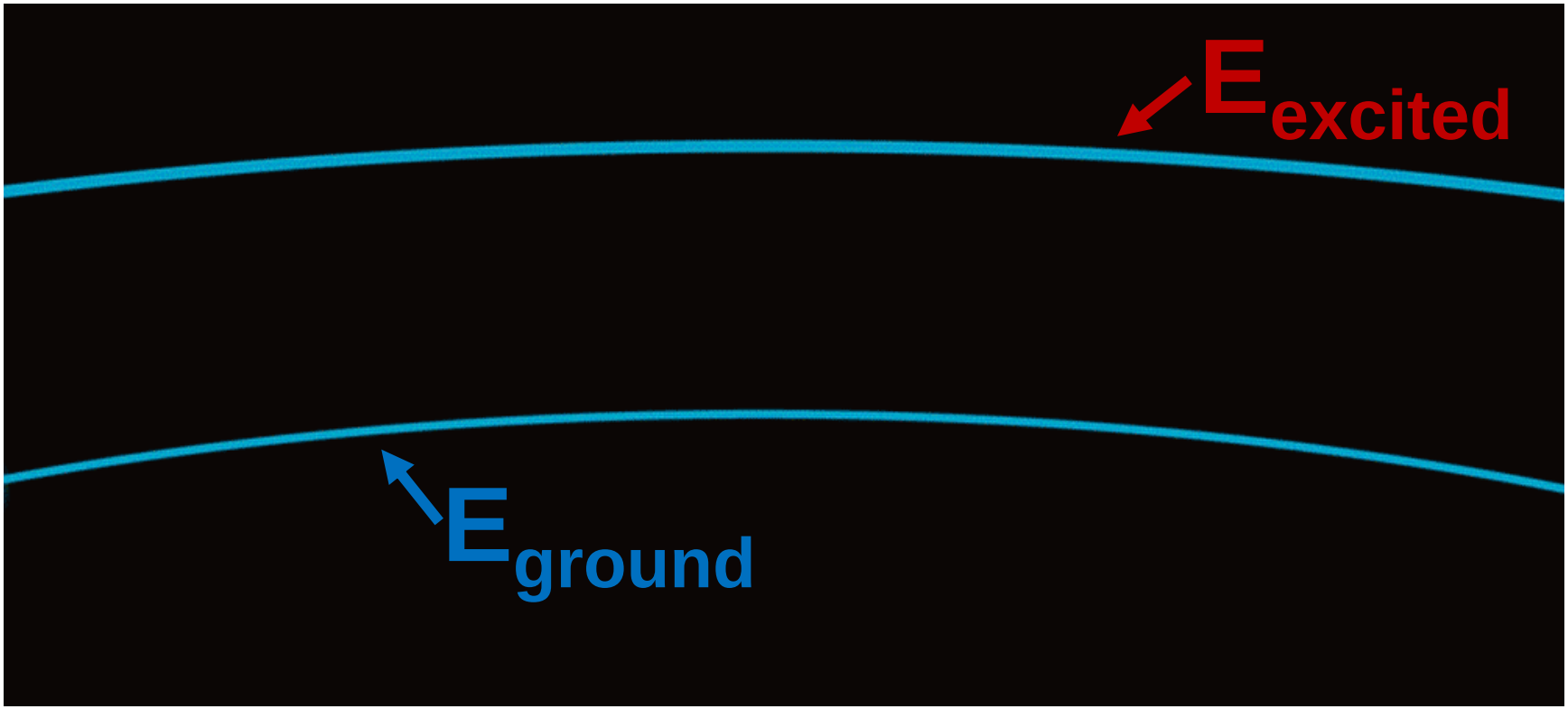
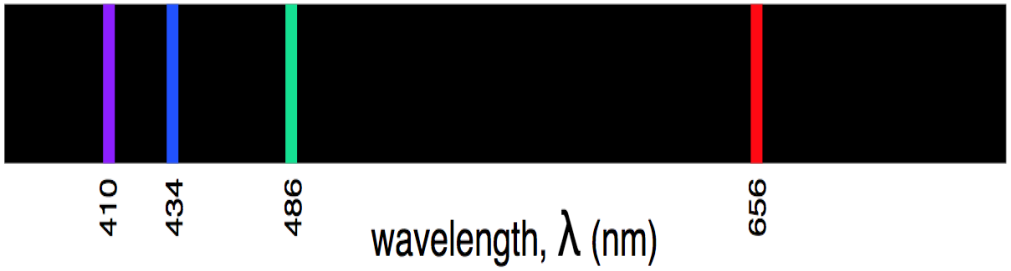
Light Emission:

