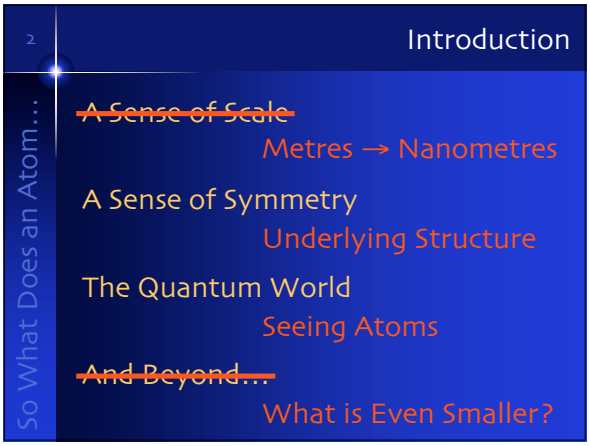
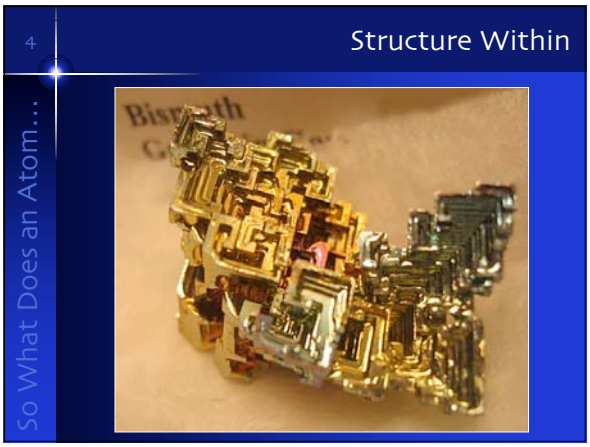
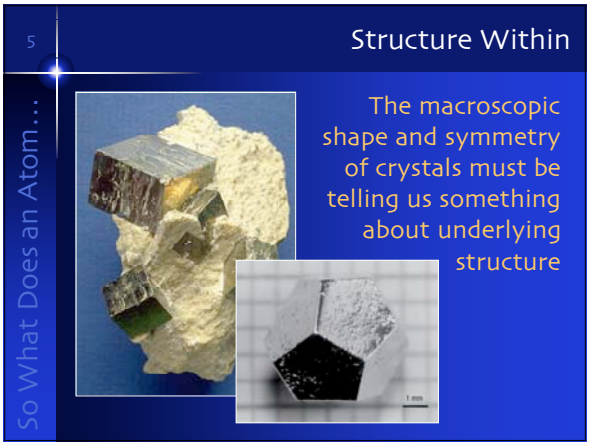
So What Does An Atom Look Like?







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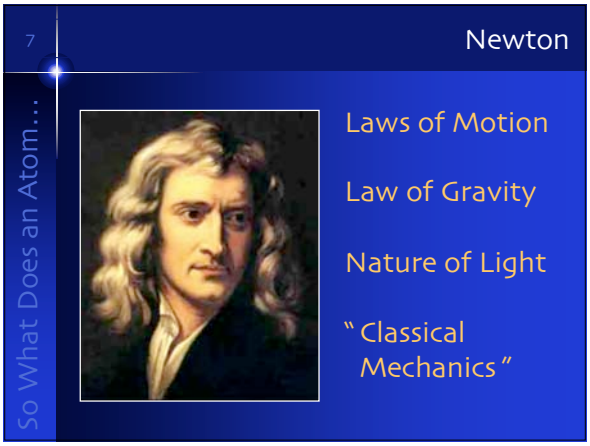

