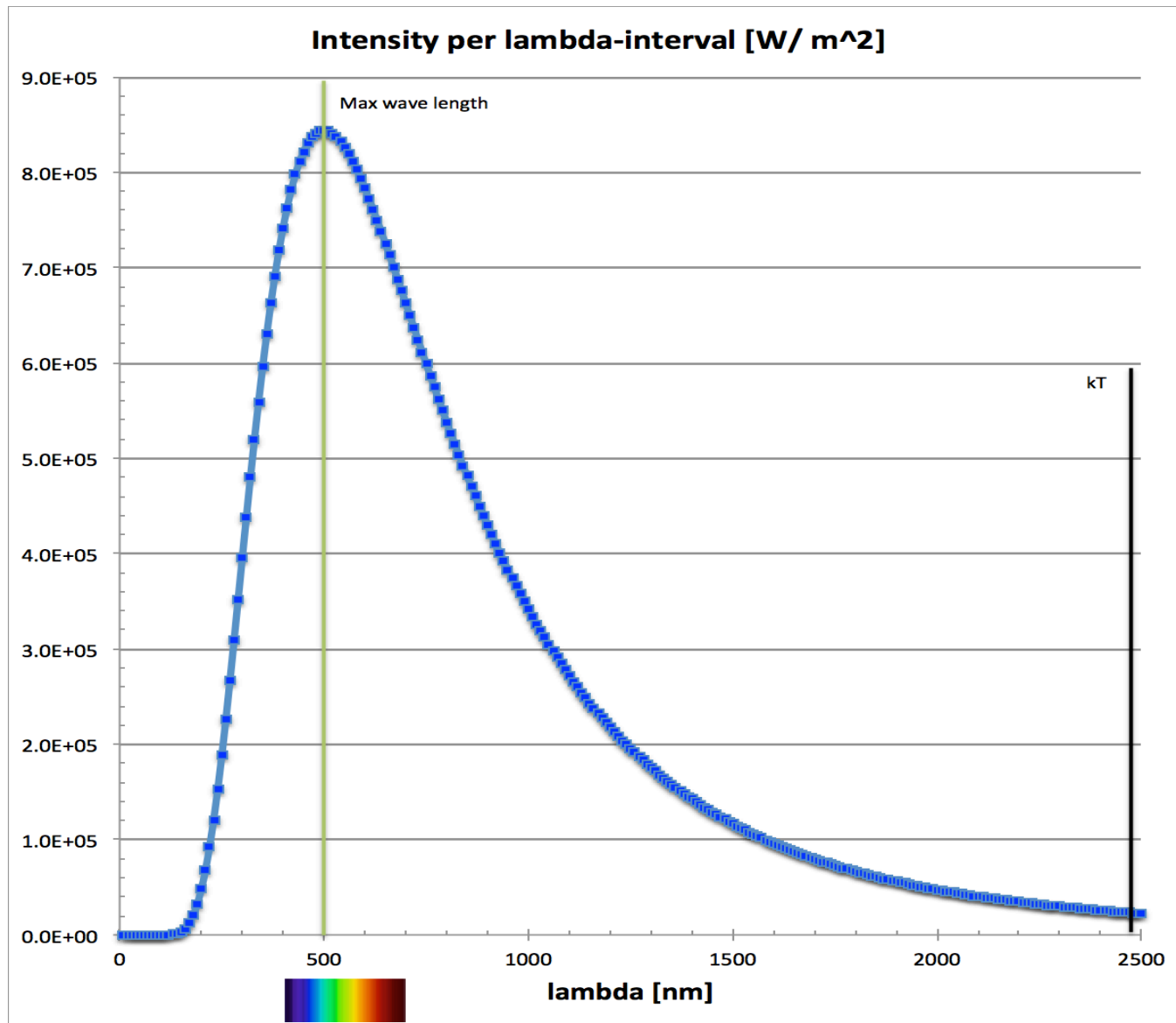
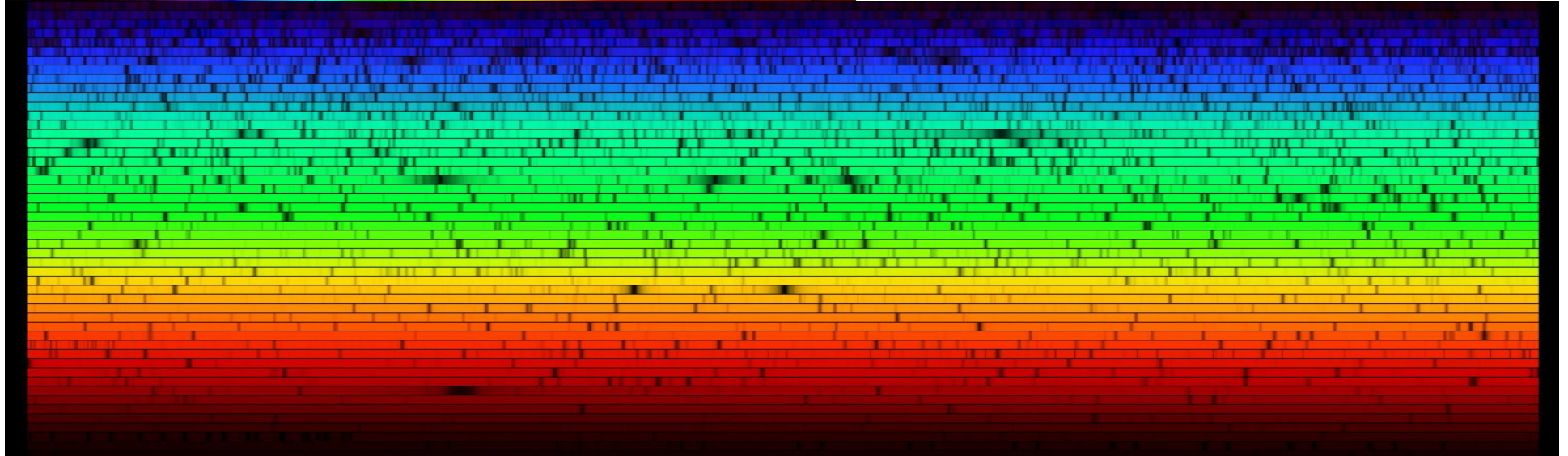
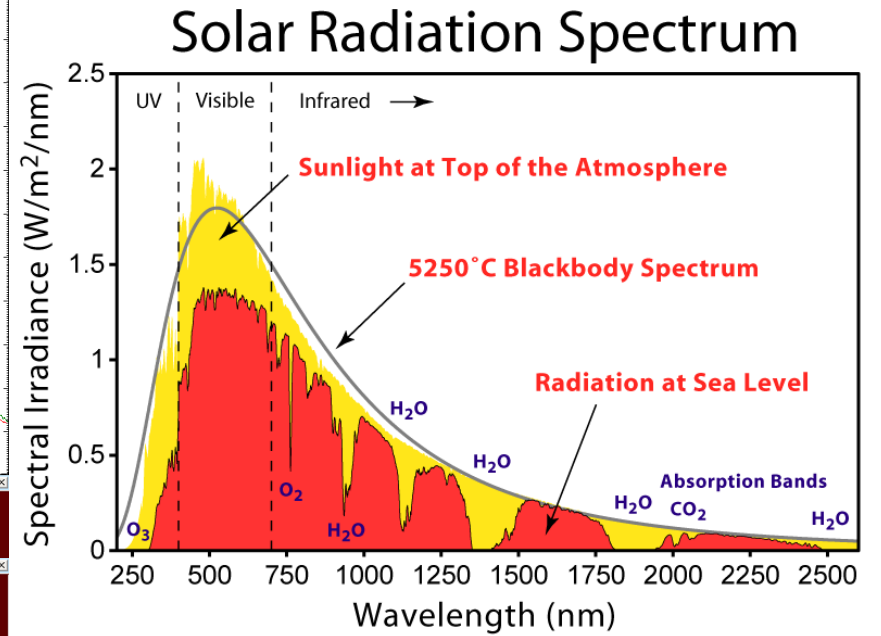
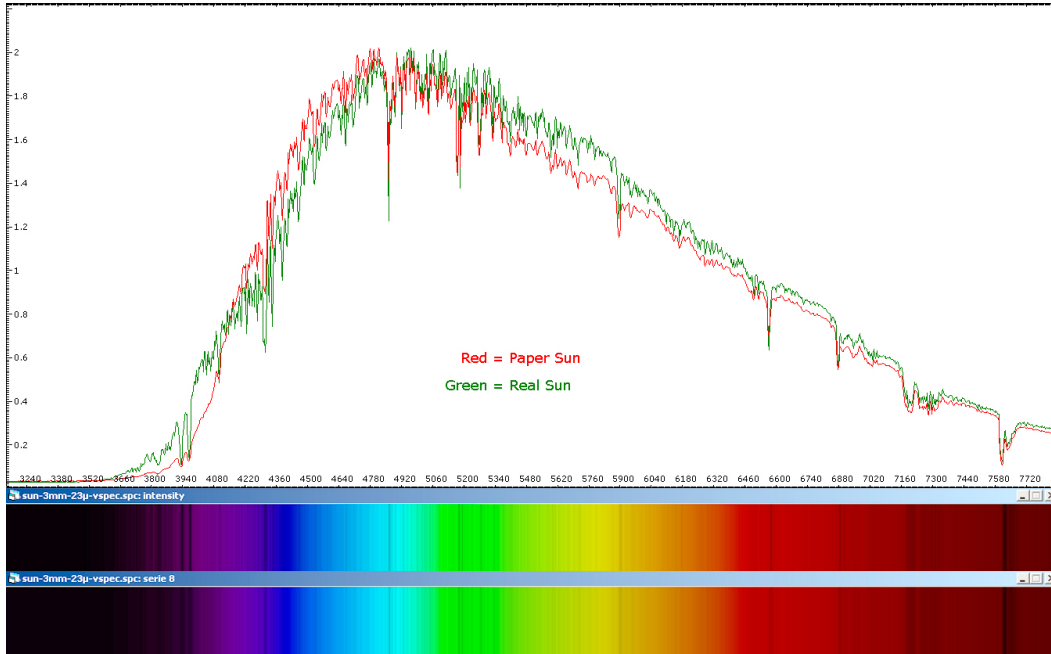