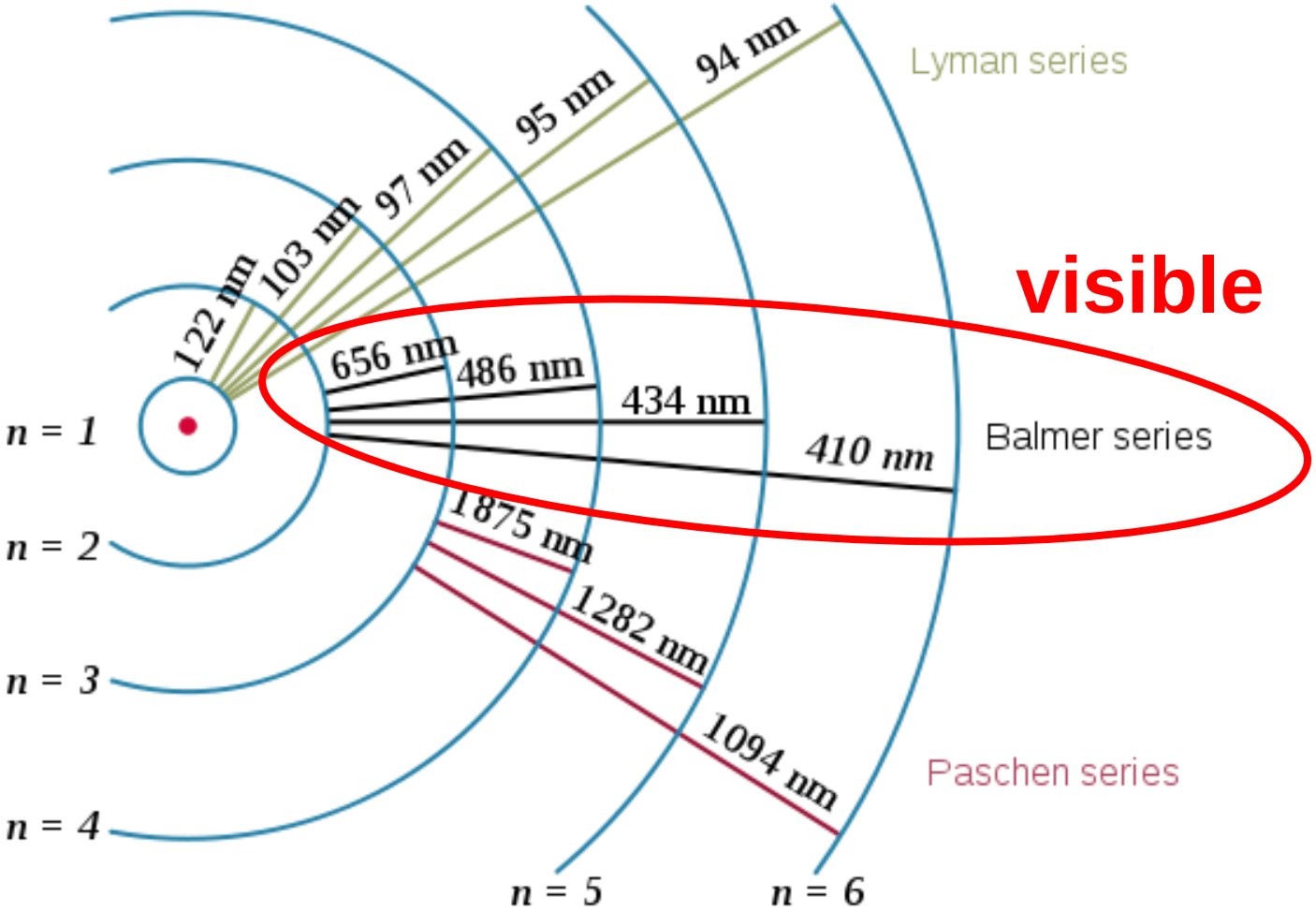
color is defined by electron transition



Photon Frequency ~ $E_{photon} = E_{excited} - E_{ground}$

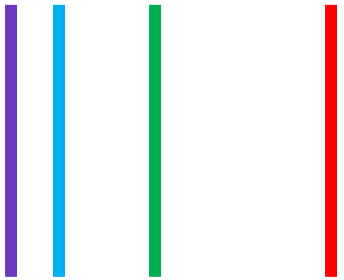
Hydrogen Atom



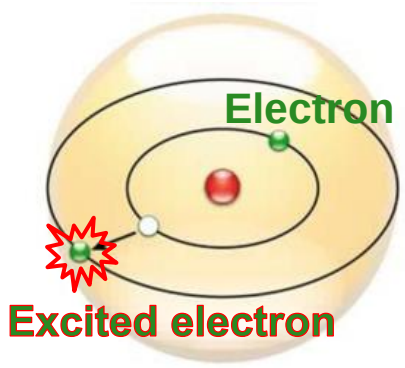