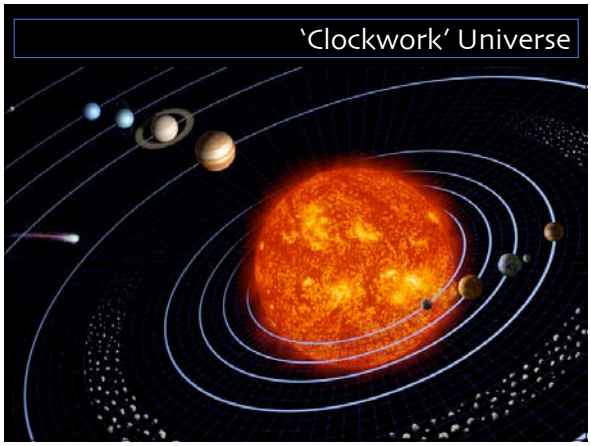

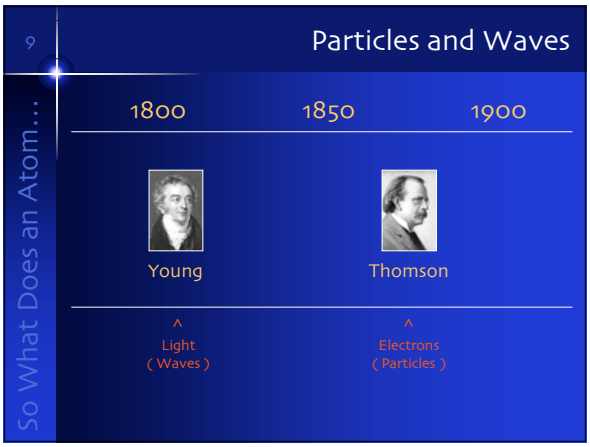

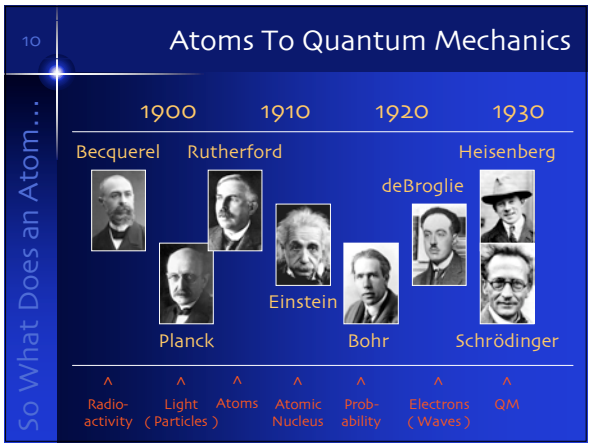

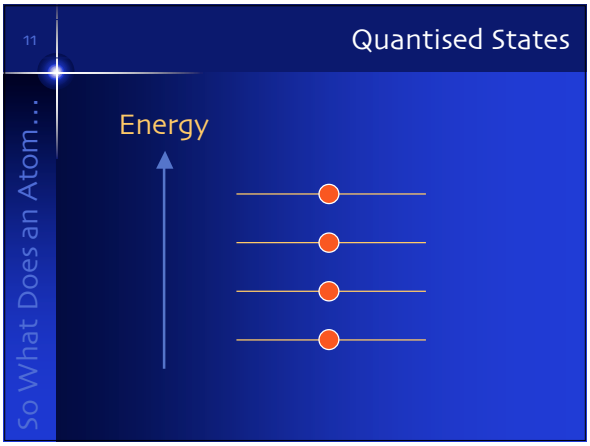

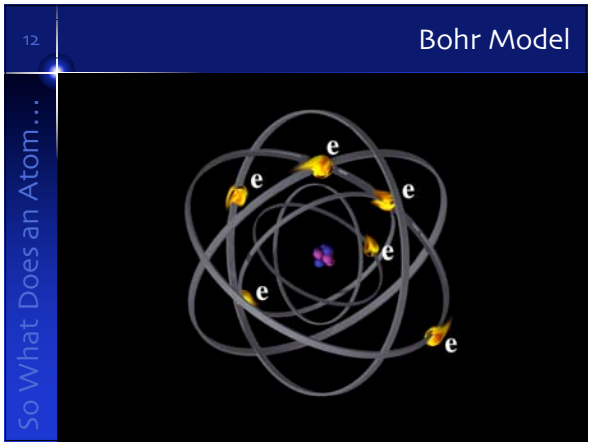

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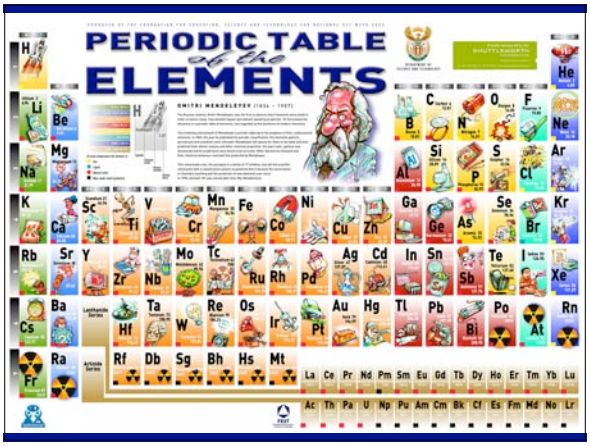
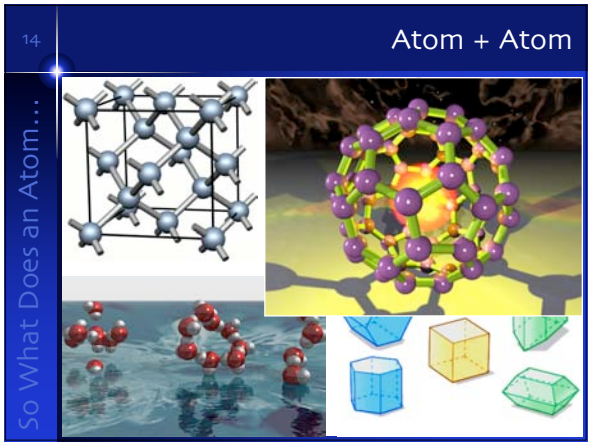
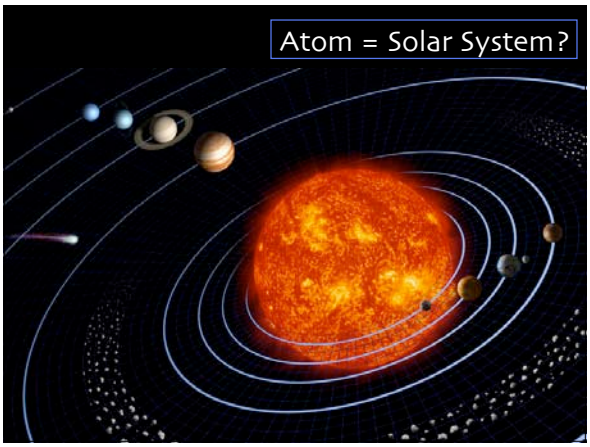
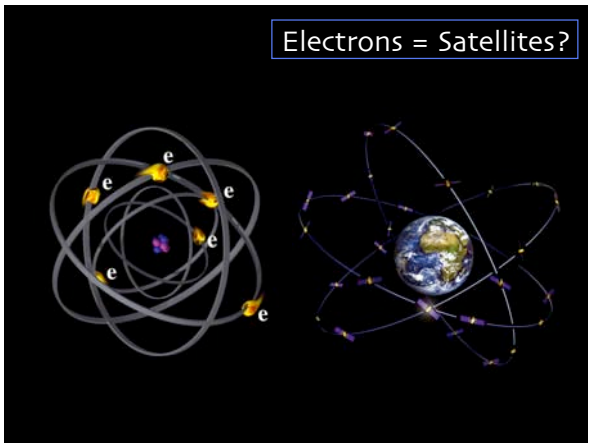