Stars

Perfect Blackbody Spectrum



Real Sun



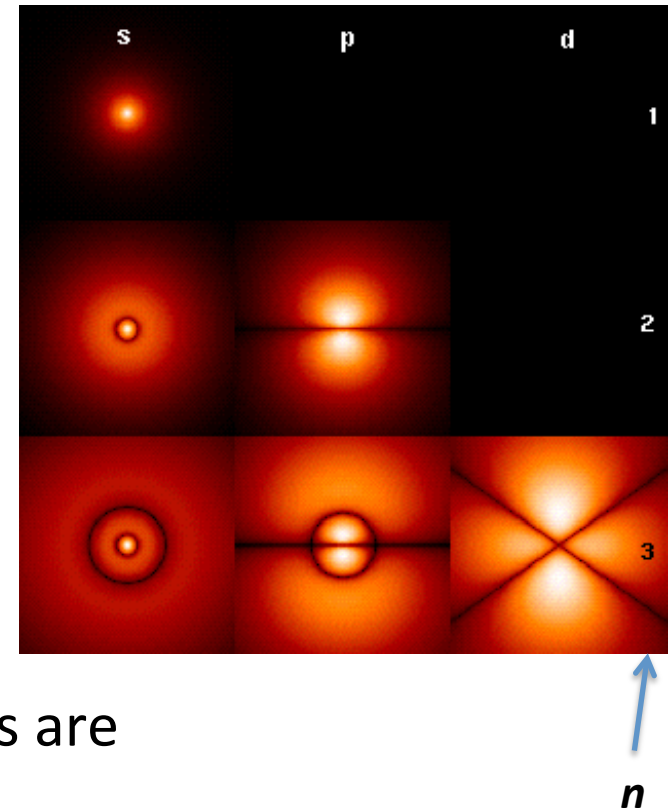
Quantum Mechanics in 20 min

- ① Many observables are quantized (i.e., cannot change by an arbitrarily small amount)
 - ① Light waves: Energy for a specific frequency f can only be absorbed or emitted in chunks (photons) of $E = hf$
 - ② Possible energy for hydrogen atom can only assume values $E_n = -Ry/n^2$ (see next slide)
 - ③ Angular momentum can only change by multiples of $\hbar = h/2\pi$
- ② All other observables are intrinsically uncertain
 - ① Position: $x \dots x + \Delta x$
 - ② Momentum: $p \dots p + \Delta p$
 - ③ Heisenberg: $\Delta x \cdot \Delta p \geq \hbar/2$
- ③ Picture: particle motion described by waves (“wave function” ψ) that cannot be located precisely.
Quantization \iff Standing Waves

