The Quantum Universe

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Abstract

This article aims to demonstrate the fundamental structure and properties of our universe from a microscopic point of view while macroscopic view is a superset including gravitational attraction time-space curvature and other not yet well known forms of space structures, like dark matter, dark energy and exotic matter.
In this subatomic context the structure and behaviour of the most important elementary particles, like hydrogen are exploited.

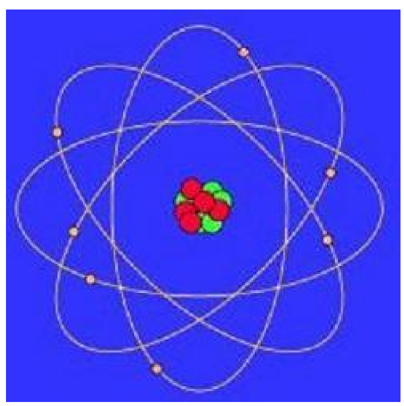


Figure 1: Bohr atom

1 General

The elements have molecules and the molecules have atoms. The basic structure of an atom contains Protons, Newtrons and Electrons.
These particles that exist in every atom of any element explored so far, are called subatomic particles embeded in 2 subatomic structures the nucleous and the electron cloud.
The nucleous contains the protons and the newtrons while the electron cloud

maintains all electrons in orbits. Each electron orbit has a specific energy. This energy depends from the orbital radius.
The smaller radius is the Bohr radius. It is the radius of the one electron of the hydrogen atom around its nucleous and it is a constant, measured ≈ 0.529A[1].
All particles together form a stable atomic system, the atom. Each atom maintains a newtral charge at most, because protonic positive charge is equal to the electronic negative charge. Newtrons have no charge at all. Ionic atoms maintain charge because their electronic negative charge does not balance to their protonic positive charge. The glue that keeps all particles together with electrons orbiting around nucleous inside the atom is the electromagnetic force.

2 Subatomic particles:Quarks

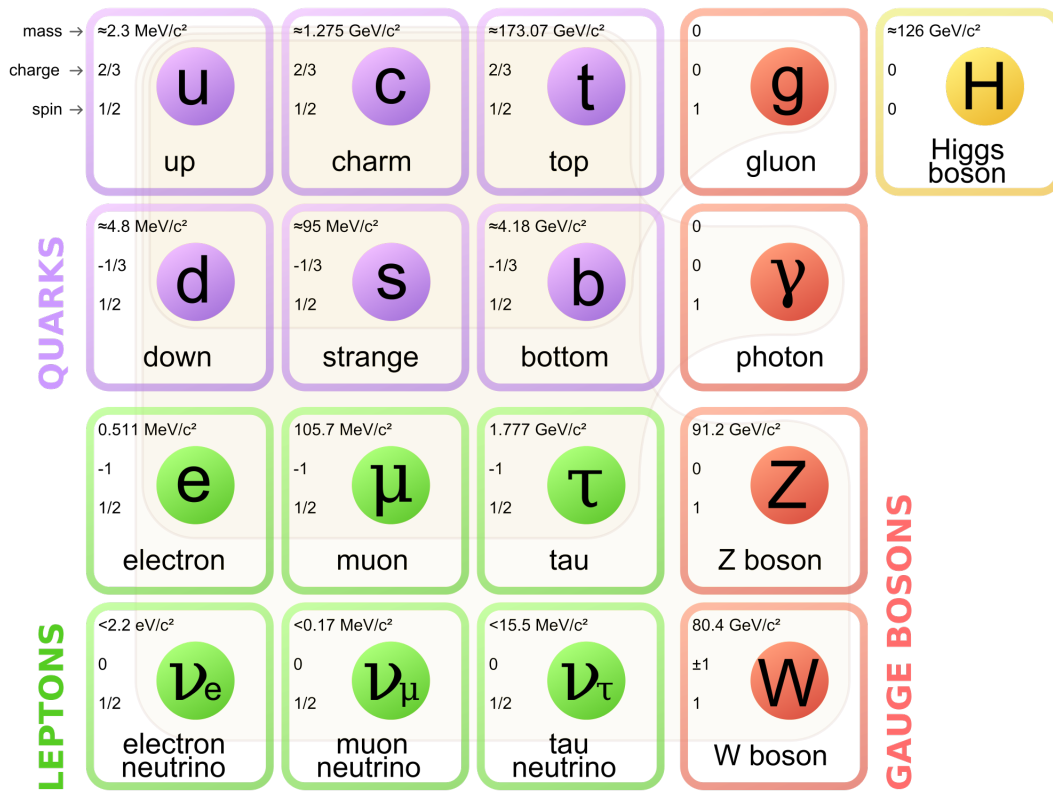


Figure 2: The standard model [4].

