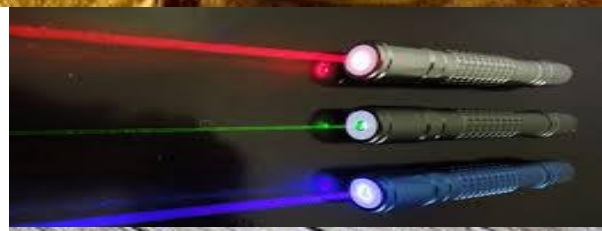
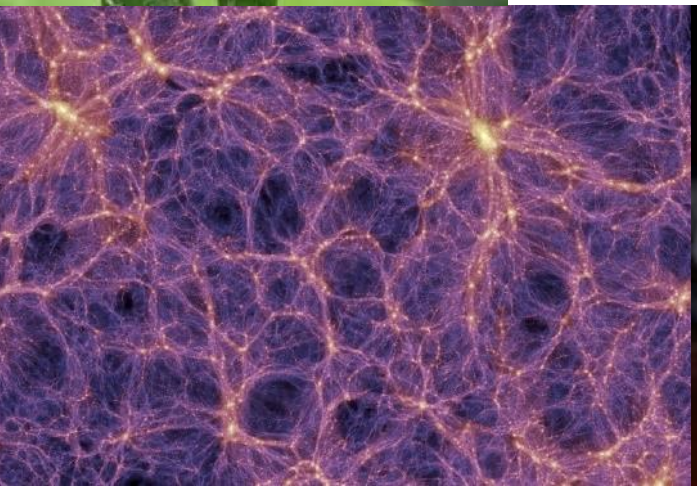



OH DEAR, WHAT CAN THE

MATTER

BE?





What is Matter?

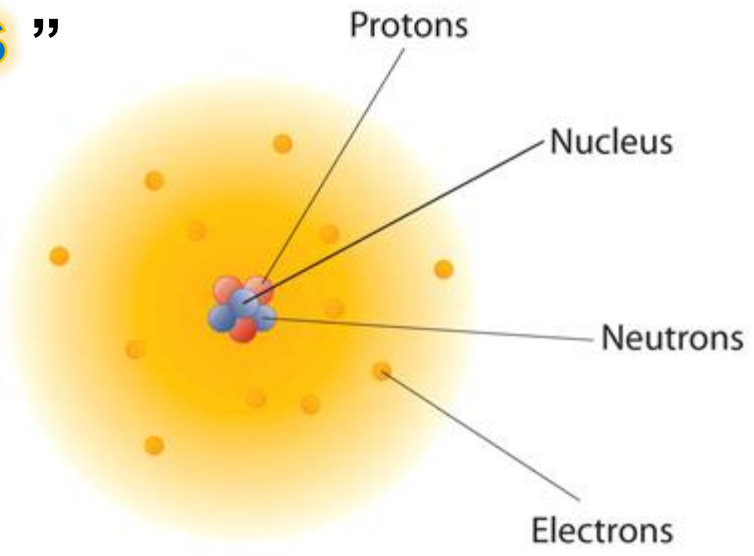
1. **Common "classical" definition (known as *mechanical, abstract mathematical*), René Descartes, Isaac Newton - 17th century:**

"Matter is anything that has mass and takes up space"