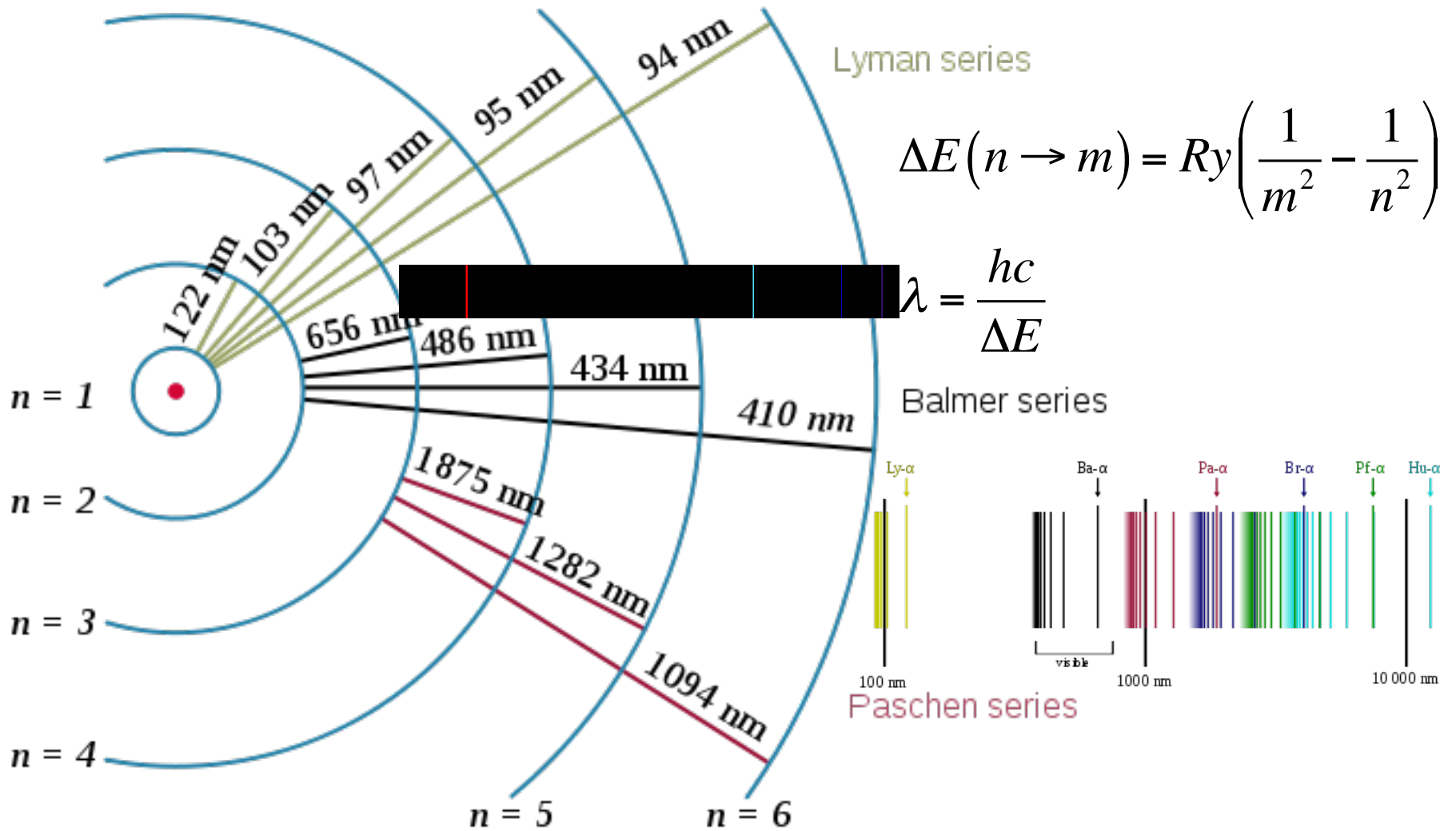
Quantum Mechanics in 20 min

- ① Electron “motion” in hydrogen atom (nucleus = proton): standing wave described by wave function $\psi(\mathbf{r})$
- ② Schrödinger: Wave function is solution of the equation $\mathbf{H}\psi(\mathbf{r}) = E\psi(\mathbf{r})$, where E is a possible energy “eigenvalue” and \mathbf{H} is a differential operator (“The Hamiltonian”)
- ③ Hydrogen atom: Only possible energies are $E_n = -Ry/n^2$ with $Ry = 13.6$ eV and $n = \text{integer}$. In general all atoms have a fixed series of possible energies E_n

