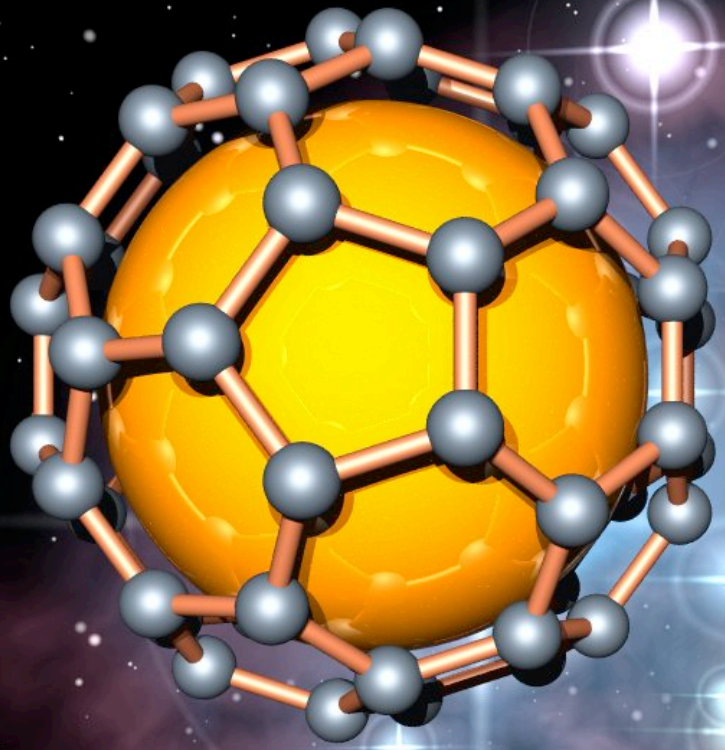
Welkom to COSMOS!



Chemistry at the Space-Time Limit

COSMOS UCI, summer 2007

Structure

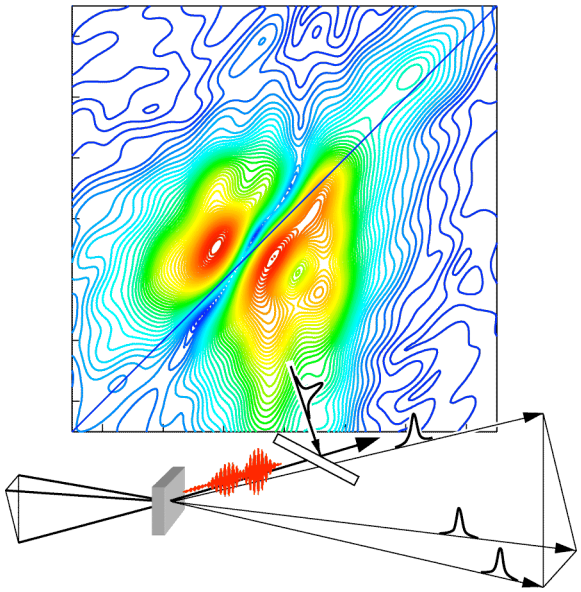
hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
7- 8:30	breakfast	breakfast	breakfast	breakfast	breakfast		
9:00- 10:15	Lecture 1	Lab/field	Lecture 1	Lab/field	Lecture 1		
10:30- 11:15	Lecture 2		Lecture 2		Lecture 2		
	lunch	lunch	lunch	lunch	lunch		
1:15- 2:30	Sci. Comm	Lab/field	Sci. Comm	Lab/field	Sci. Comm		
3:00- 5:00	Special	Project	Special	Project	Special		
5:00- 6:30	dinner	dinner	dinner	dinner	dinner		

groups

Group 1	Group 2	Group 3	Group 4
Ahmed Afifi	Magali Barba	Stephanie Chan	Ji Seok Choi
Andrew Glidden	Julie Han	Peter Han	Levey Hao
Yuskuke Harada	Jasmine Harris	Steven Lin	Bianca Manzano
Jiten Mehta	Brian Moon	Amisha Patel	Danielle Crumley
Gil Tabak	Brian Toms		

Instructors

Prof. Nien-Hui Ge



2D IR spectroscopy

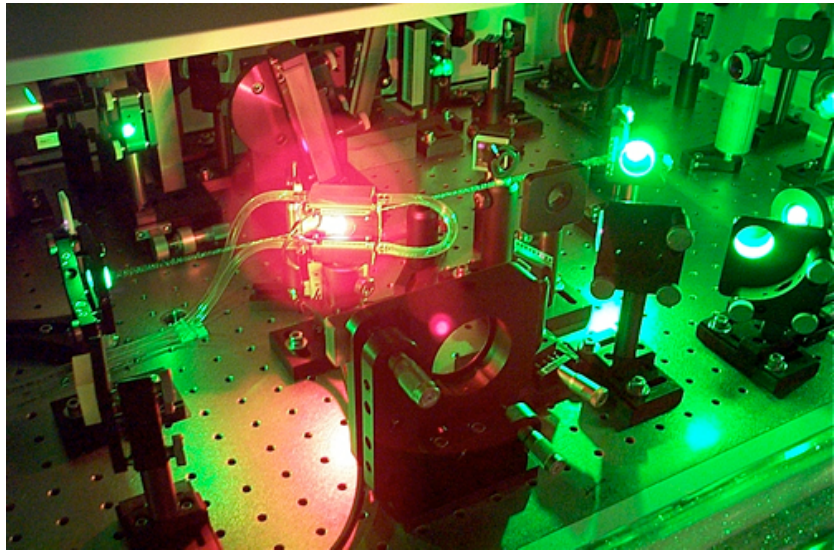
When Atoms Meet

Understanding the Covalent Bond

Bonding in Solids

Instructors

Prof. Ara Apkarian



Ultrafast Molecular Spectroscopy

Lasers
Pulses of Light
Fast Photography

Instructors

Prof. Shaul Mukamel

Nonlinear Spectroscopy

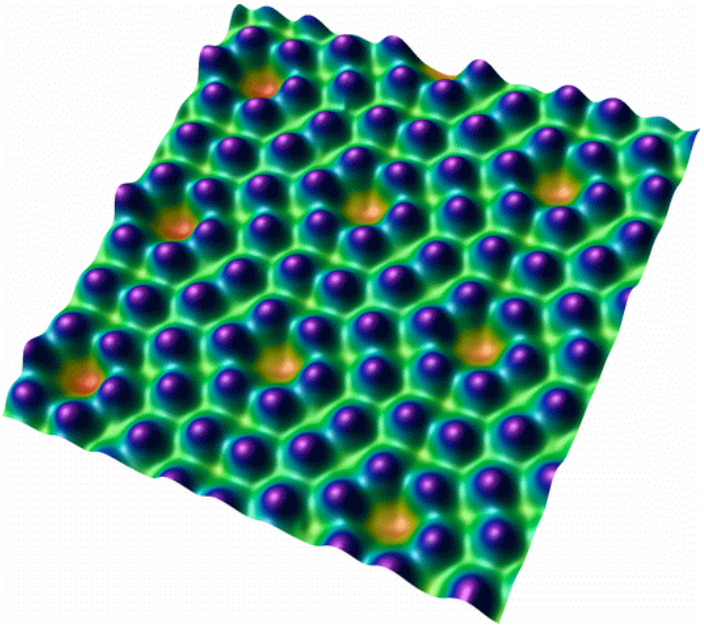
Light and Matter: Absorption and Emission