[1] 1 A=1 angstrom=0.1 nanometer=0.00001 picometer and so on...

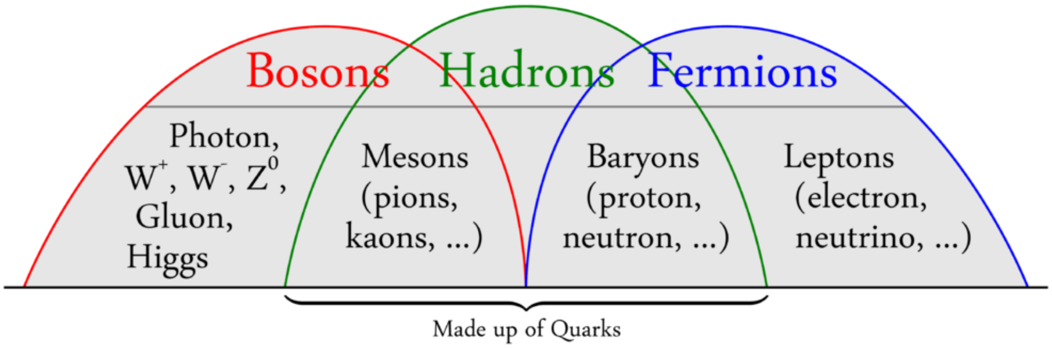


Figure 3: Bosons,hadrons,fermions [5]

The nucleous of the atom includes protons and newtrons joined together by the strong nuclear force. Quarks are elementary particles which reside insidethe nucleous and are the main matter constructors. Quarks are interconnected with energy carriers the gluons. Following standard model quarks are divided in 6 main types. Up,down,charm, strange,top, botton as illustrated in figure 2. Their main characteristics are:mass,charge and spin.
Baryons and leptons are matter constituents part of fermions and hadrons, while bosons are only force carriers and include mesons.
Higgs boson created by the excitation of Higgs field was discovered in 2013 and is responsible for the existence of matter in the universe. Higgs boson trigered new expectations for discovering new particles like dark matter.
Fermions and mesons, Z,W bosons and Higgs boson all have masses from muon neutrino the lightest up to Higgs boson the heavier.Photons and gluons have no equivalent masses.

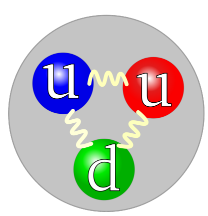


Figure 4: Quarks in a proton [4]

3 Hydrogen

Hydrogen [1] is a chemical element with chemical symbol H and atomic number of 1.
With an atomic weight of 1.00794 u [2], hydrogen is the lightest element on the periodic table.

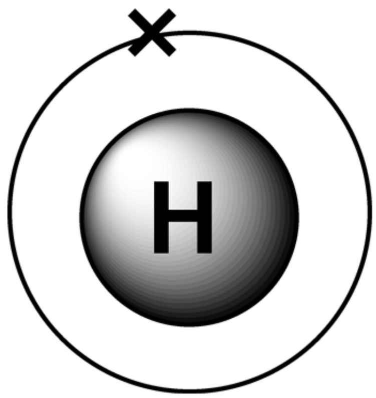


Figure 5: Hydrogen configuration

Its monatomic form (H) is the most abundant chemical substance in the Universe, constituting roughly 75 % of all baryonic mass [3].

3.1 Hydrogen spectral series

Balmier series:

$$\frac{1}{\lambda} = R(\frac{1}{2^2} - \frac{1}{n^2})n = 3, 4... \tag{1}$$

where R is the Rydberg constant:
$R = 1.097 * 10^7 m^{-1}$
and $\lambda = wavelength$
If we want to find energy we can adjust R multiplying by h the Plancks constant and c the speed of light.
$E = \frac{hc}{\lambda}$

[2] Atomic mass unit=1g/mol.
[3] Baryonic mass is the mass of the particles inside the nucleous

The emission spectrum of atomic hydrogen is divided into a number of spectral series, with wavelengths given by the Rydberg formula. These observed spectral lines are due to the electron making transitions between two energy levels in the atom. The classification of the series by the Rydberg formula was important in the development of quantum mechanics. The spectral series are important in astronomical spectroscopy for detecting the presence of hydrogen and calculating red shifts.[3]