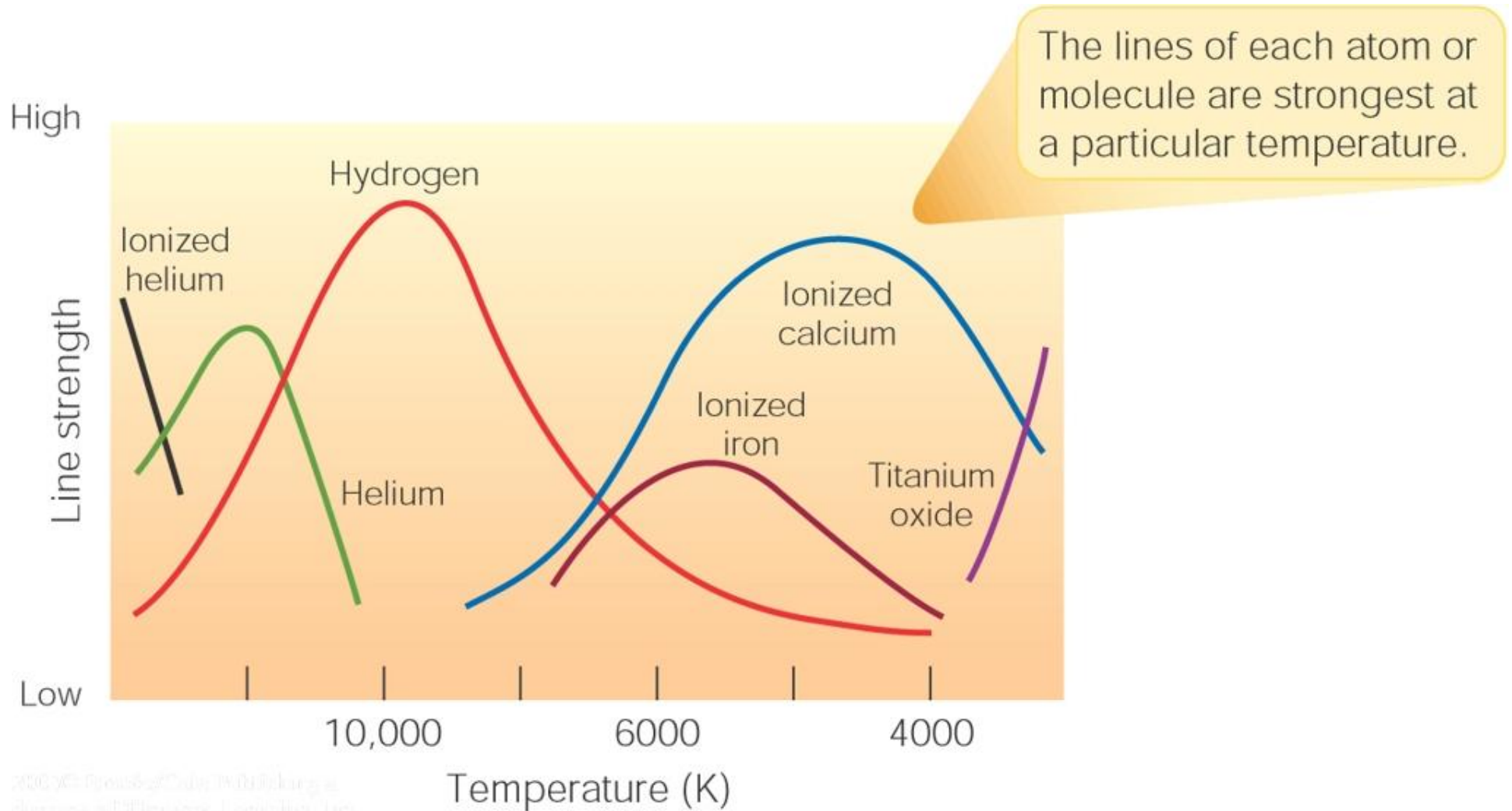
Light can only be emitted with frequencies given by $hf = E_n - E_m$