Molecular Spectroscopy

Multiphoton Spectroscopy

Instructors

Prof. Wilson Ho



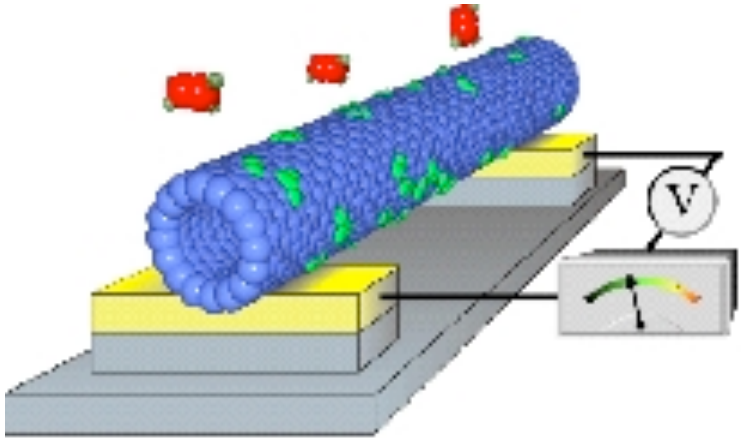
Scanning Tunneling Microscopy

Seeing Single Molecules

Lasers and Microscopes

Instructors

Prof. Phillip Collins



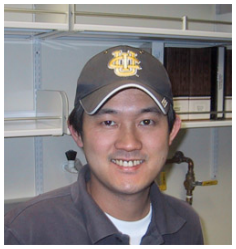
Nanoscopic Devices

More than One, less than a Mole

Access to the Nanoworld

Nanoscience vs. Nanotechnology

Lab sessions



Min Kim

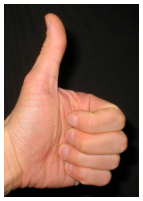
Lab 1: Infrared Fourier Transform Spectroscopy