Gases

atoms far apart



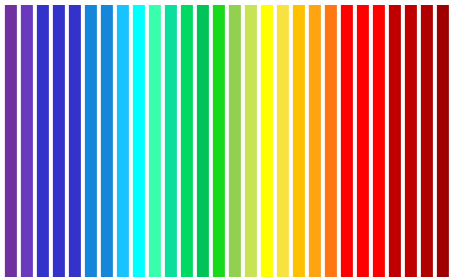
limited set of distinct colors



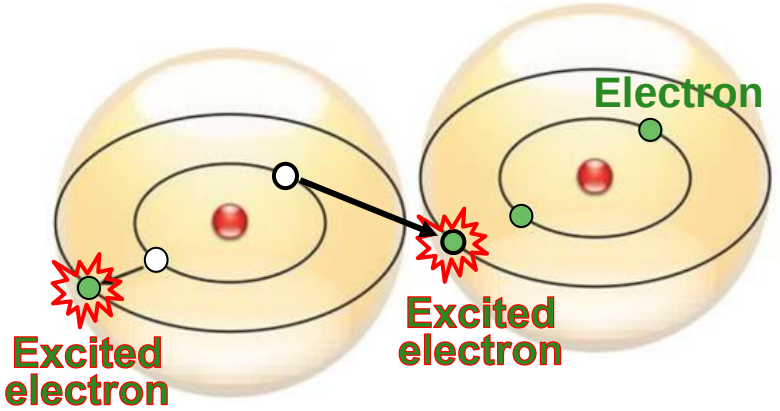
VS

Solids/Liquids

atoms close to each other