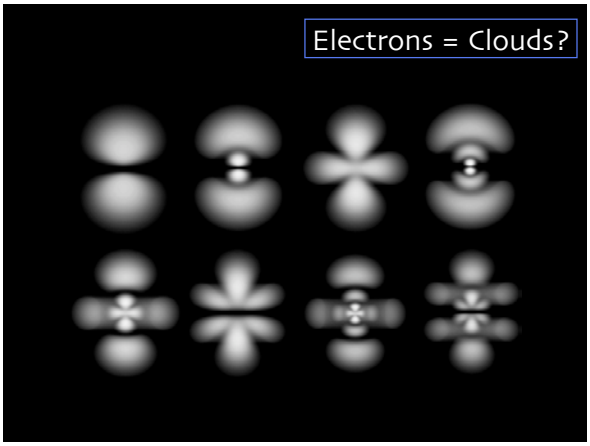
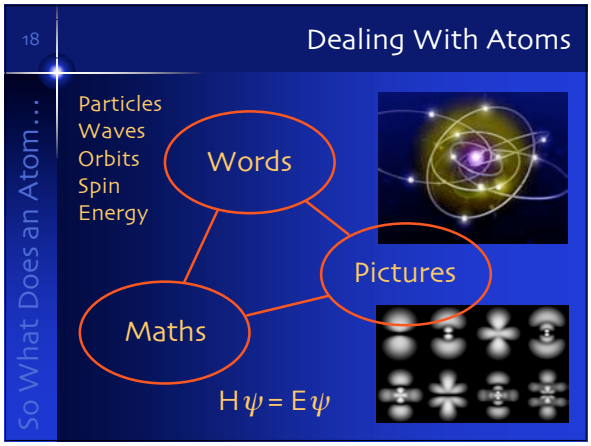












So What Does An Atom Look Like?

19 Heisenberg

So What Does an Atom…

"We wish to talk about the structure of atoms. But we cannot talk about atoms in ordinary language"

20 Dealing With Atoms

So What Does an Atom…

Would it be better to use words that don't carry any 'baggage', or preconceptions?