Hrant Seferyan

Lab 2: The Nature of Light

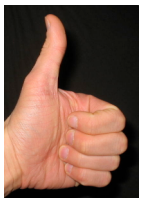
Max Zimmerley

Lab 3: Two-photon Microscopic Imaging



Danny Wan

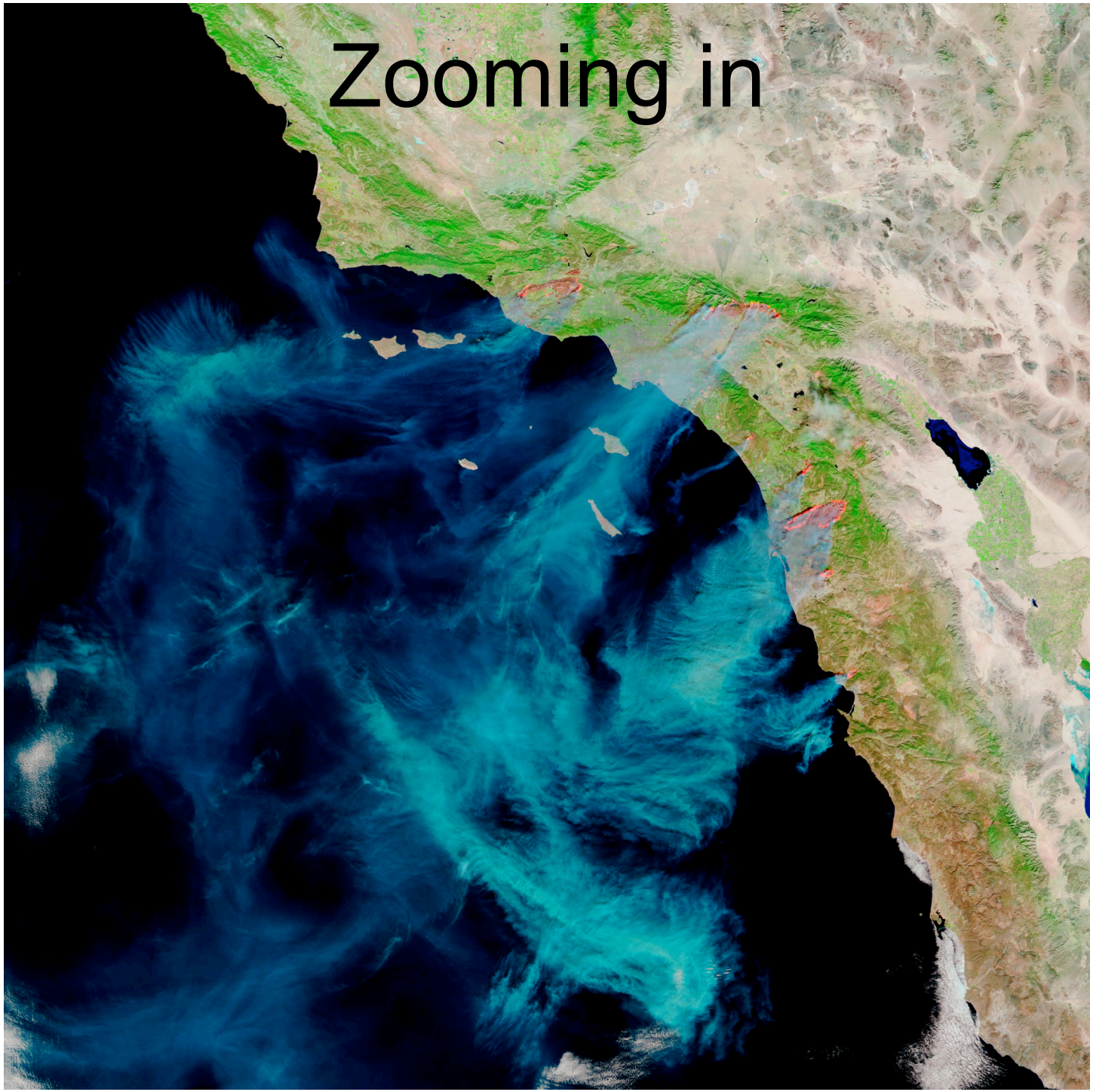
Lab 4: Imaging at the Nanoscale



Wendong Xing

Lab 5: Millikan Oil Drop Experiment

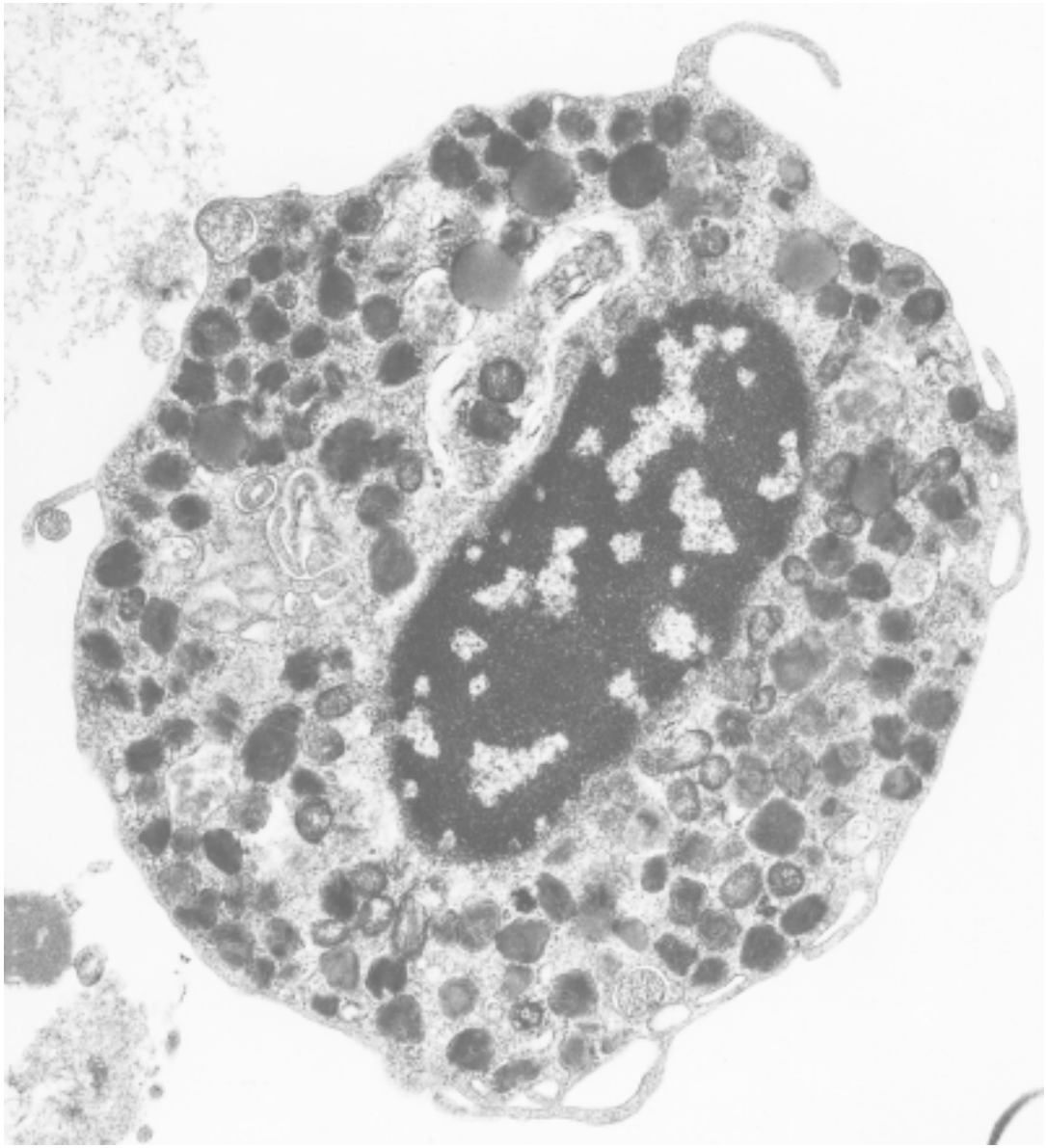
What is matter?