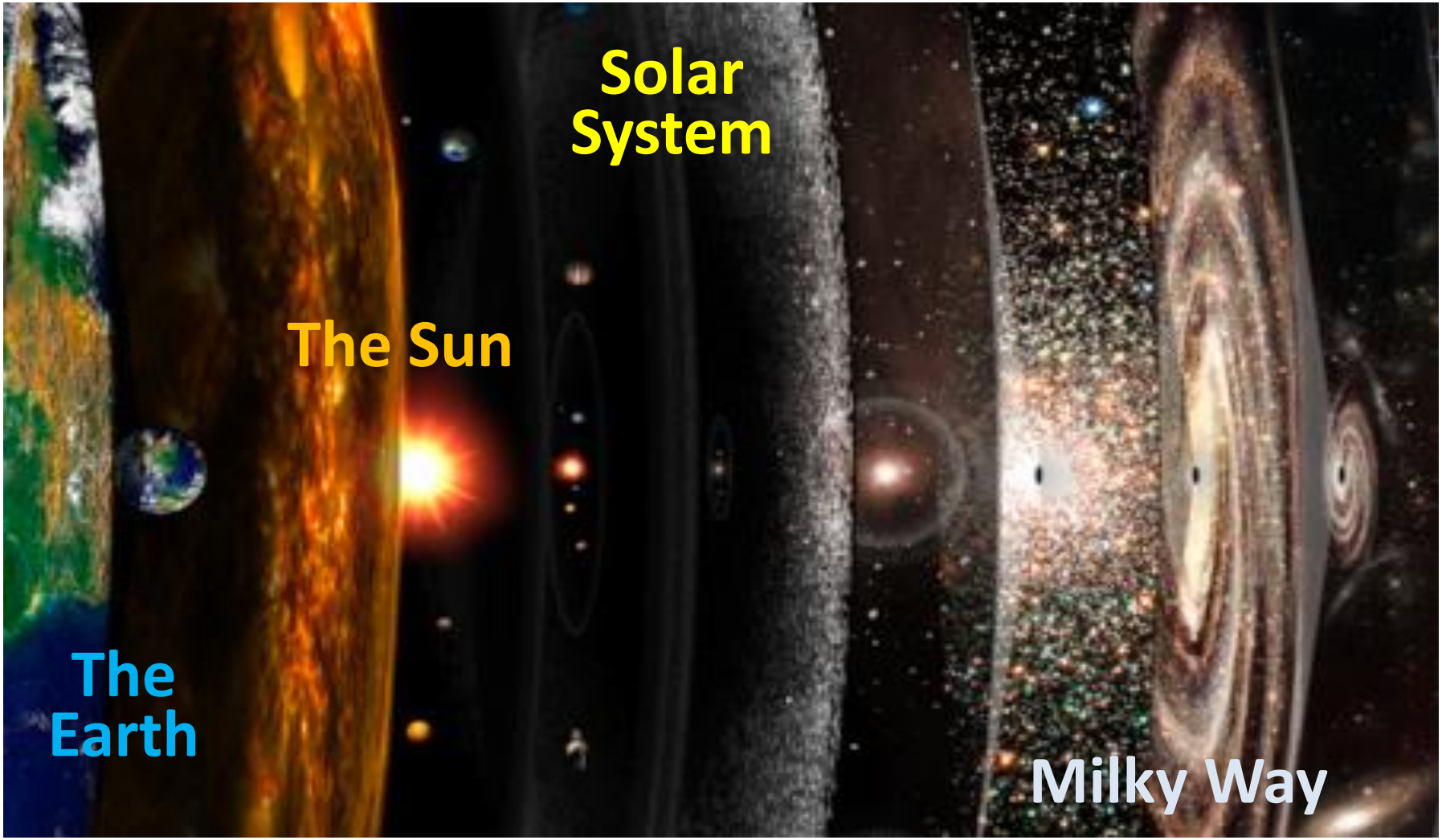
2. **Late 19th century definition (based on physical and chemical structure):**

"Matter is made up of atoms"

This *atomic*, or *ordinary*, matter is in turn made up of interacting *subatomic particles* — usually a nucleus of *protons* and *neutrons*, and a cloud of orbiting *electrons*.