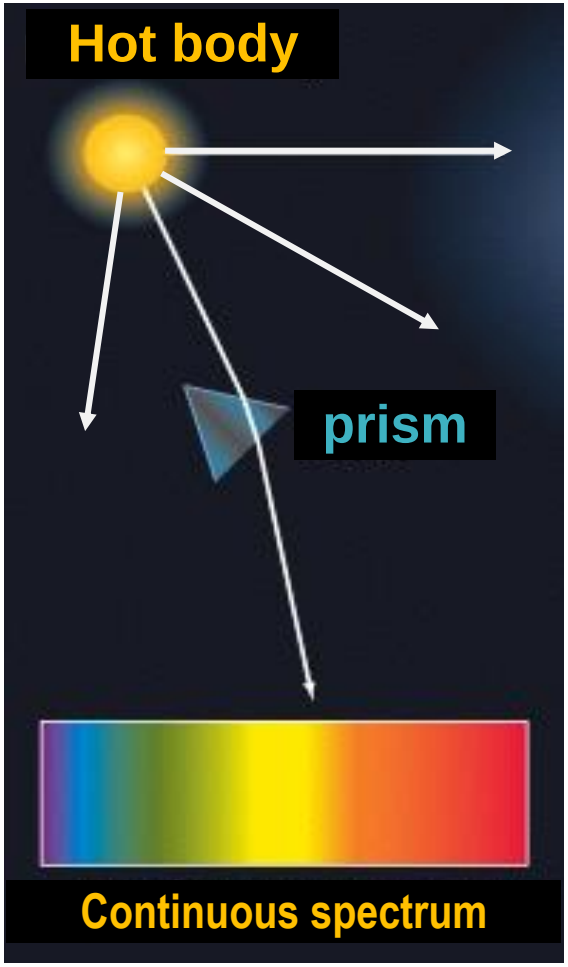
much greater number of possible colors



Thermal Radiation

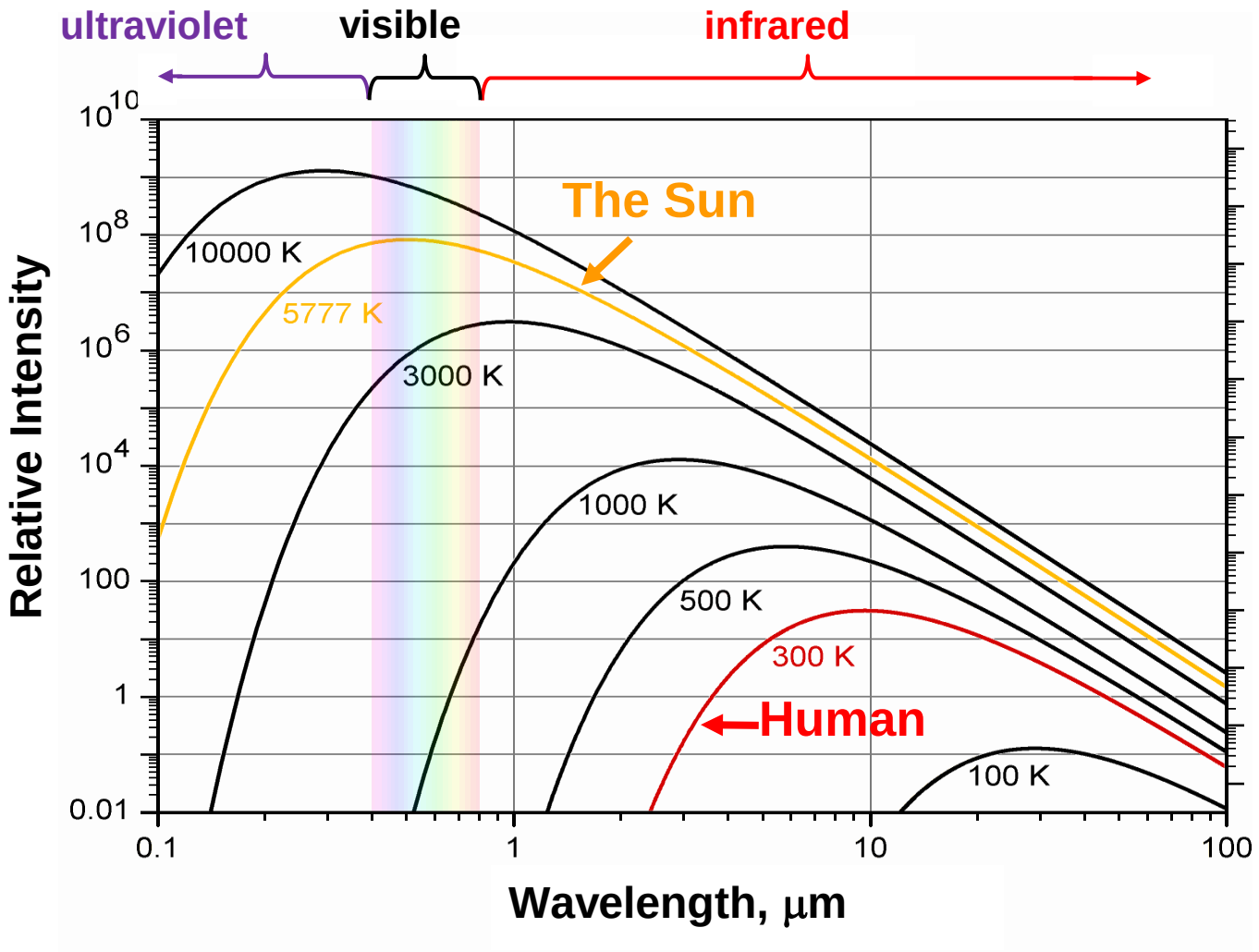
All normal matter emits electromagnetic radiation when it has a temperature above absolute zero.