Zooming in

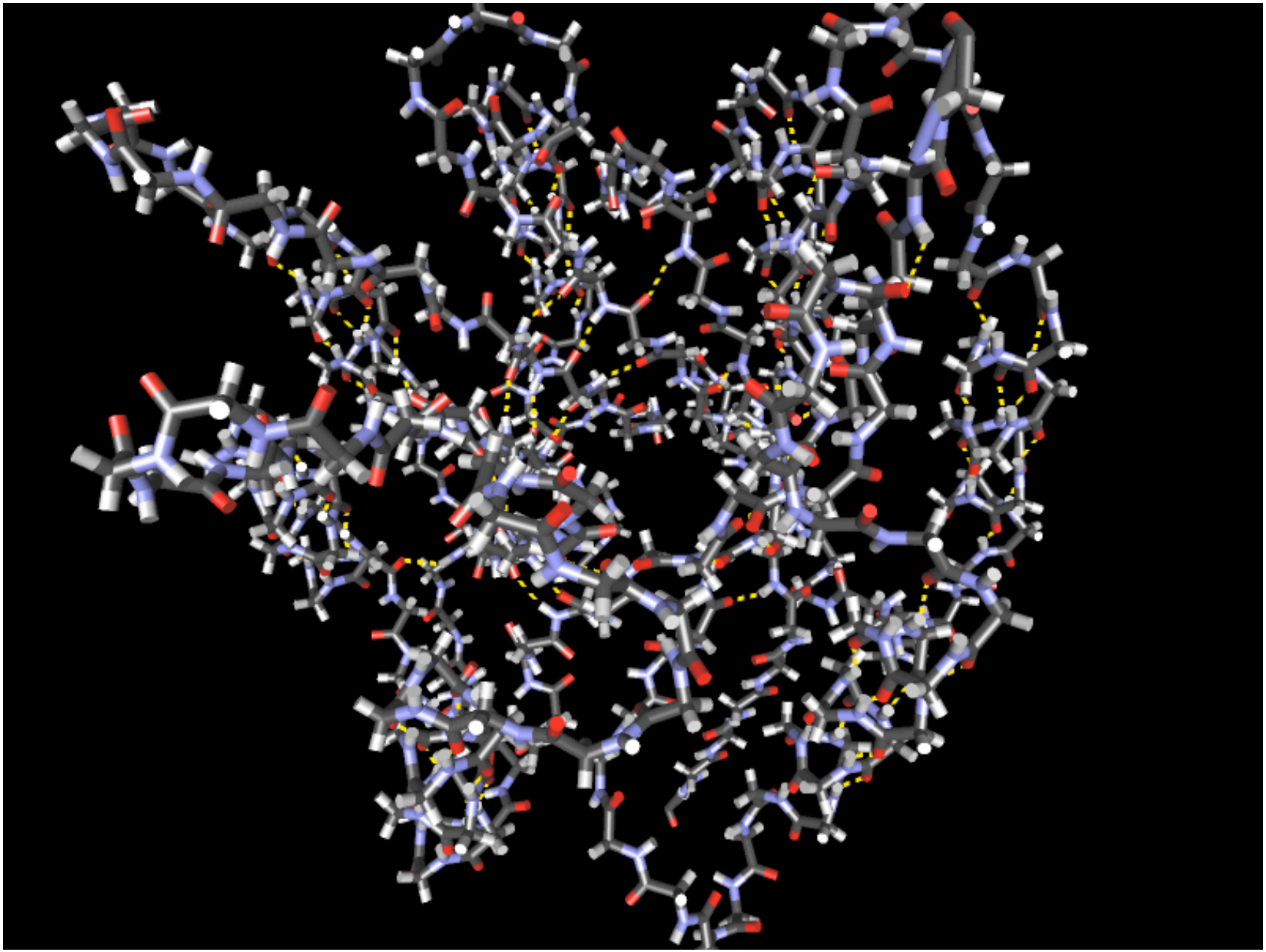
Zooming in

Zooming in

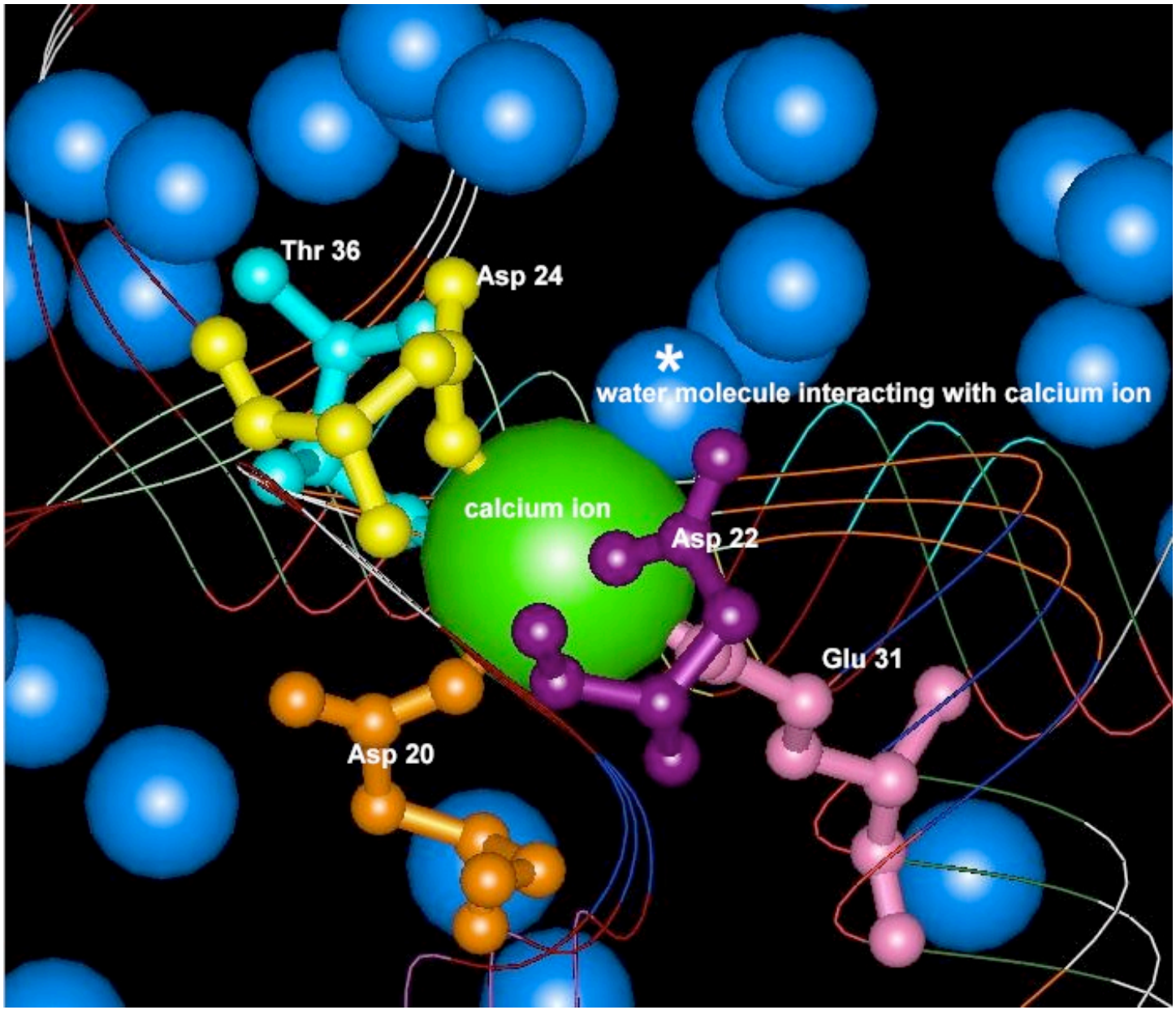
Zooming in



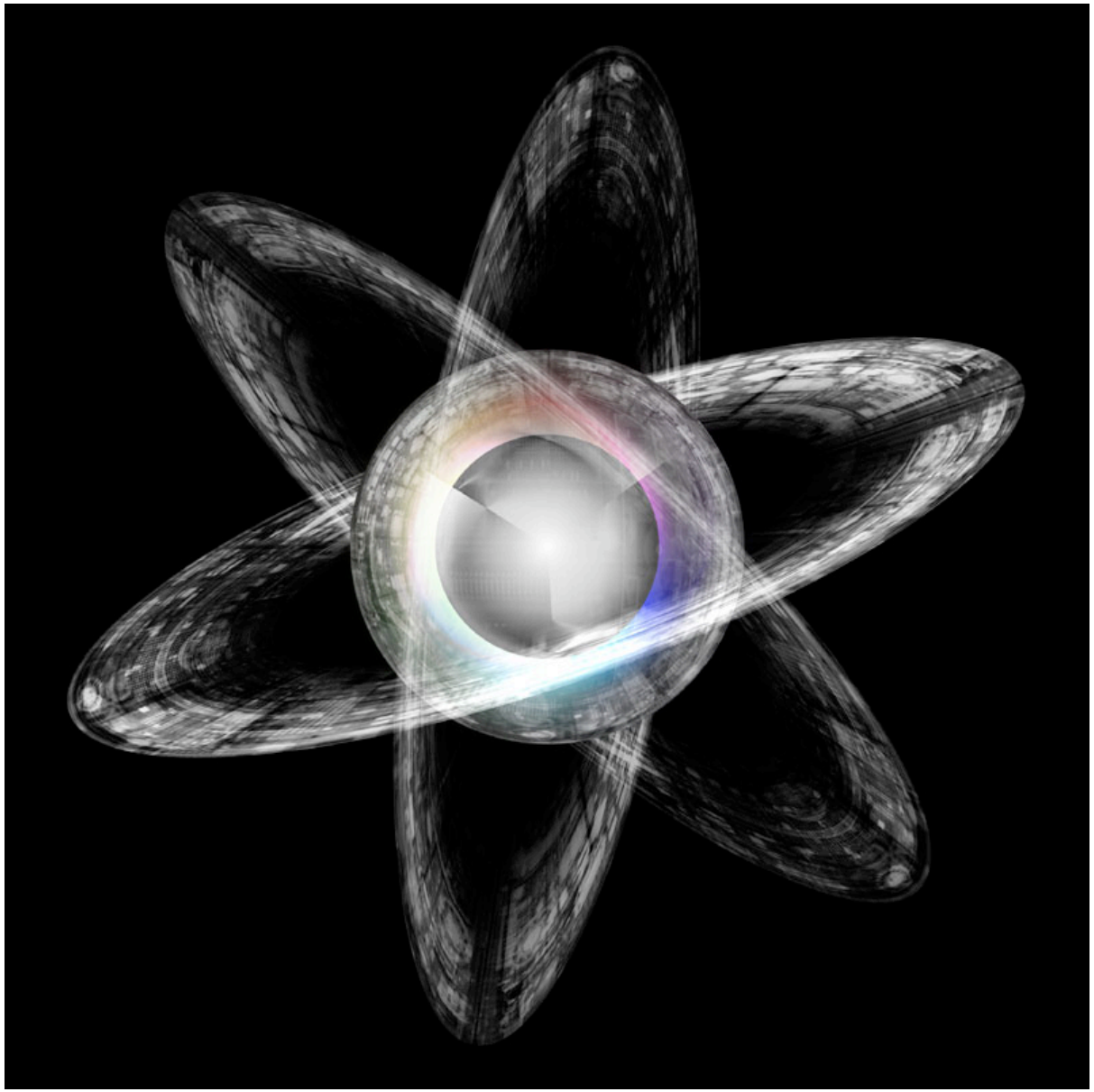
The world is made of molecules



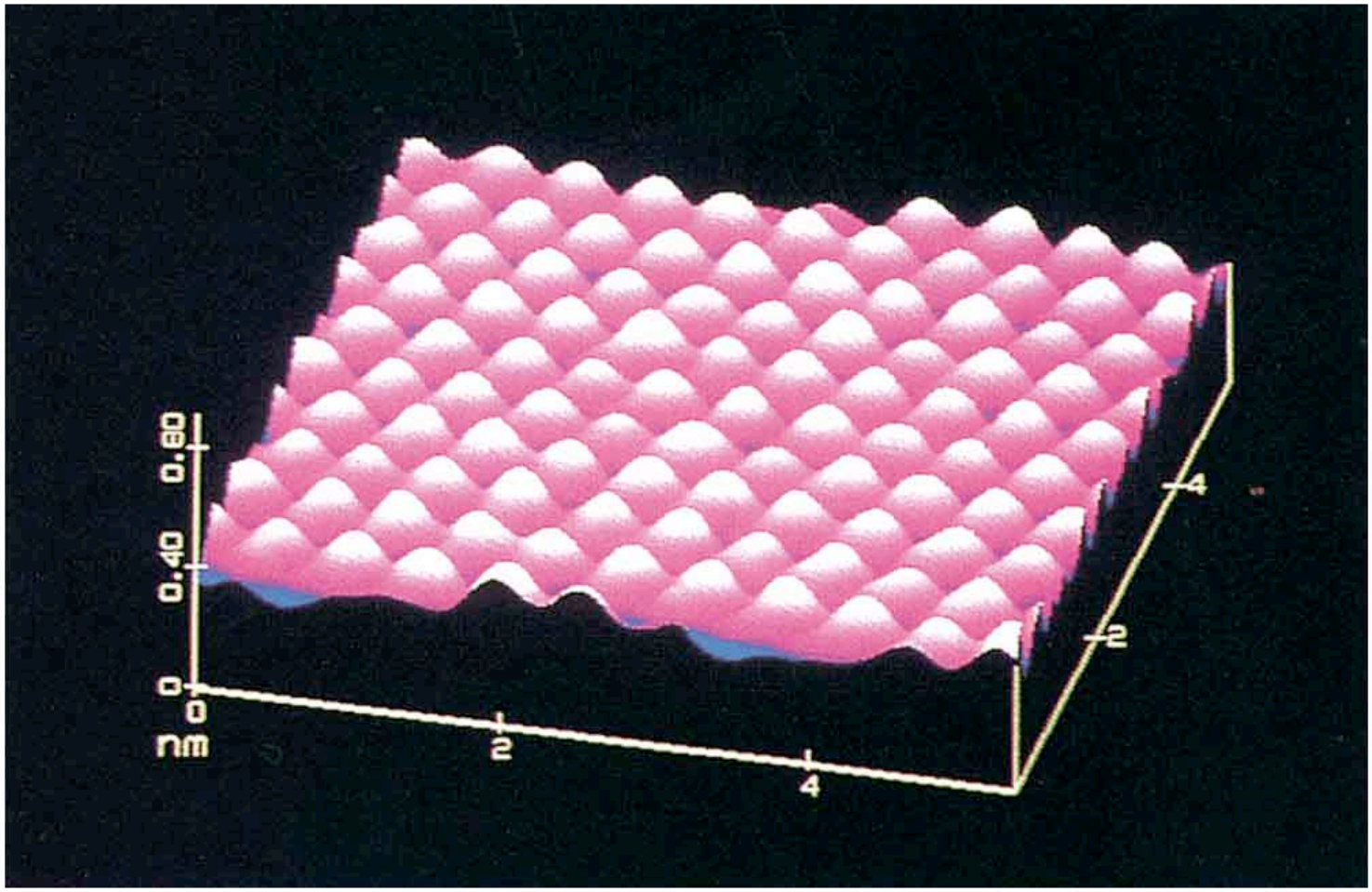