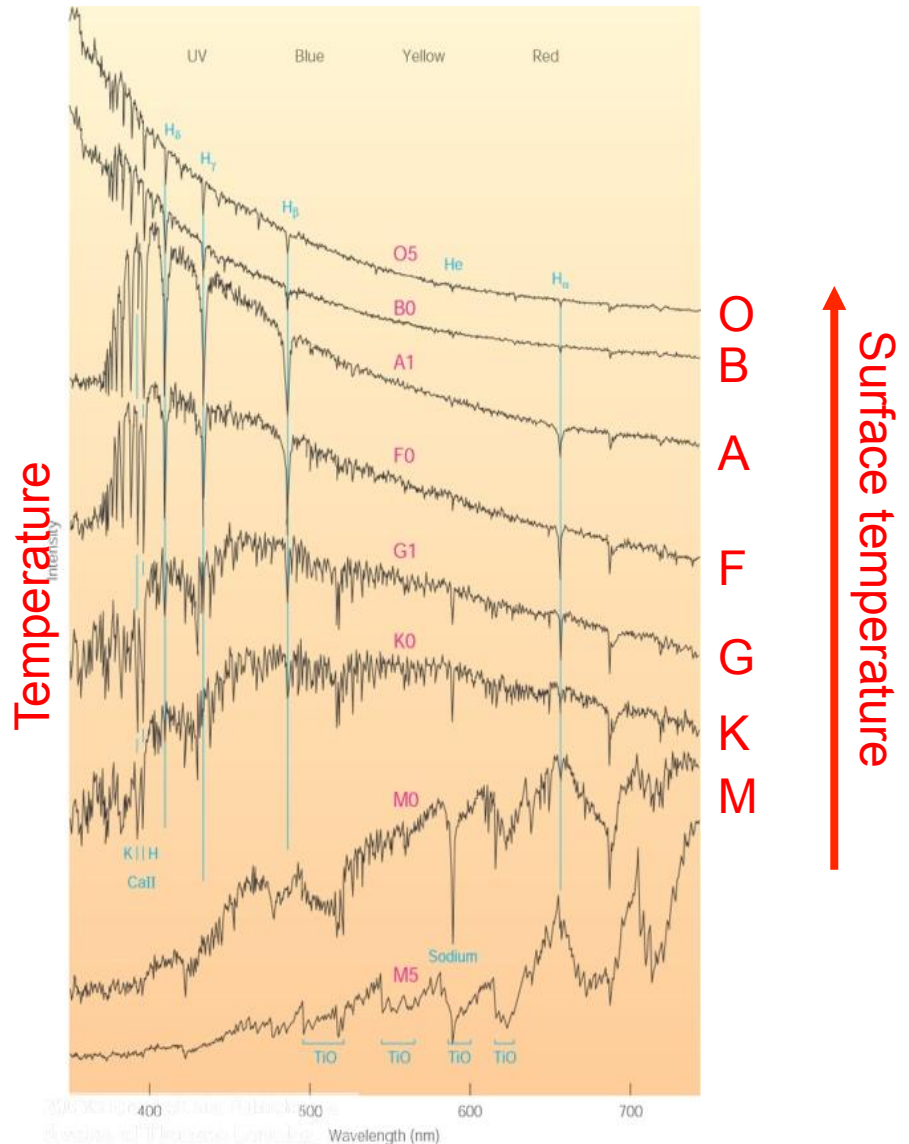
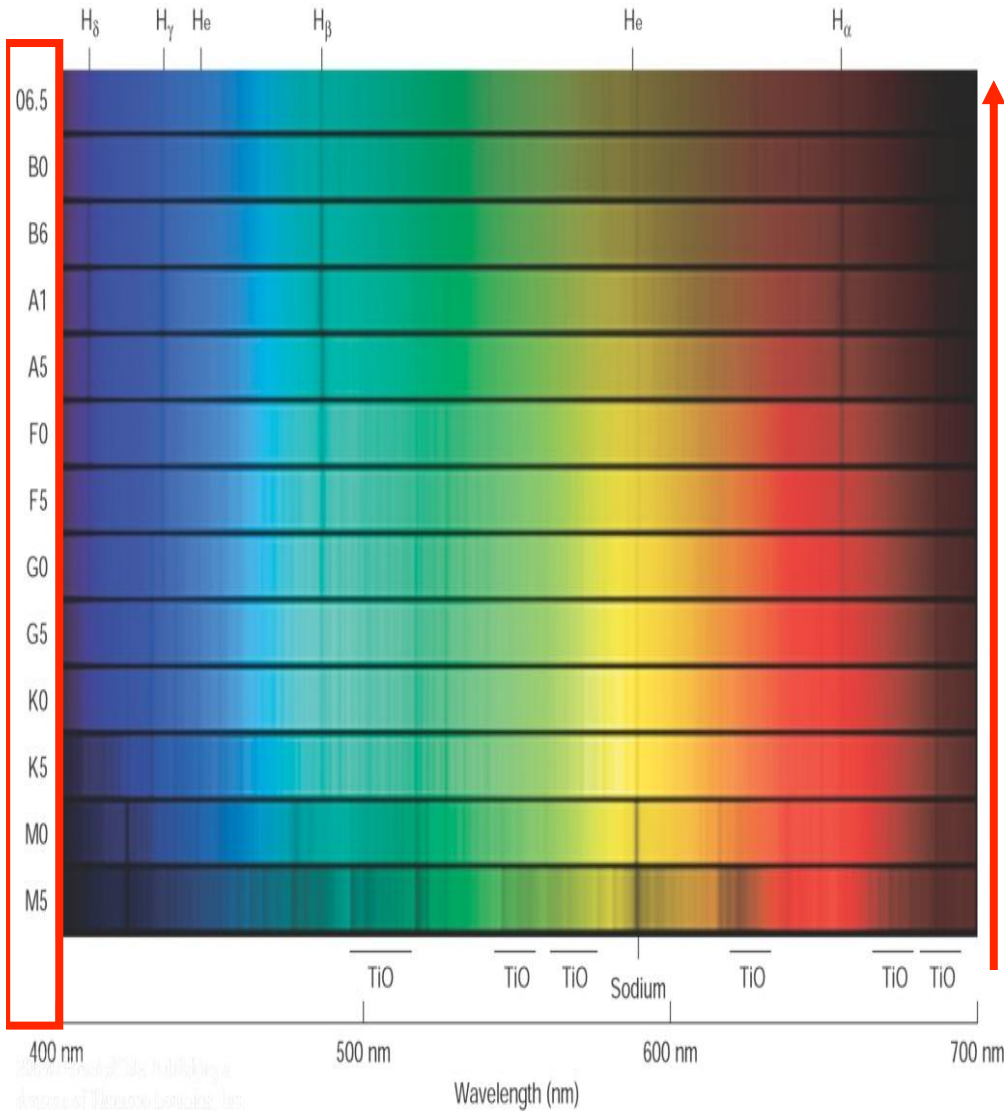
Quantum Mechanics and Line Spectra