- **This radiation represents a conversion of a body's thermal (heat) energy into electromagnetic energy, and is therefore called thermal radiation.**
- **When the atoms are in a condensed state (solid or liquid matter), the "hot" electrons can make transitions not only within the energy levels of their own atom, but also between the levels of neighboring atoms (that can be of same or different kind).**
- **This results in a much larger number of possible transitions with corresponding frequencies of radiant energy, producing a continuous color spectrum.**



Thermal Radiation Spectrum

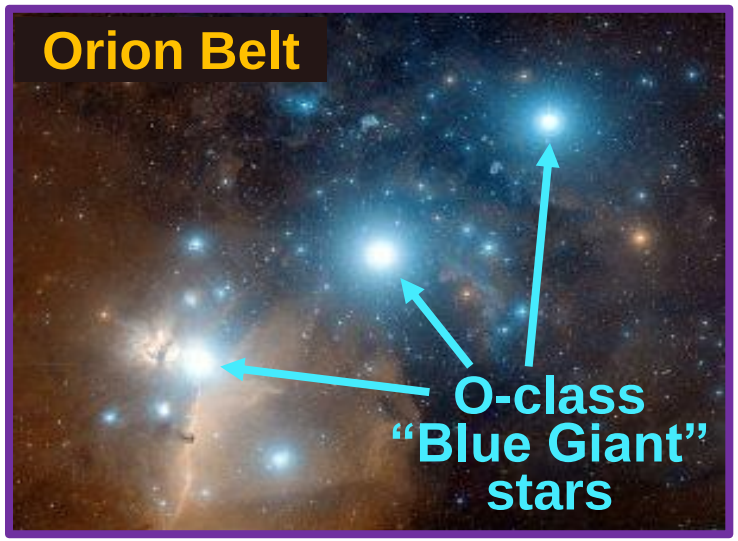
The exact thermal radiation spectrum depends upon properties of the material and the temperature.



In general, as the temperature increases, the peak of the radiation curve moves to higher intensities and shorter wavelengths.

Everything Glows!

- The temperature at which all solids glow a dim red is about 800 K (over 500℃ or 900℉).