Molecules are made of atoms



Atom



Atoms are real

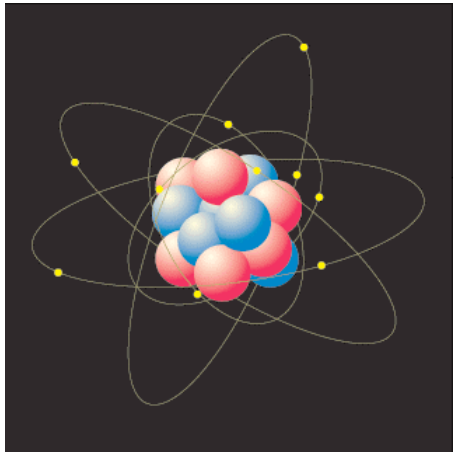


Sodium chloride crystal lattice

Atoms are small

0.5 mm (5×10^{-4} m) ~ 1/50 ”

10 million times



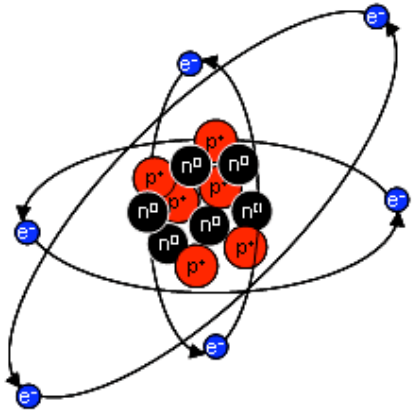
50 pm (5×10^{-11} m)