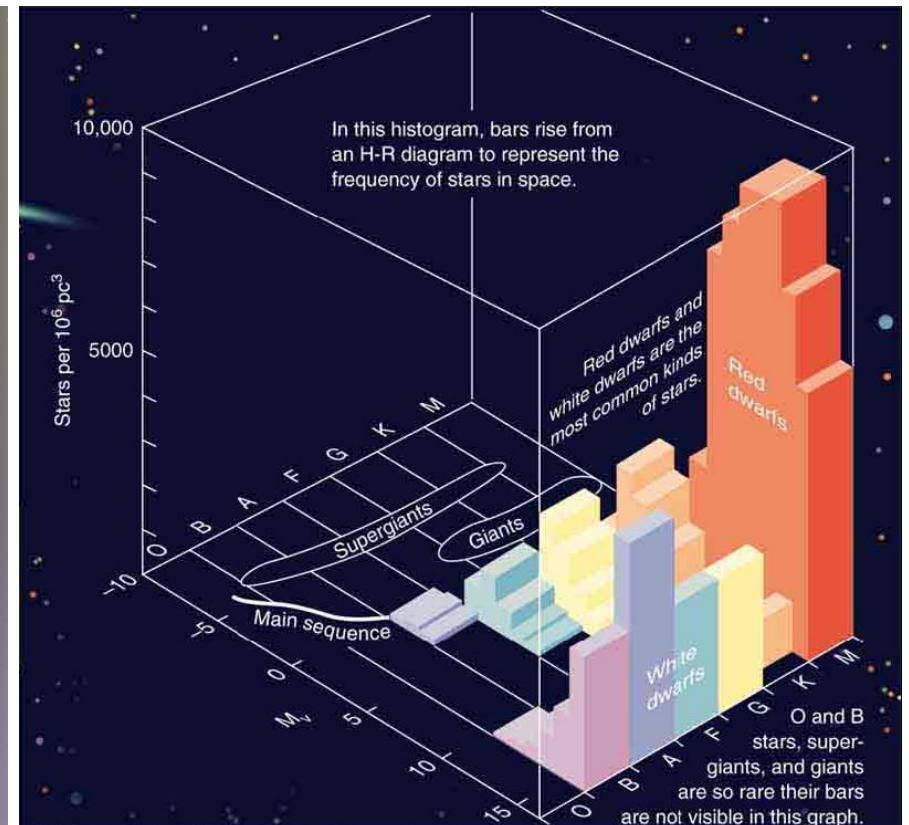
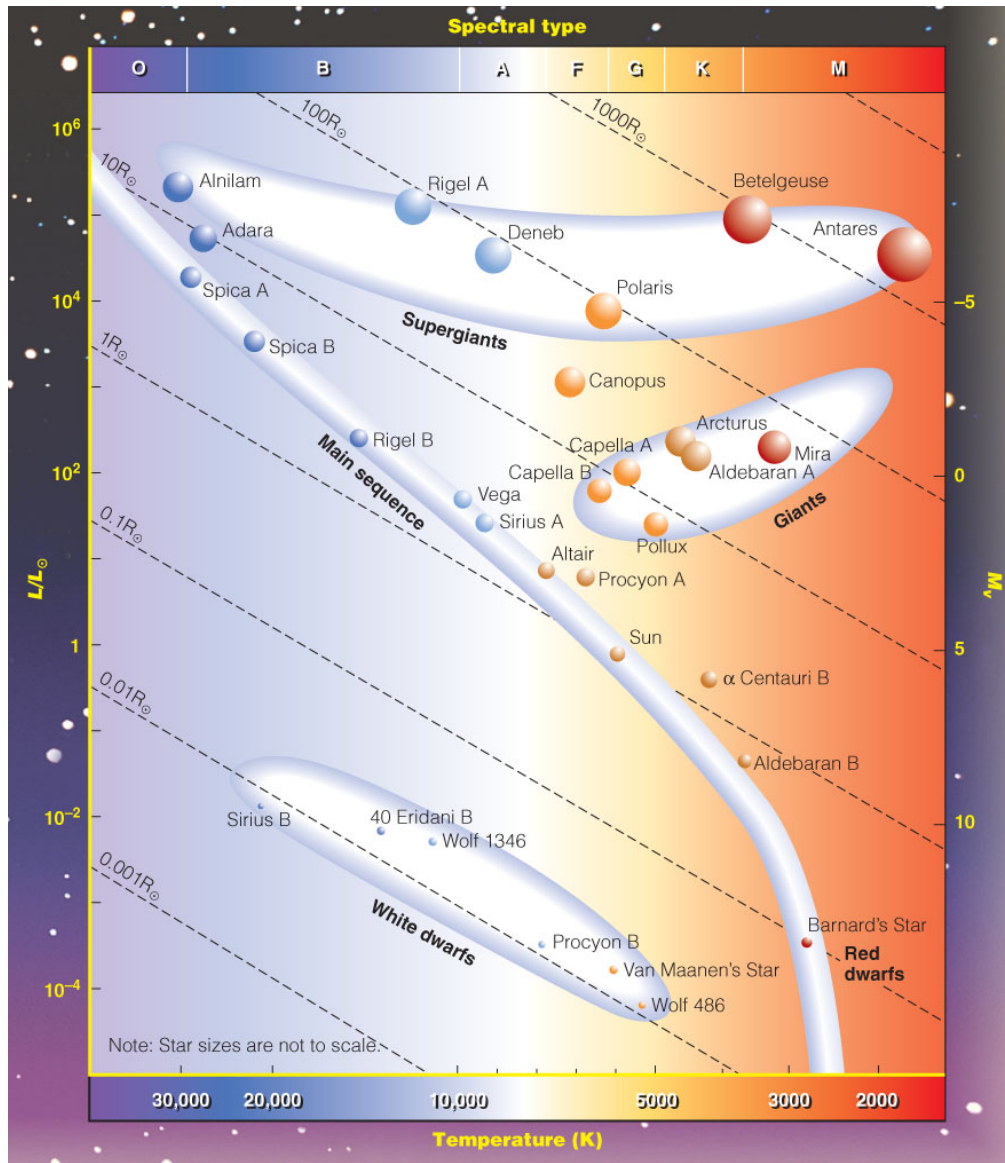
Measuring Temperature