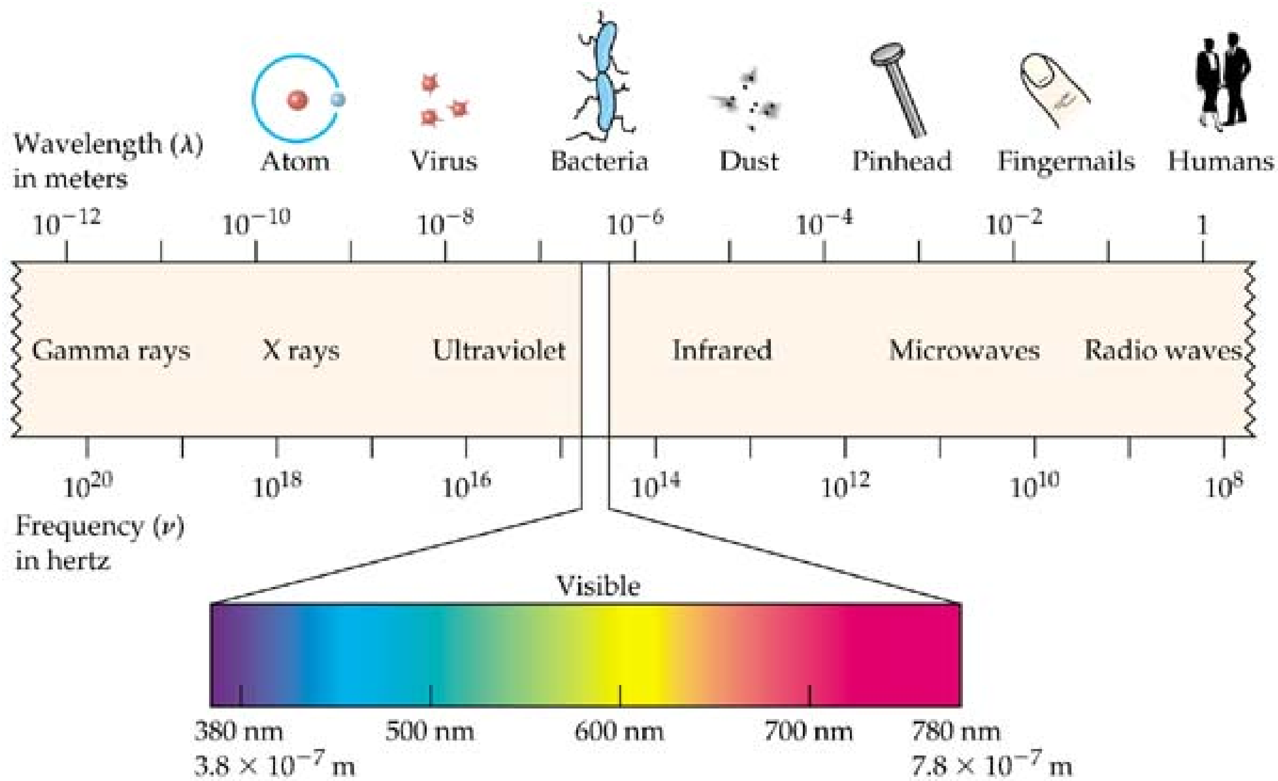


Figure 6: Spectrum

3.2 Electronic configuration

Electronic configuration [2] of atomic element is the configuration that sets the orbits of the electrons around the nucleous.
Following the Bohr model electronic configuration is comprised by the quantum numbers. A quantum number define the energy levels that electrons orbit around nucleous.

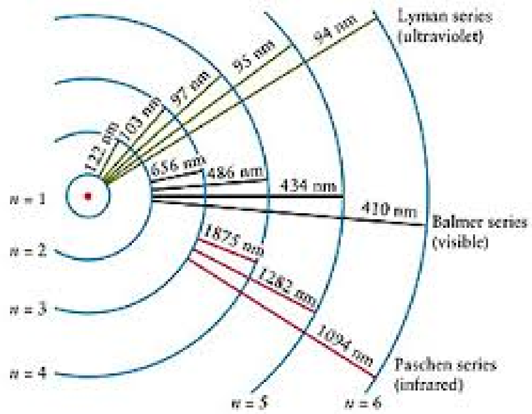


Figure 7: Hydrogen Balmier series

Principal quantum number(n) describe the size of the orbit and the energy level of an electron.
For example an electron with quantum number n=1 has lower energy than an electron with quantum number n=2(Charles Barkla).
The **angular quantum number (l)** describes the shape of the orbital.
Orbitals that have the same value of the principal quantum number form a shell.Each shell is divided into subshells. Subshells are identified as follows:

1. l=0=s
2. l=1=p
3. l=2=d
4. l=3=f
5. etc...