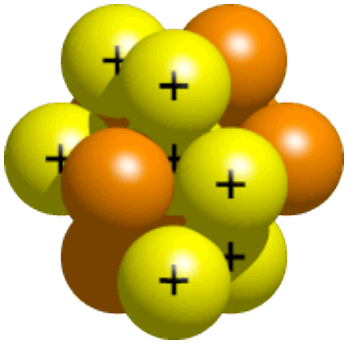
13×10^{5} m ~ 8×10^{3} mi

10 million times

~10 cm

Atoms have tiny masses



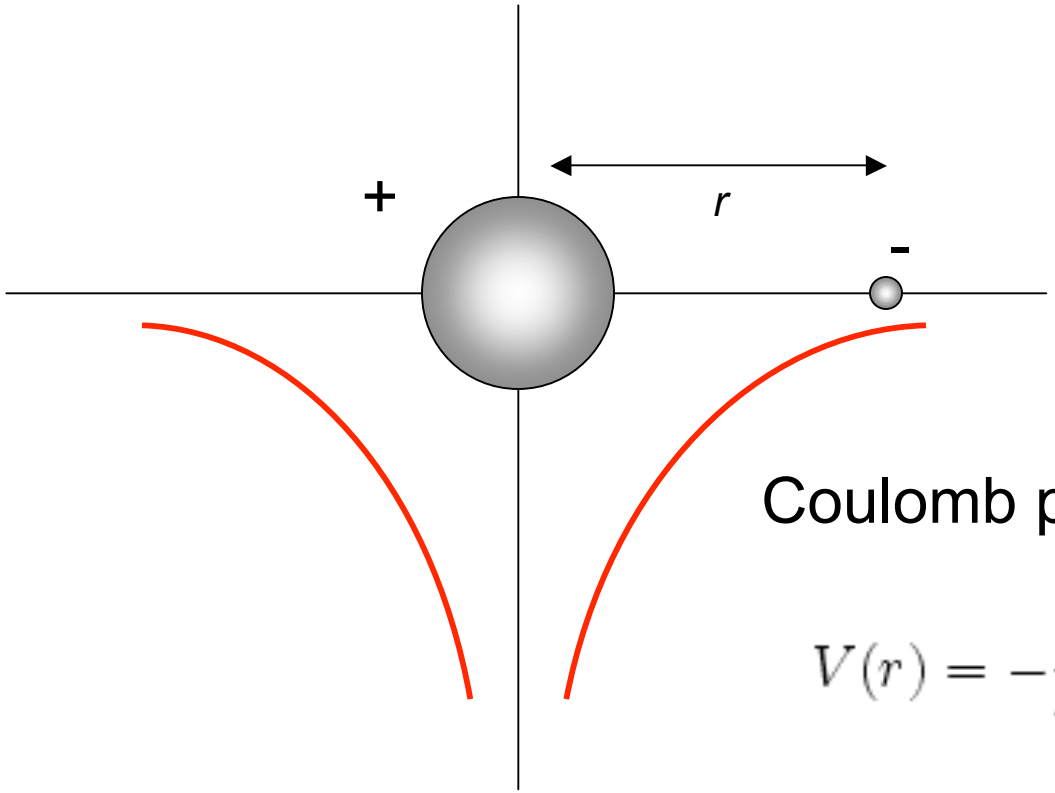


Proton (charge 1+): $m_p = 1.672 \times 10^{-27}$ kg

Neutron (charge 0): $m_n = 1.674 \times 10^{-27}$ kg

Electron (charge 1-): $m_e = 9.109 \times 10^{-31}$ kg

Why the Atom stays together



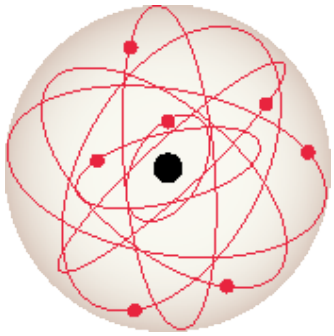
Coulomb potential

$$V(r) = -\frac{e^2}{4\pi\epsilon_0}\frac{1}{r}$$

There is an attractive force between the electron and the nucleus

$$F = -\frac{dV(r)}{dr}$$

The World of Atoms



Atoms are extremely small

Protons, neutrons and electrons are extremely light

Electrons are confined to the vicinity of the nucleus

How do electrons move around the atom?

What Newton predicts

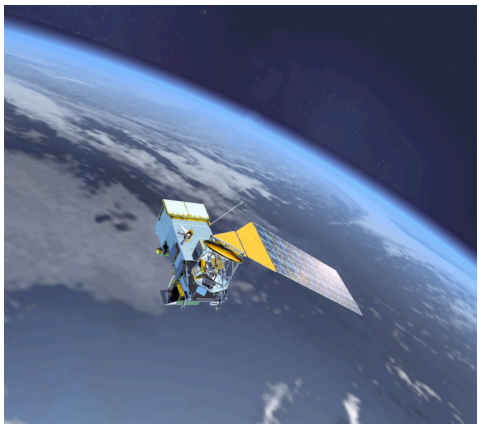
Sir Isaac Newton
(1642-1727)

Motion of object can be precisely calculated from a set of observables:

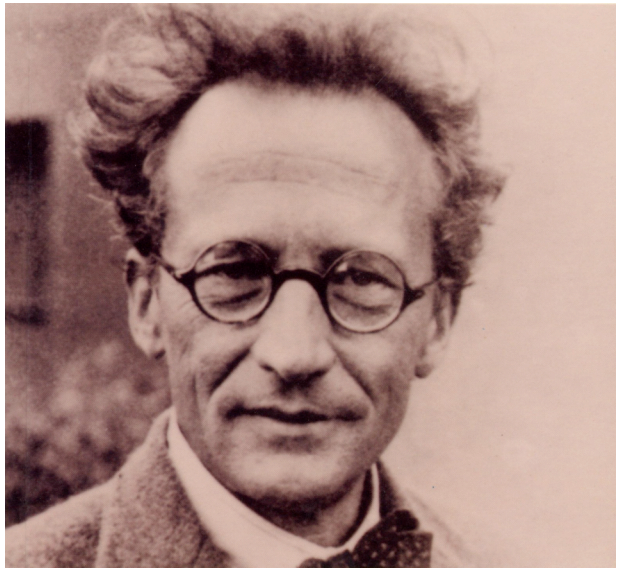
x - position of object

v - velocity of object

E - energy of object

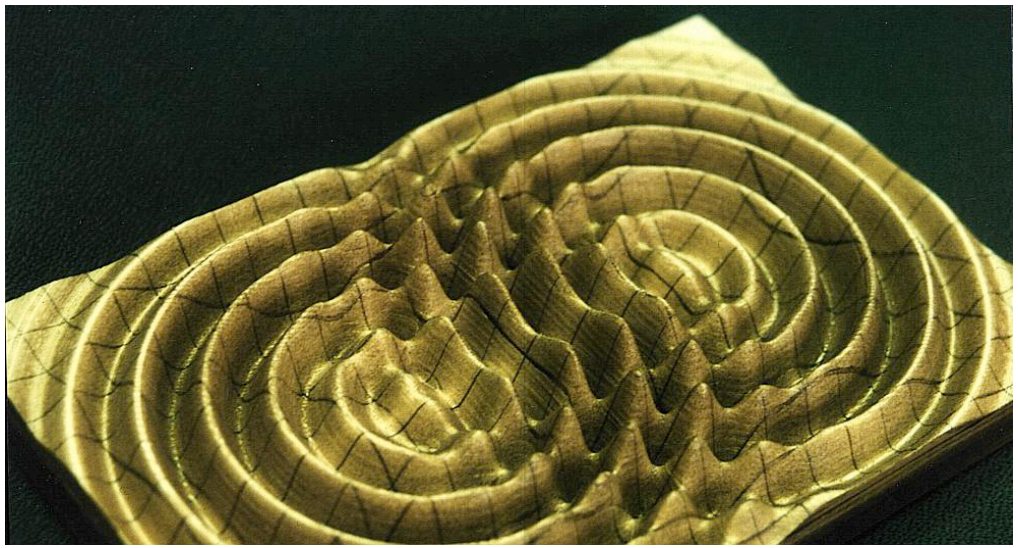


What Schrödinger says



Erwin Schrödinger (1887-1961)

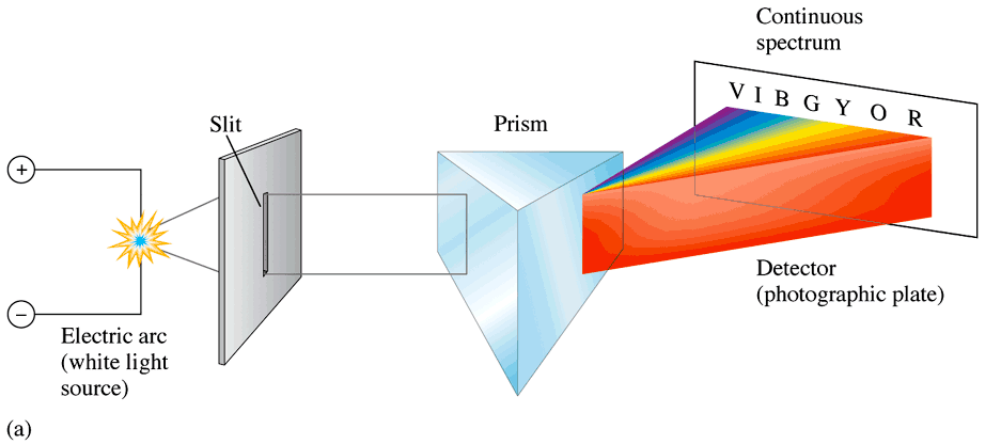
Position, v and E of very small object can not have any random value.