Spectral Type



Hertzsprung-Russel Diagram



Earth



Venus



Mars



Mercury



Pluto



Jupiter

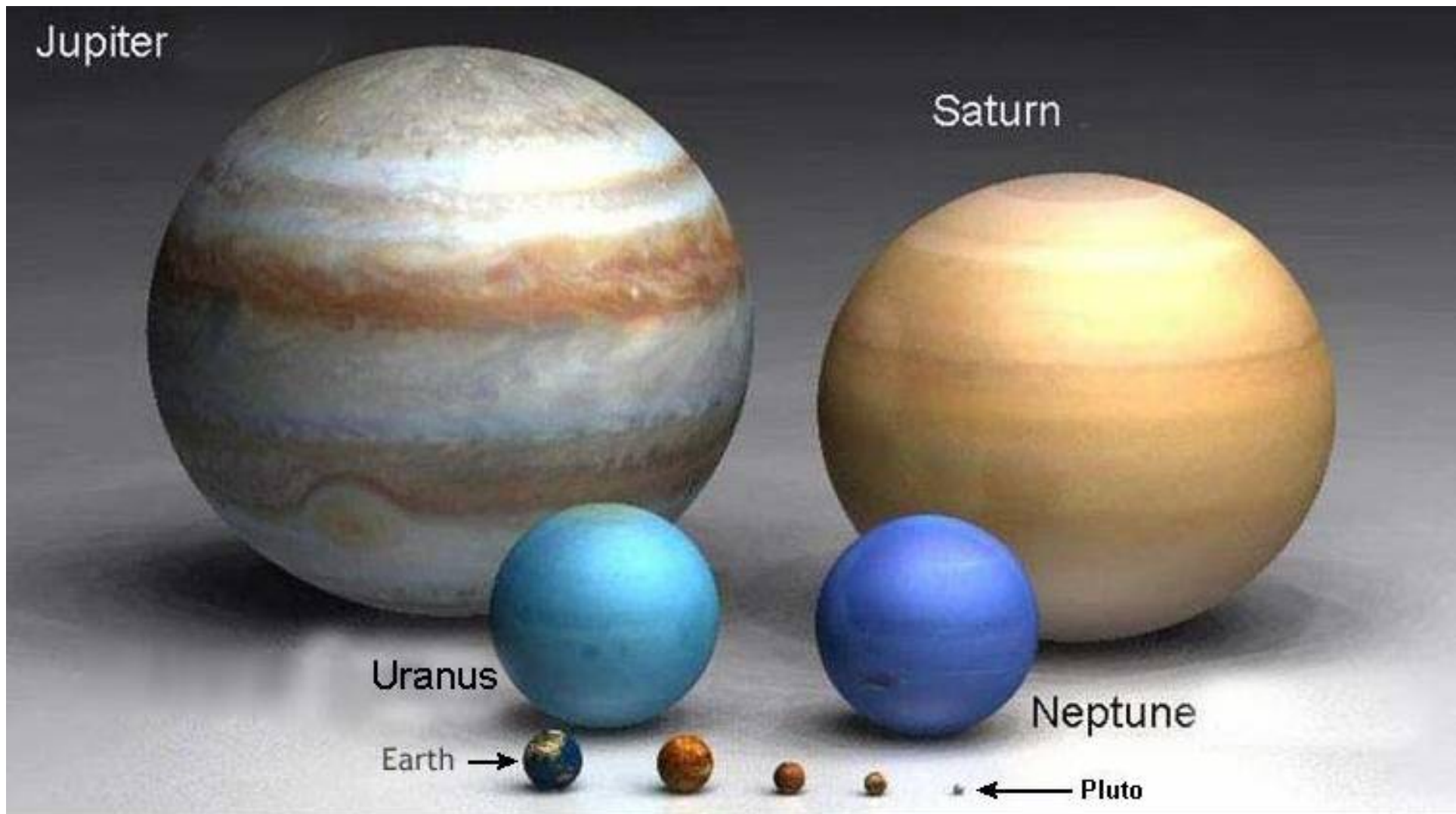
Saturn

Uranus

Neptune

Earth →

← Pluto

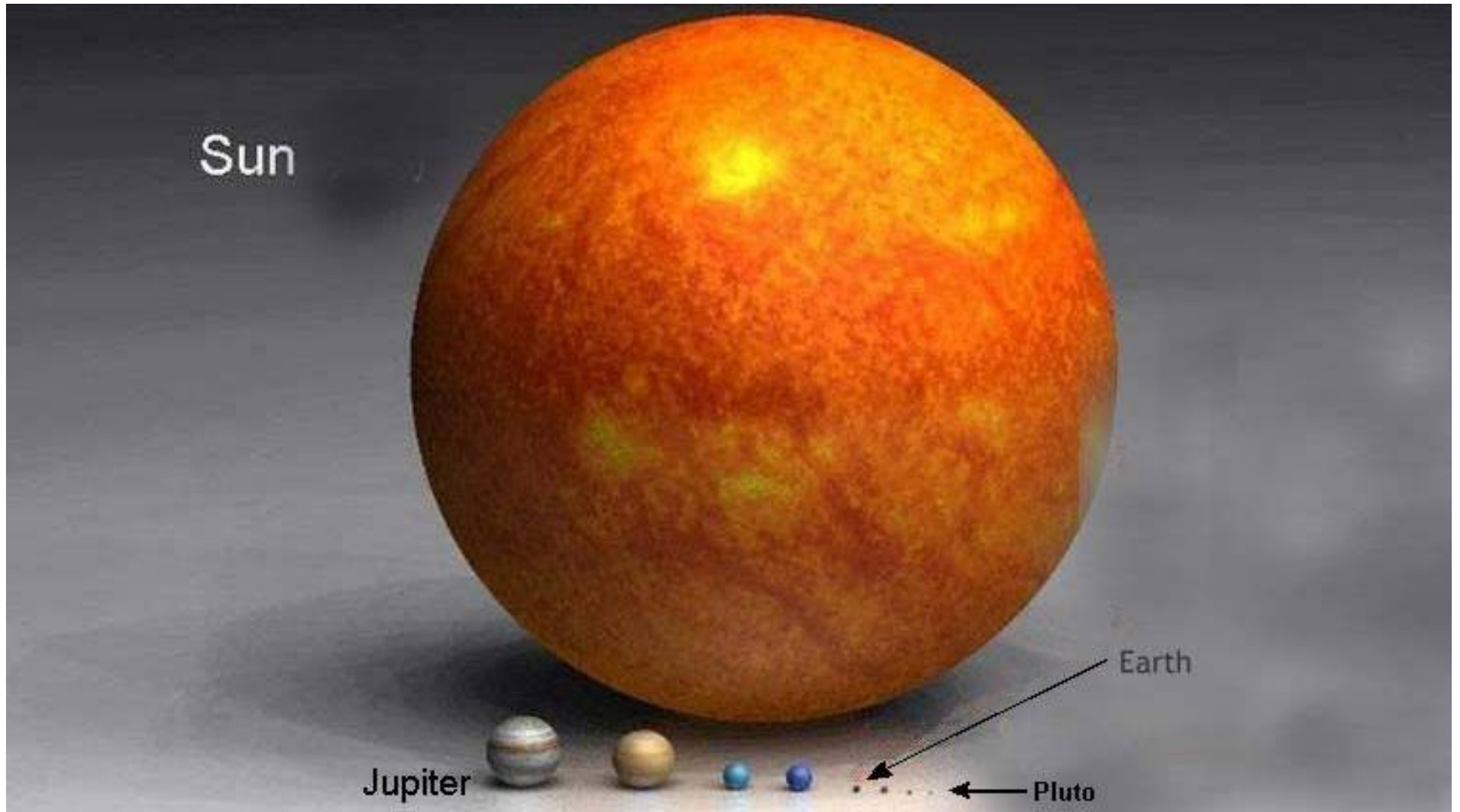


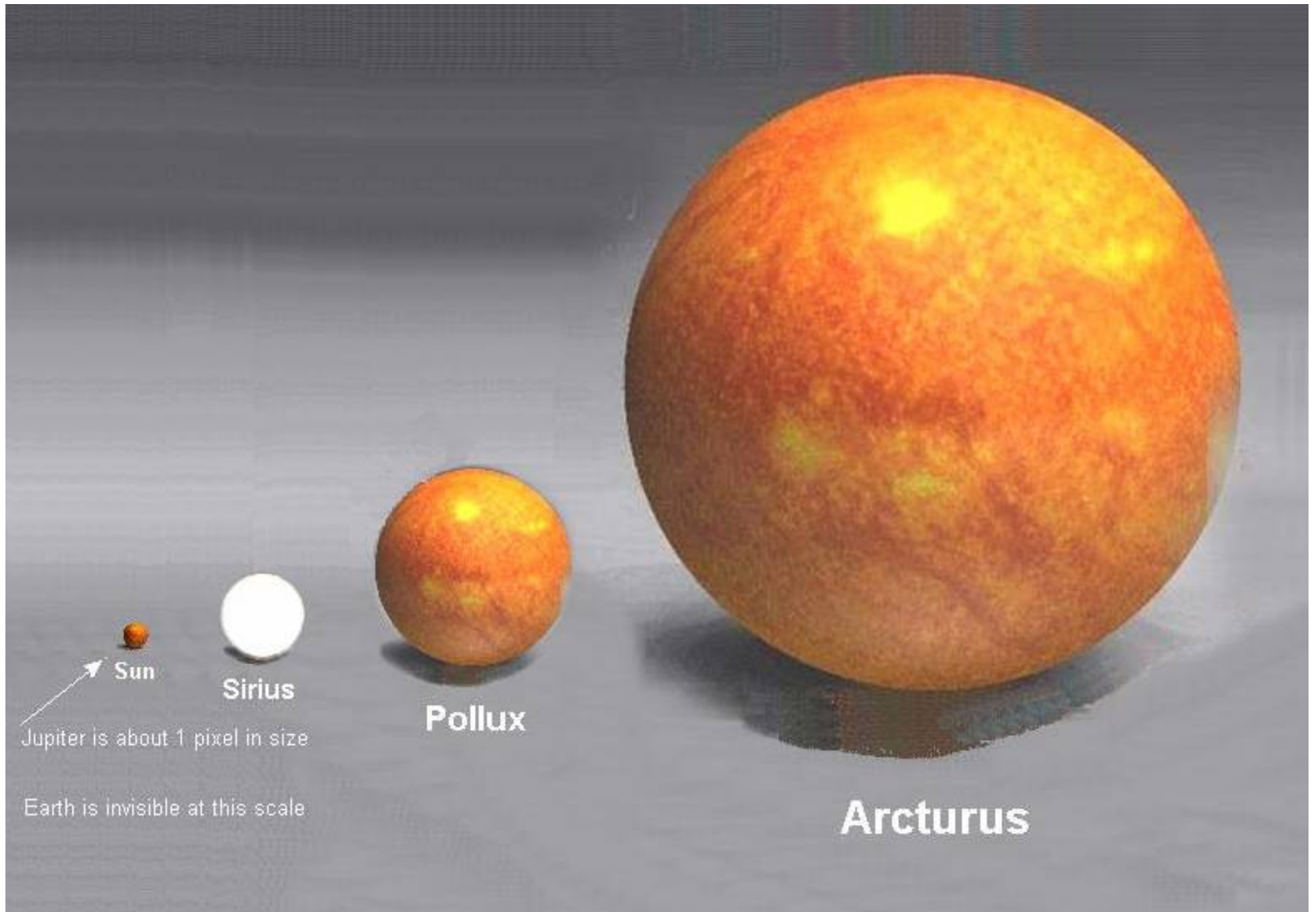
Sun

Jupiter