Each shell can hold up to $2n^2$ electrons. Each subshell is constrained to hold $4l + 2$ electrons at most.
The magnetic quantum number associated with the quantum state is designated as m.
The **magnetic quantum number (m)** refers to the projection of the angular momentum for any given direction, conventionally called the z direction. L_z of the angular momentum, L, which is related to its quantum number **l** by the following equation:
$\mathbf{L} = \hbar\sqrt{l(l+1)}$
The component of angular momentum L in the z direction L_z, is given by the formula:
$\mathbf{L_z} = m\hbar$

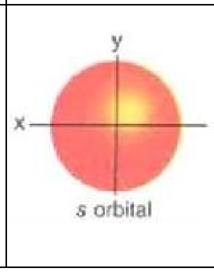
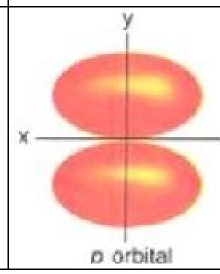
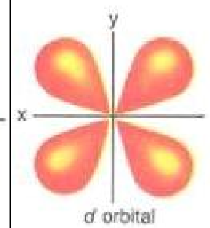
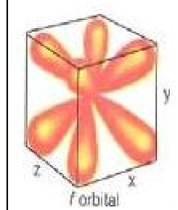
Sub shell	s	p	d	f
Value of l	0	1	2	3
Shape	Spherical	Dumb bell	Double-dumb bell	Complex
Structure				

Figure 8: l configurations

Presumably, hydrogen having 1 electron orbiting around the nucleous at the nearest orbit(Bohr radius), has an electronic configuration: $1s^1$

3.3 Covalent bonds

A covalent bond is a chemical bond that comes from the sharing of one or more electron pairs between two atoms. Hydrogen is an example of an extremely simple covalent compound.
Hydrogen is # 1 on the periodic table. The hydrogen found in nature is often not comprised of an individual atom. Its primarily found as the diatomic (two atom) compound:H_2

3.4 Hydrogen isotopes ${}_1^2H, {}_1^3H$

The first is deuterium and the second tritium.If you fuse deuterium and tritium (high energy required) you get Helium(He) plus energy (higher than that used for the fusion) and a free newtron.

3.5 Production of Tritium

Bombarding of lithium with newtrons will give the following reaction:

$${}_3^6Li + n ---> {}_2^4He(2.05MeV) + {}_1^3T(2.75MeV)$$

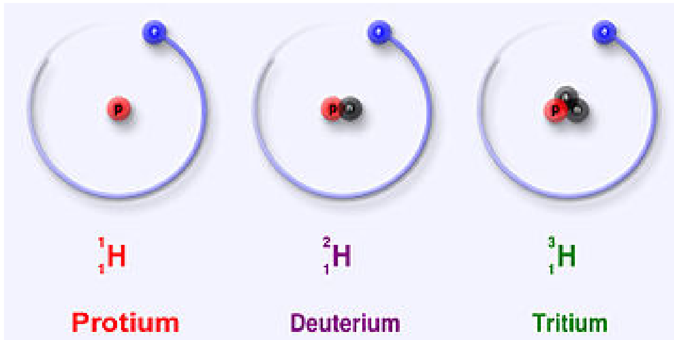


Figure 9: Hydrogen isotopes

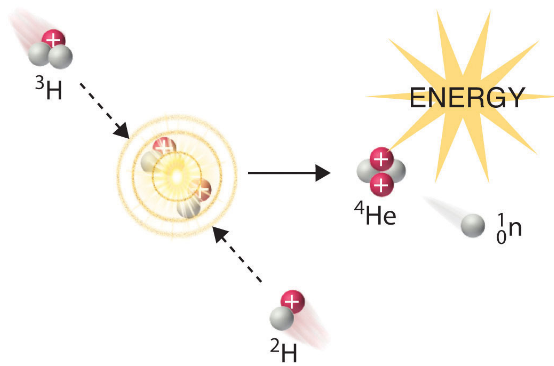


Figure 10: Nuclear fusion with hydrogen

References

[1] Wikipedia *https://en.wikipedia.org/wiki/Hydrogen* Hydrogen

[2] Wikipedia *https://en.wikipedia.org/wiki/Electron_shell* Electron shell

[3] Wikipedia *https://en.wikipedia.org/wiki/Hydrogen_spectral_series* Hydrogen

[4] Wikipedia *https://en.wikipedia.org/wiki/Quark* Quarks

[5] Wikipedia *https://commons.wikimedia.org/wiki/File:Bosons-Hadrons-Fermions* Bosons-Hadrons-Fermions -RGB-png2.png