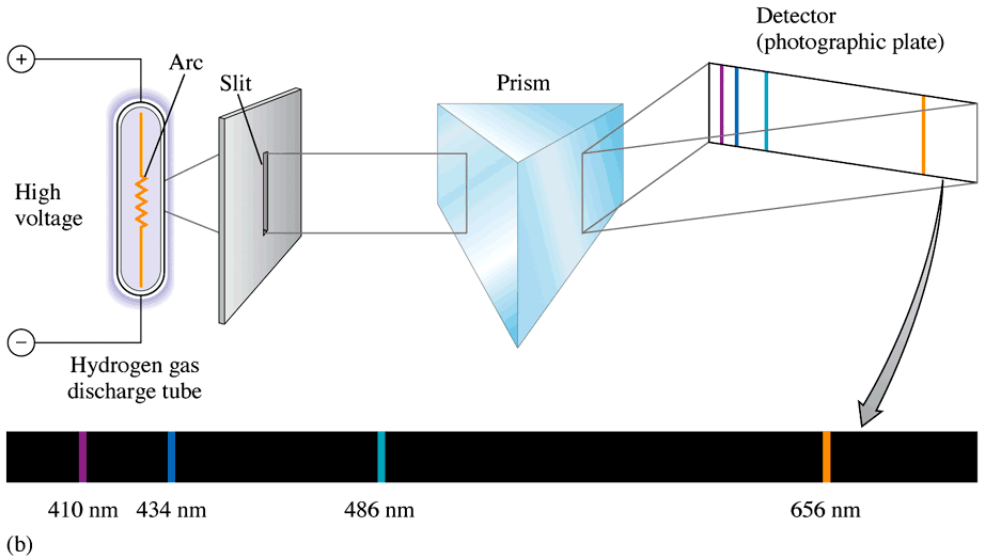
Small particles behave like waves!

Observables have only certain *discrete* values

Who's right?



White light passing through a prism produces a continuous spectrum.

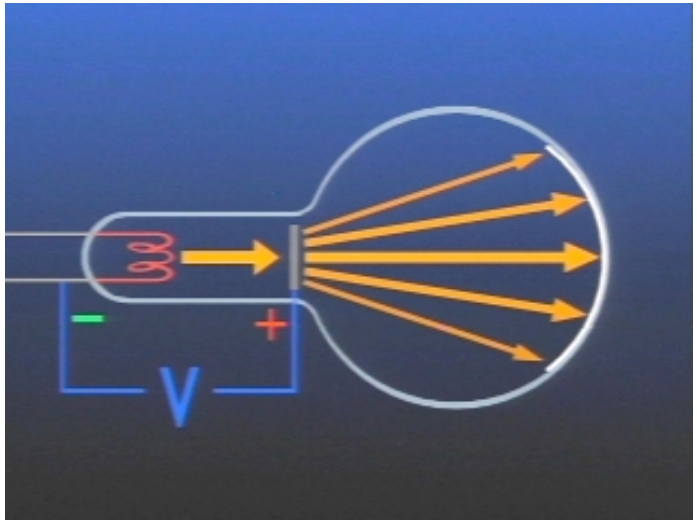


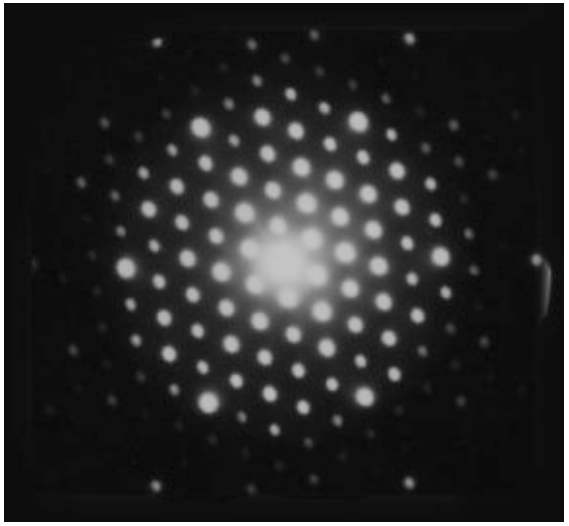
Hydrogen gas exposed to an electric discharge gives a line spectrum.

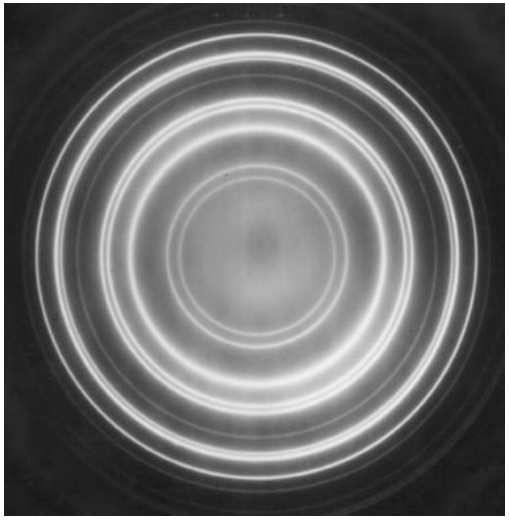
Who's right?

Electrons are particles with a rest mass of $m_e = 9.109 \times 10^{-31}$ kg

Do they also behave like waves?

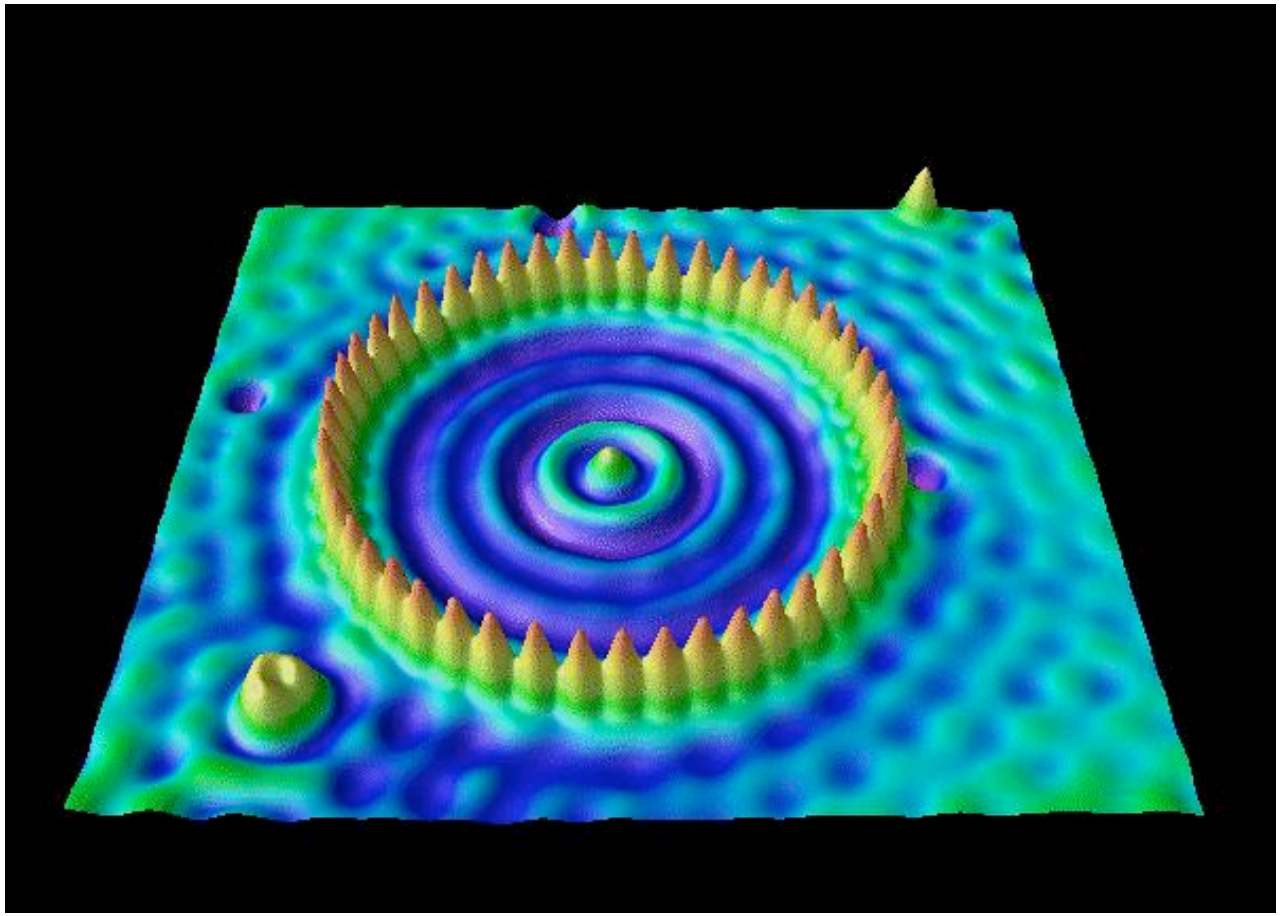






Looks like the pattern that a wave would make!