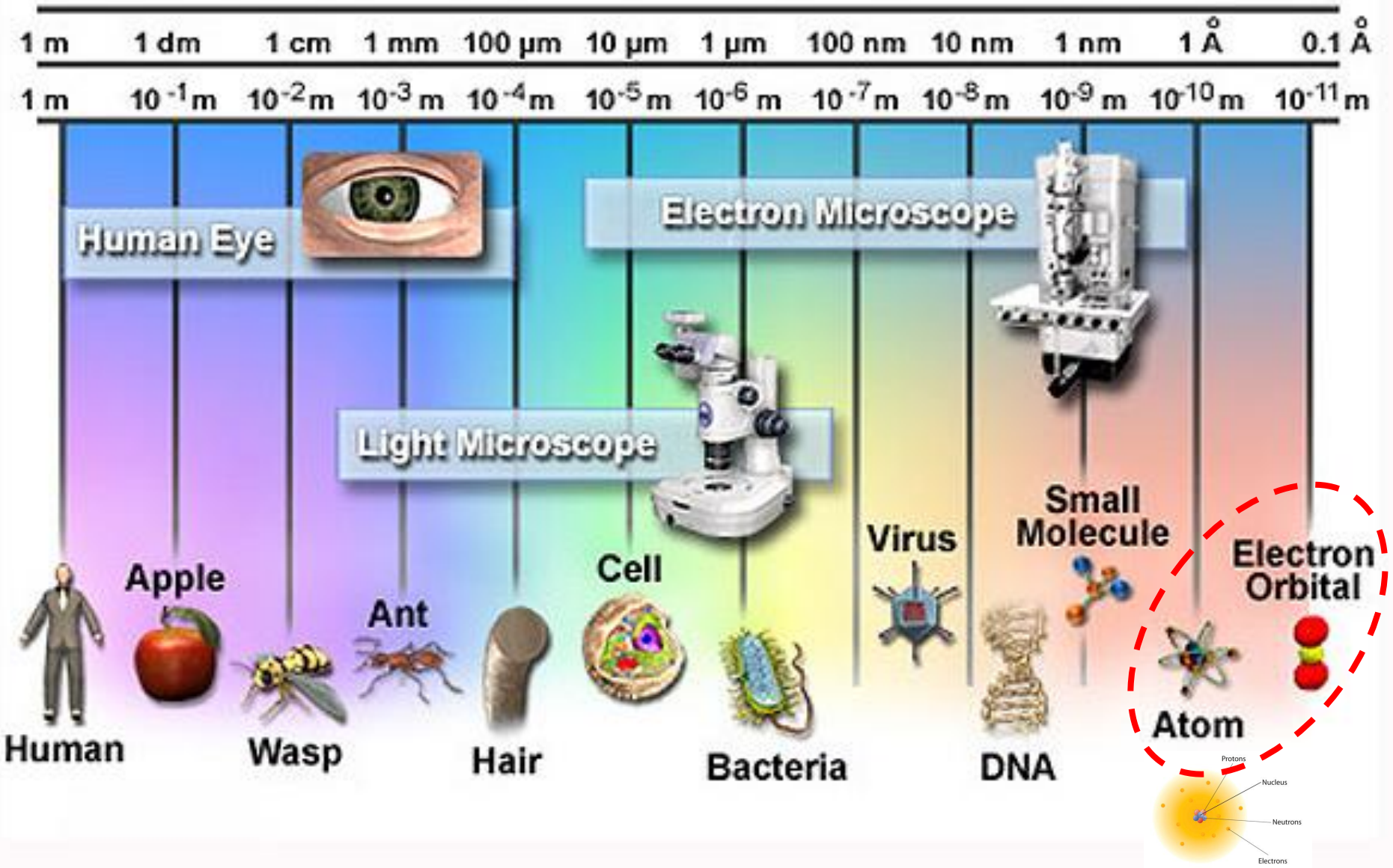


Some Bigger (>1 million m) Things

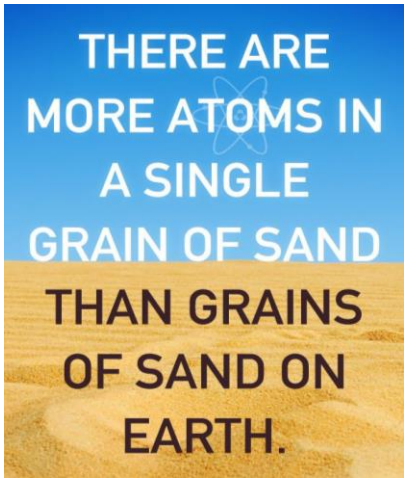


10^{7} m 10^{9} m 10^{13} m 10^{21} m

Some Smaller (<1 m) Things