Rather than say…

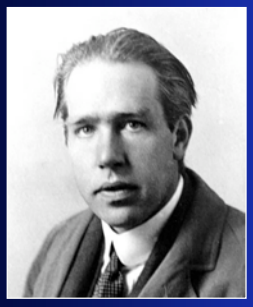
"The electrons orbit and spin in the atom"

Would it be better to say…

"The slithy toves did gyre and gimbal in the wabe"

21 Bohr

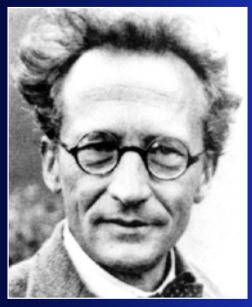
So What Does an Atom…



"Everything we call real is made of things that cannot be regarded as real"

22 Schrödinger

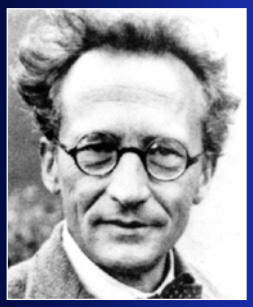
So What Does an Atom…



"Atomic physics has shown that atoms have no meaning, but can only be understood in experimental measurement"

23 Schrödinger

So What Does an Atom…



"I don't like it, and I'm sorry I ever had anything to do with it"

24 QM vs Common Sense

So What Does an Atom…

Atoms (indeed, all particles) are unpredictable

We can know ***only*** the ***probability*** of an atom having a particular position, speed, energy, …

Atoms do not have a finite size

Electron 'in' an atom could be ***anywhere***

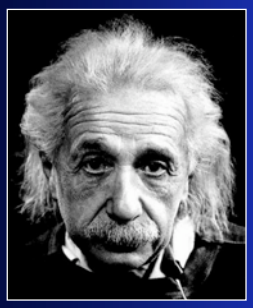
Atoms can be in two states at the same time

Electron 'spin' can be ***simultaneously*** clockwise and anticlockwise

So What Does An Atom Look Like?

25 Einstein

So What Does an Atom…



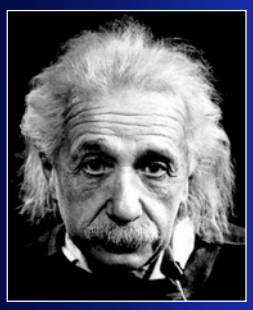
"Common sense is the collection of prejudices acquired by age eighteen"

26 Heads or Tails?

So What Does an Atom…

27 Einstein

So What Does an Atom…



"God does not play dice"

"God is subtle but he is not malicious"

28 Three Aspects of QM

So What Does an Atom…

- Order matters
- ~~Schrödinger's Cat~~
- Using QM to see atoms

29 Order Matters

So What Does an Atom…

In algebra

$$A \times B = B \times A$$

In Quantum Mechanics

$$A \times B \neq B \times A$$

So what?

30 If Order Matters

So What Does an Atom…

Top pair : carnivores

Bottom pair : veggies

Left pair : 4 legs

Right pair : wings

So What Does An Atom Look Like?

31 So What Does an Atom…

If Order Matters

Pick 2 out of the 4

For instance, pick the **veggie** animals

From these, pick again

For instance, pick the **4-legged** animals

You're left with waterbuck **and** lion!

32 So What Does an Atom…

If Order Matters

If we had picked in a different order…

First pick the **4-legged** animals

Then from these pick the **veggie** animals

You're left with waterbuck **and** roller!

33 So What Does an Atom…

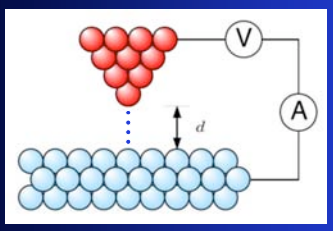
QM and Dogs

"Ohhh, look at that… dogs are so cute when they try to comprehend quantum mechanics"

34 So What Does an Atom…

Scanning Tunnelling Microscope

Sharp tip



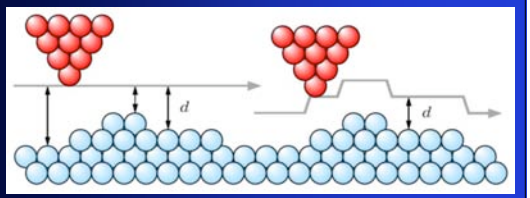
Current flows

Sample

35 So What Does an Atom…

STM

Move tip across sample…



…measuring current at each point

36 So What Does an Atom…

Surface Science

The STM is sealed inside an ultra-high vacuum vessel (10^{-13} atms) to keep it and the sample surface clean.

So What Does An Atom Look Like?