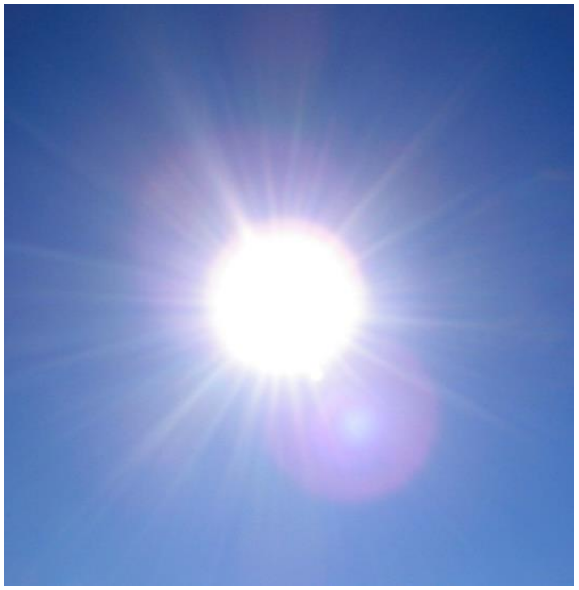
- A very hot object (10,000 K) would emit a significant amount of energy in the ultraviolet and x-ray region of the spectrum.

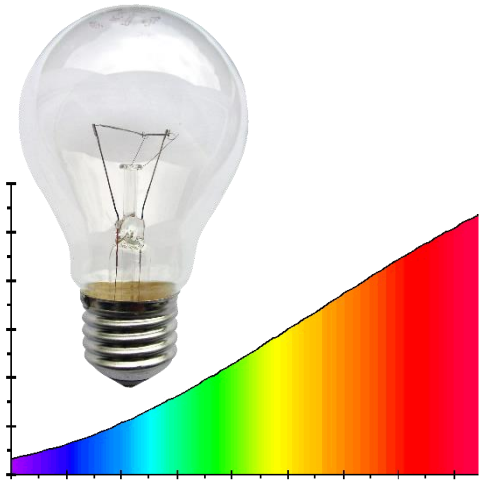
- People are emitters of light in the infrared region (peak ~9.5μm).

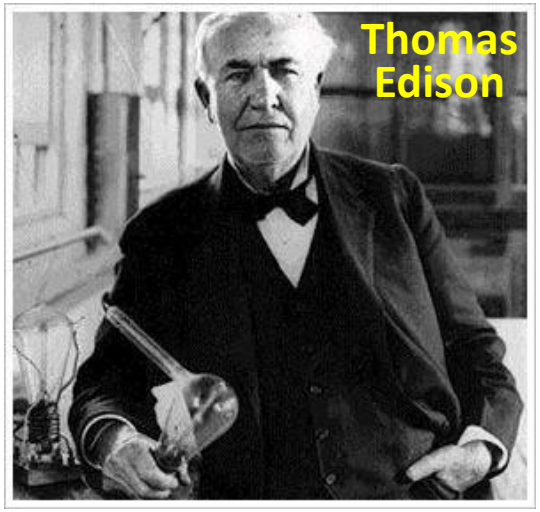
Incandescence

Incandescence (from Latin "glowing white") is a special case of thermal radiation, specifically **emission of visible light by a hot body.**

Sunlight is the incandescence of the "white hot" surface of the Sun.





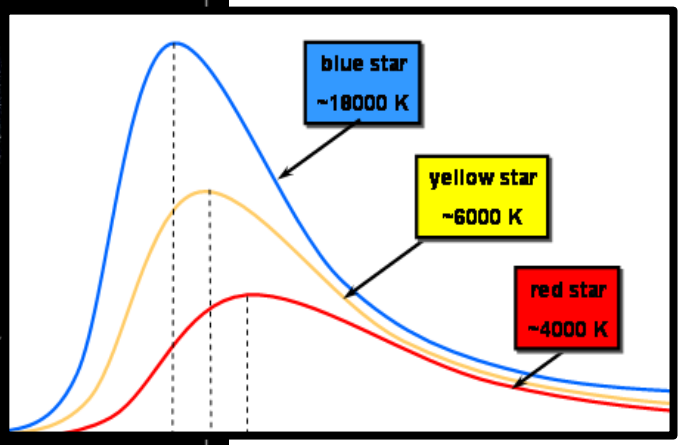


Incandescent bulb:

- electricity passes through a thin piece of metal wire called a filament
- the filament heats up and gives off thermal radiation composed of ~5% visible light and ~95% infrared light…
- …very low energy efficiency!