Earth

Pluto



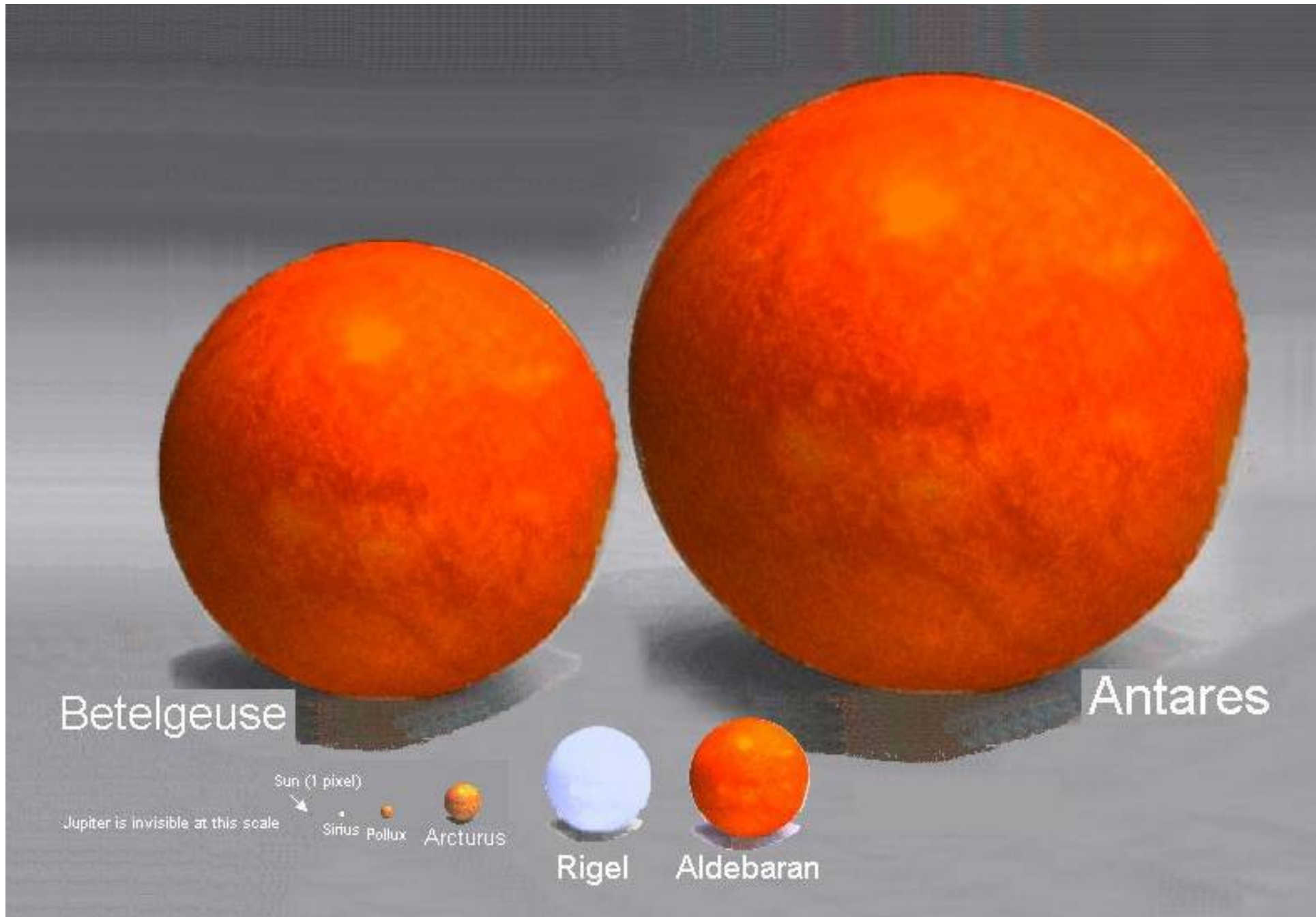


Sun

Sirius

Pollux

Arcturus



Betelgeuse

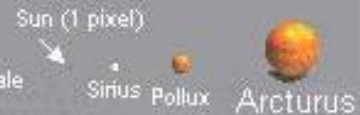
Antares



Rigel



Aldebaran



Sun (1 pixel)

Sirius Pollux Arcturus

Jupiter is invisible at this scale

Hertzsprung-Russell Diagram