Who's right?



Electrons confined to a circular well

Schrödinger wins first prize!

Newton: 2nd prize

Electrons, protons, atoms have wave-like properties

The world of atoms is described through *Quantum Mechanics*

Math tools

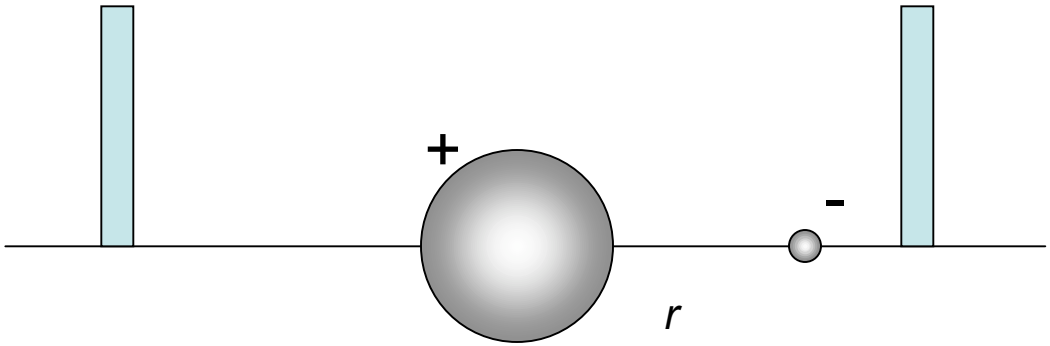
Newton: $f(r,t)$ x ⟶ v, E etc.

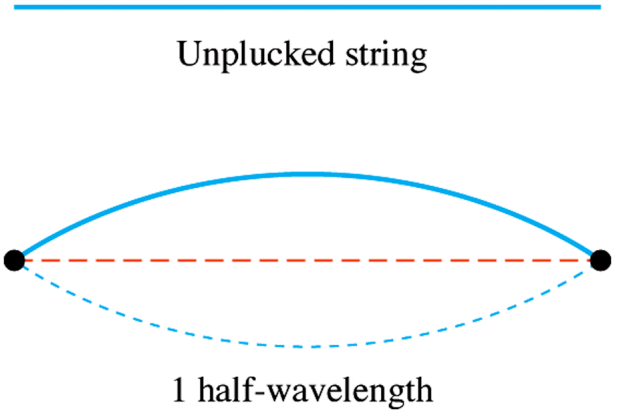
Quantum: $\Psi(r,t)$ ⟶ x, v, E etc.

The shape of the wavefunction can be obtained from the Schrödinger equation:

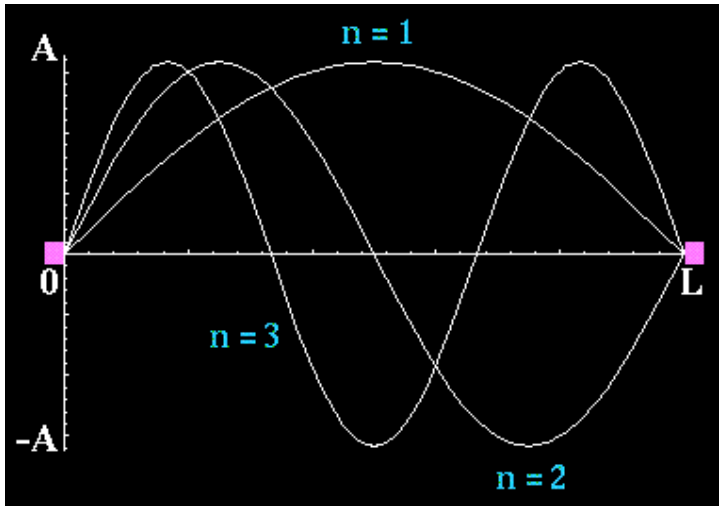
$$-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\Psi(r,t) = E\Psi(r,t)$$

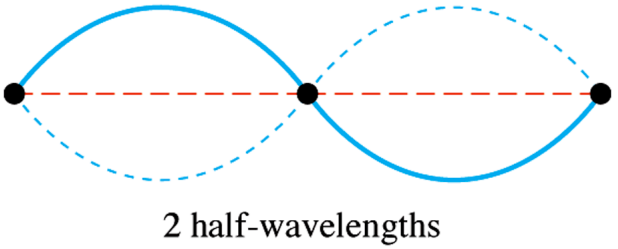
Wave properties

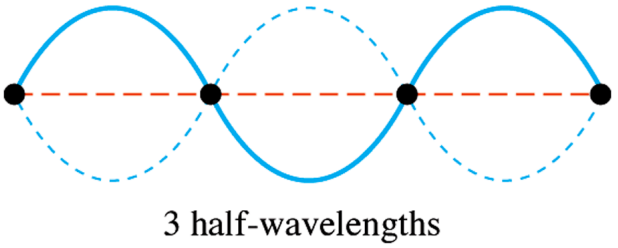




The electron bound to the atom looks like a standing wave.

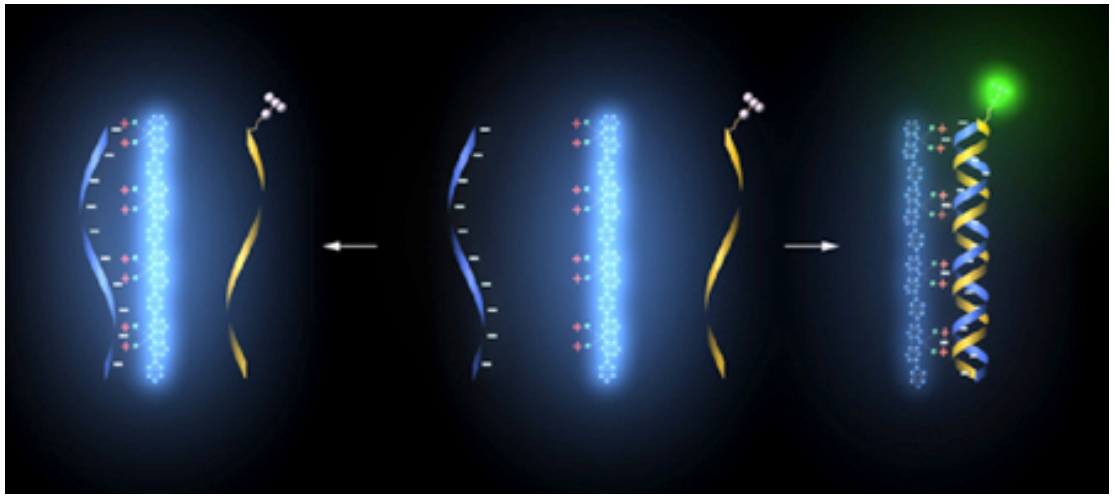






Instructors

Prof. Gui Bazan



Molecular Sensors

Molecules, Light and Solar Cells