Colors of the Stars

are defined by how hot their *surfaces* are



The Sun surface is about 5700 K

Luminescence

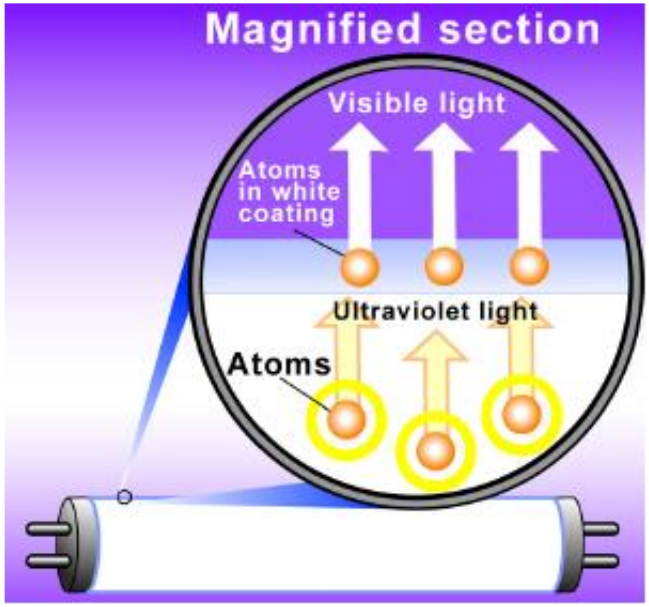
Luminescence is **emission of light** by a substance **not resulting from heat**:

Glow Sticks

- ***Chemiluminescence*** **(including *bioluminescence*), a result of a chemical reaction.**
- ***Electroluminescence*, emission of light due to electric current passed through a substance.**

LED

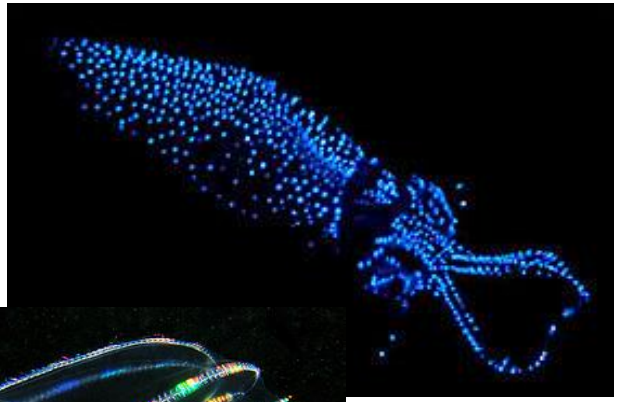
- ***Photoluminescence*** **(*fluorescence* and *phosphorescence*) due to absorption of photons with subsequent re-emission.**
- **Some other types.**

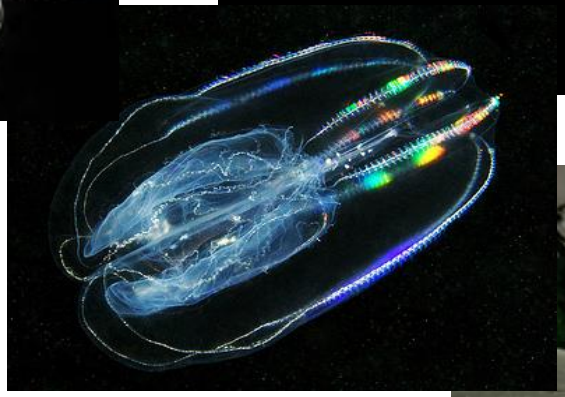


Fluorescent Lamps

Bioluminescence

Bioluminescence is emission of light by a living organism by means of a chemical reaction (type of *Chemiluminescence*).





It occurs widely among animals (many creatures of the open sea, and insects) as well as in some fungi and bacteria.