Lecture 24

Thurs: Seminar Wubben 218, 12:30pm

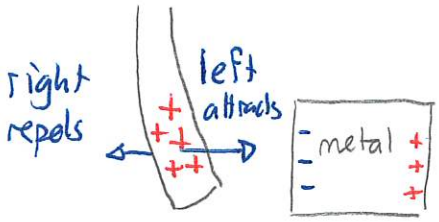
Fri: 8.3

Mon: HW by 5pm

- Note video search – must be Electricity / Magnetism
  – several questions in HW assignment related to this.

Electric Charges and Matter

The fact that charged tape is attracted to apparently neutral objects can be explained by polarization of material.
This means that all material contains charged particles.



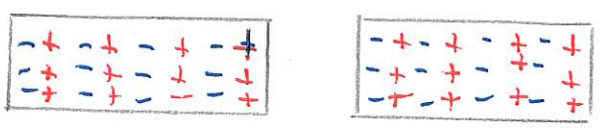
DEMO: Tape

We can then consider the possibility of otherwise neutral objects exerting electric forces on each other.

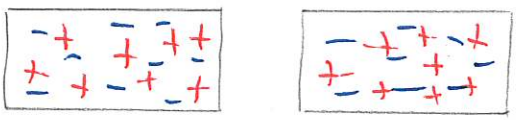
Quiz 1 80%

Quiz 2

This illustrates how two objects that contain charge could exert no forces on each other



In a regular arrangement with very many charges almost all forces cancel



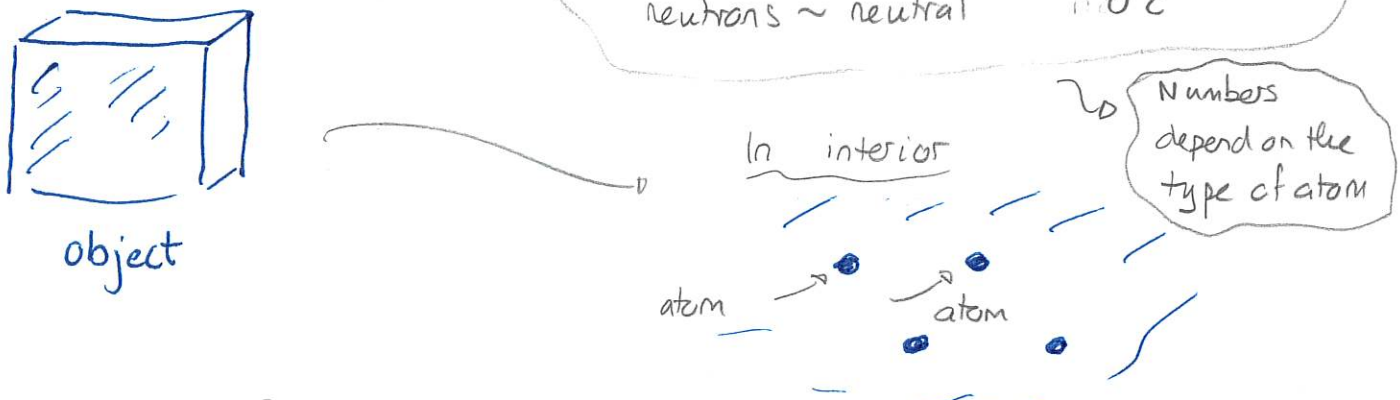
In a random arrangement all forces cancel

Electric forces and atoms

Where do the charges and electric forces in matter come from. The main idea is

All ordinary matter consists of atoms → All atoms consist of the same types of charged particles:

electrons ~	negative	-1.6×10^{-19} C
protons ~	positive	$+1.6 \times 10^{-19}$ C
neutrons ~	neutral	0 C



Thus the origin of charge in ordinary matter arises from the subatomic particles within the matter.

Quiz 3

The normal interactions between ordinary matter are also the result of the presence of these charged subatomic particles.

We can now ask: "Within a given atom, how are the subatomic particles arranged?" Various models for this existed from the time of the discovery of electrons (by J.J. Thomson, 1897)

DEMO: PhET Rutherford Scattering
- Plum Pudding Model.

