & understand in atomic scale

Chemistry : Goal → make Organic & Inorganic compounds in precise atomic composition & structure

Thi a course for : Engineers, material scientists, & experimental physicists.

Example 1: Deoxyribonucleic acid molecule (DNA)

Too many atoms to track the position & activity of each atom.

Engineers + Chemists + Biologists use QM to track the behavior of DNA molecule (S. Weiss, Science 283, 1676 (1999)).

Attach a flurophore and study the laser induced flurosence of the atom. →

QM photon stimulation & photon emission.

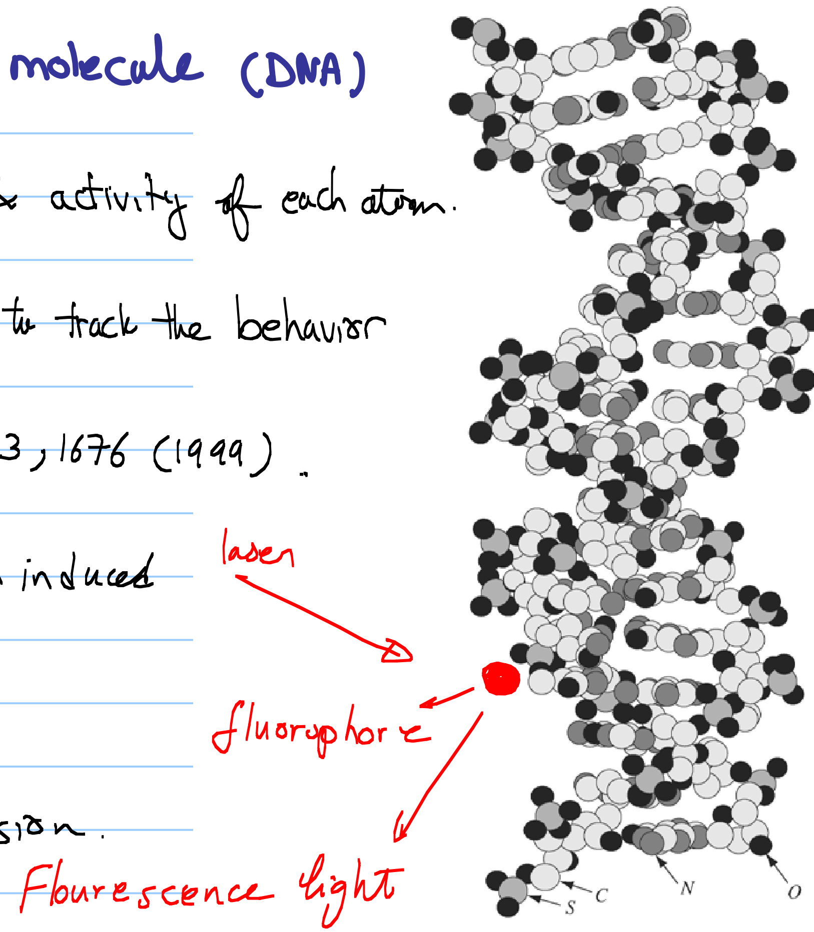
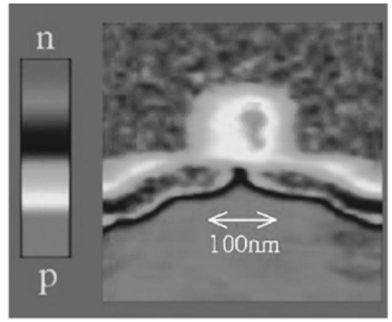


Fig. 1.1 Ball and stick model of a DNA molecule. Atom types are indicated.

Example 2:



1st transistor in 1947

$\beta = 18$

Brattain & Bardeen's p-n-p point contact Ge transistor

~ a few mm

Si p-type MOSFET, 1998

Channel length ~ 20 nm (~ 60 atoms)

Scanning capacitance microscope cross-section image

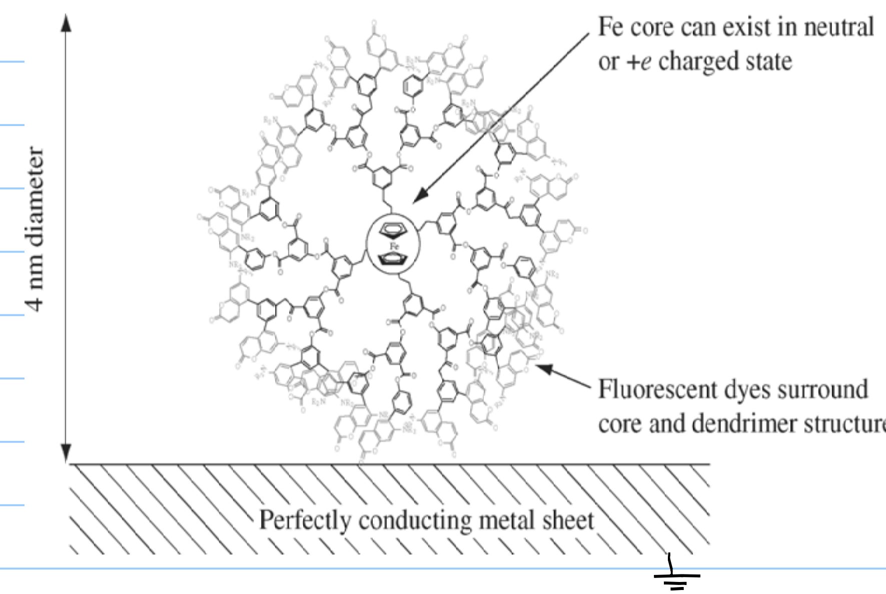
Quantum effect dominate device performance!

All of QM is: $-\frac{\hbar^2}{2m}\nabla^2\psi + V\psi = i\hbar\frac{\partial\psi}{\partial t}$

All we need to learn is how to approximate! to simplify our problem.

Example 3: Suppose a chemist has made this spherical dendrimer. The core is an active redox molecule, Fe^+ (Iron). calculate the force on the Fe^+ ion.

(Assume $d = 4\,nm$, $\epsilon_r = 2$)



Use the symmetry to simplify the problem:

$$F = \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{-e^2}{r^2} \quad (r = 2d)$$

$$= -7.2 \times 10^{-12}\ N \quad \text{(very small)}$$

↓

negative sign for attractive force