Voyage into the World of Atoms

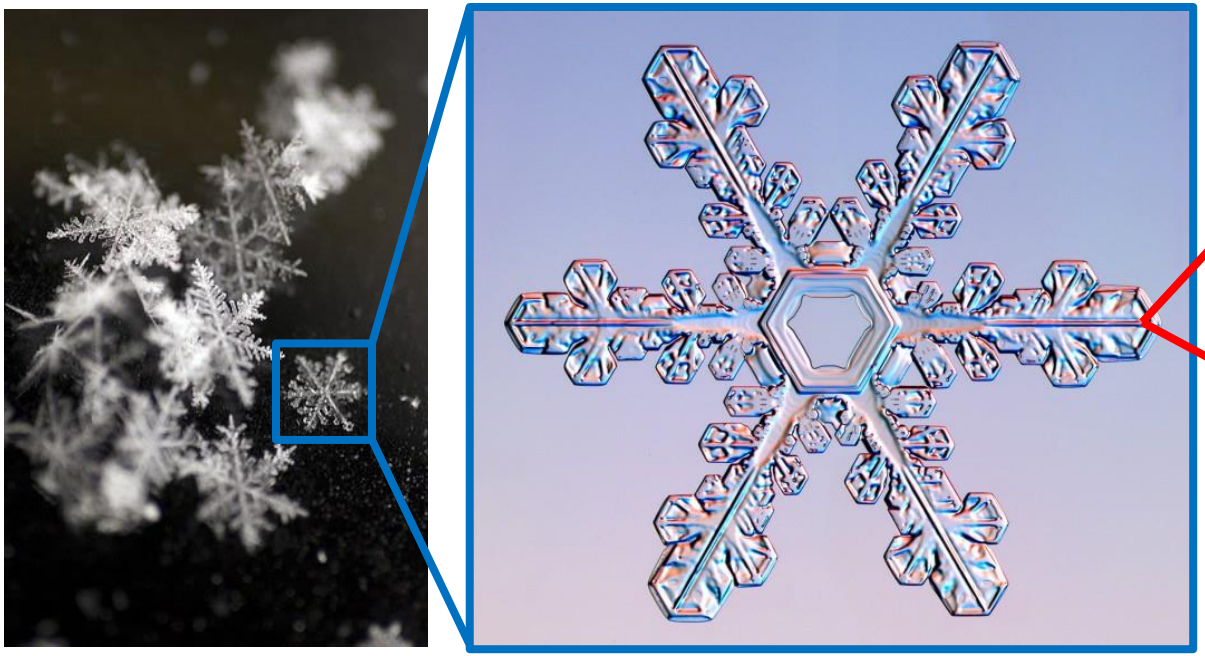


Atoms are very small!

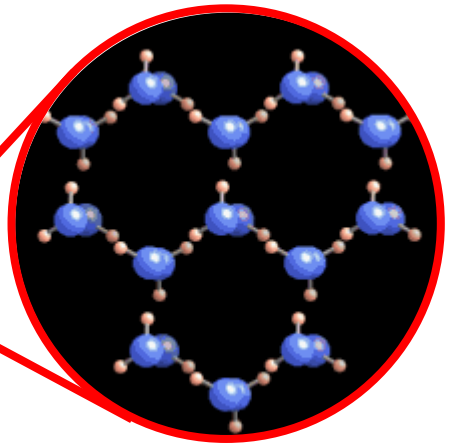
Voyage into the World of Atoms:

https://www.youtube.com/watch?v=7WhRJV_bAiE

Snowflake ~1-3 mm



Ice crystal unit cell 5 nm

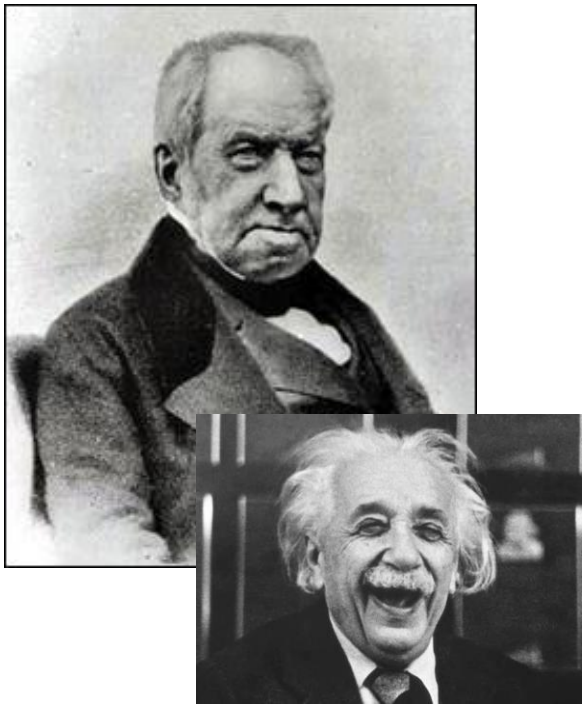


Single atom ~1Å=10^{-10} m

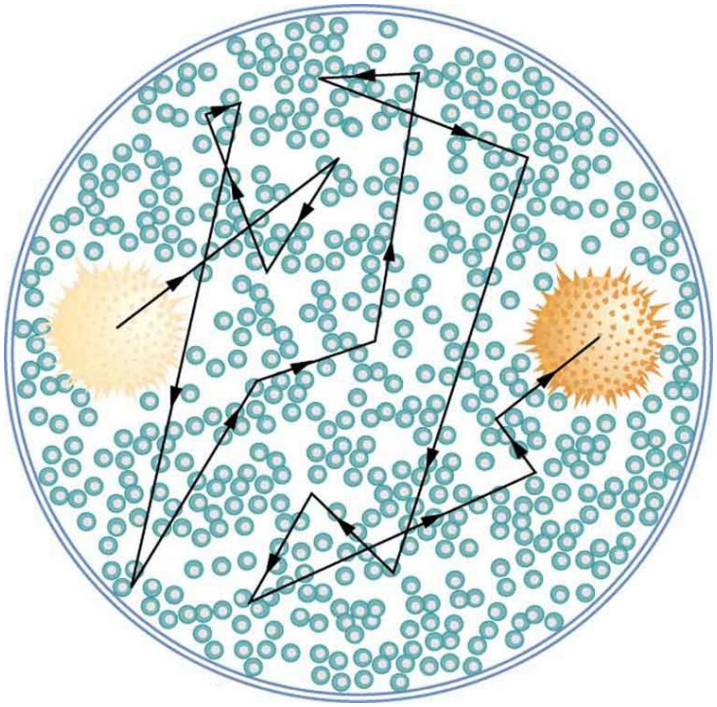
A typical snowflake is made of about 10^{18}-10^{19} atoms.

Brownian motion

Robert Brown, 1827



- In 1827, while looking through a microscope at particles found in pollen grains in water, **Brown noted that the particles moved through the water** but was not able to determine the mechanisms that caused this motion.



- **Albert Einstein, 1905:** Any minute particle suspended in a liquid (or gas) moves chaotically under the action of collisions with surrounding molecules. The intensity of this chaotic motion is increased with an increase in temperature.
- This explanation of Brownian motion served as **definitive confirmation** that **atoms and molecules actually exist**.

Study of Matter

- **Physics** – ***physical science*** **that studies forms of matter, its change and motion through space-time, and related concepts such as energy and force.**
- **Chemistry** – ***physical science*** **that studies material substances, their composition and change of composition (chemical reactions), as well as matter behavior related to chemical reactions.**

Physical science – branch of natural science that studies non-living systems.

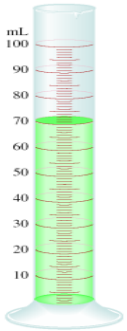
Natural science – major branch of science, that tries to explain and predict nature's phenomena, based on empirical evidence.

Science – systematic effort of acquiring knowledge—through observation and experimentation coupled with logic and reasoning.

Physical Properties of Matter

We can describe physical properties of matter in terms of physical quantities and laws.

- **An *extensive* property depends upon how much matter is being considered:**
  - **mass**
  - **volume**
  - **electrical charge**



- **An *intensive* property does *not* depend upon how much matter is being considered:**
  - **density**
  - **temperature**
  - **color**

  - **elasticity**
  - **metallicity**
  - **solubility etc…**