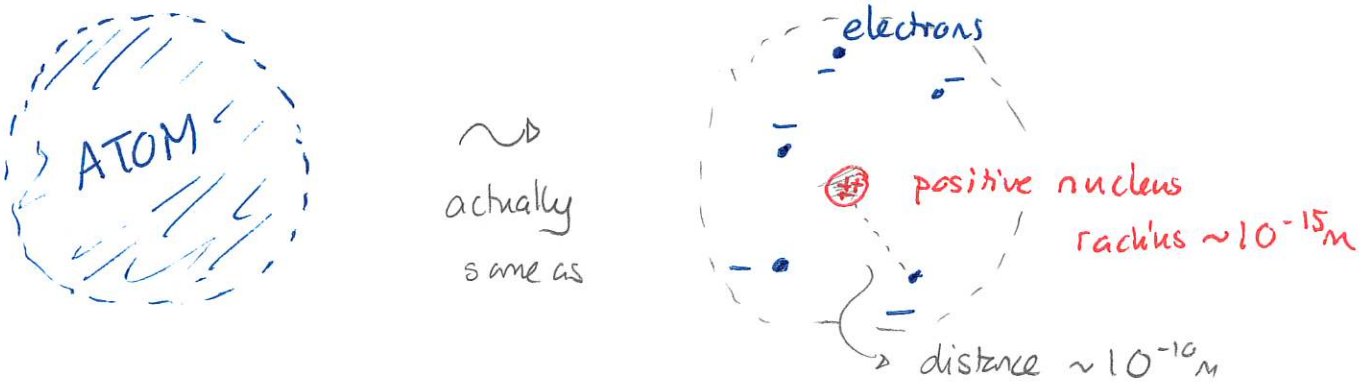
One could investigate such models by bombarding the atom/matter with high energy subatomic particles. This was done in a series of experiments by Ernest Rutherford (done 1910-11) and compared to the predictions of models.

DEMO: PhET RS- plum pudding model with α-particles

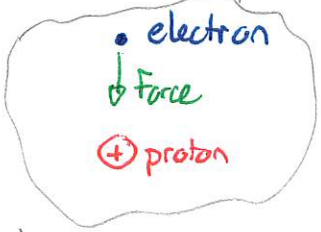
- Rutherford Atom

Rutherford's experiments support a model of the atom where

* the bulk of the mass and all the positive charge resided in a very small central region (nucleus)
* the electrons were on the periphery of the atom and they were extremely light compared to the rest of the atom
* most of the atom is empty space

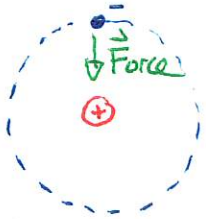


We should then be able to explain how the atom works in terms of electric forces. The simplest such atom is the hydrogen atom which consists of one proton and one electron.

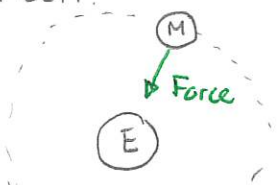


Hydrogen

Electric force keeps electron orbiting in a circle



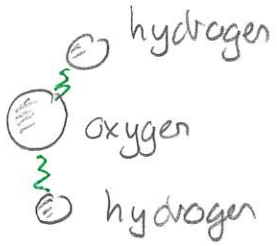
The inward force on the electron is similar to the inward force Earth exerts on Moon.



Force keeps Moon orbiting in a circle.

Then such electric forces might explain:

* how an individual atom stays stable and functions
* how multiple atoms interact to form molecules, e.g. water



various electric forces keep molecule intact.

2 Sodium and chlorine atoms and ions

The chemical element sodium, one of the constituents of table salt, is a highly reactive metal. A single sodium atom contains of 11 protons, 12 neutrons and electrons. The chemical element chlorine, the other constituent of table salt, is a highly reactive toxic gas. A single chlorine atom contains 17 protons, 18 neutrons and electrons.

a) How many electrons does a neutral sodium atom contain?

b) How many electrons does a neutral chlorine atom contain?

c) Suppose that two neutral sodium atoms are held near each other. Will they attract or repel each other?

An ion is an atom that has gained or lost electrons.

d) Sodium readily forms ions by losing one electron. Will such an ion be positively or negatively charged or neutral?

e) Chlorine readily forms ions by gaining one electron. Will such an ion be positively or negatively charged or neutral?

f) Consider two such sodium ions. Will they attract or repel each other?

g) Consider two such chlorine ions. Will they attract or repel each other?

h) Consider such a chlorine and sodium ion. Will they attract or repel each other?

i) Imagine trying to assemble a collection of sodium and chlorine ions in a regular arrangement so that the forces that they exert hold them together but prevent them from collapsing. Can you construct such an arrangement?

a) 11 same as protons

b) 17 " " "

c) Neither, they are neutral

d) Positively charged, 11 protons, 10 electrons $\Rightarrow$ charge $+1.6\times10^{-19}$C

e) Negatively " 17 protons, 18 electrons $\Rightarrow$ " -1.6×10^{-19}C

f) Like charges $\Rightarrow$ repel

g) Like " $\Rightarrow$ repel

h) opposite charges attract

i) ⊕ → ⊖ collapses

⊖ ← ⊕ → ⊖ outside ones collapse

zero force

small residual force

⊕ ⊖ ⊕ ⊖ ⊕

zero force

⊖ ⊕ ⊖ ⊕ ⊖ grid

⊕ ⊖ ⊕ ⊖ ⊕

ChemTube 3D