Introducing: The Universe!

Part 2: Fingerprinting the Cosmos

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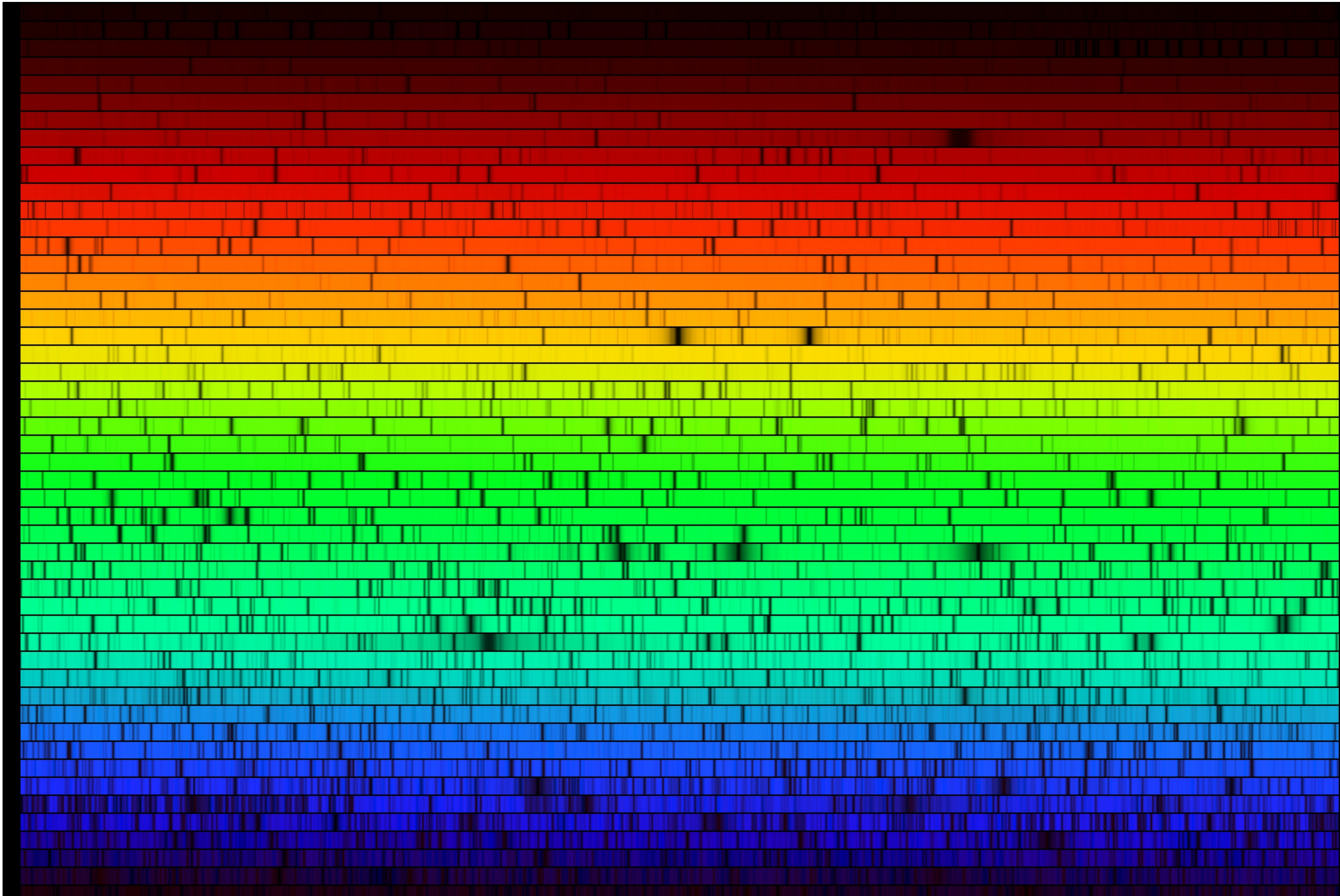
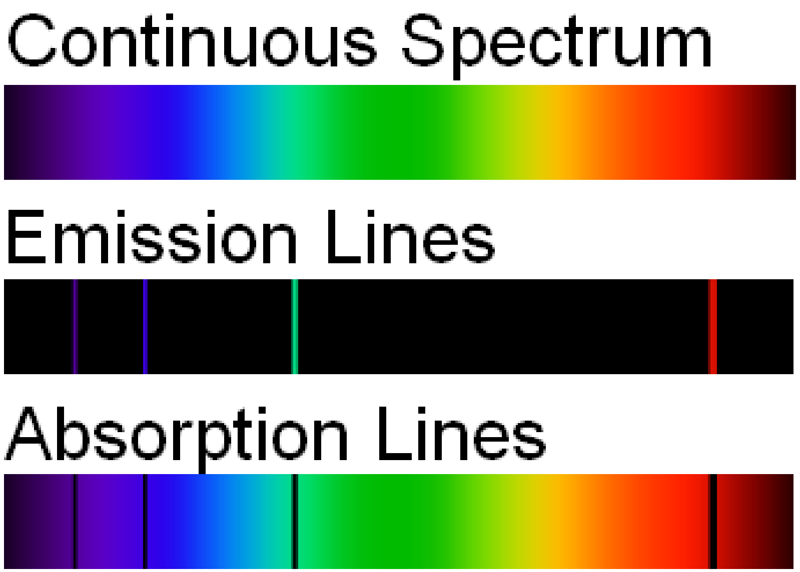


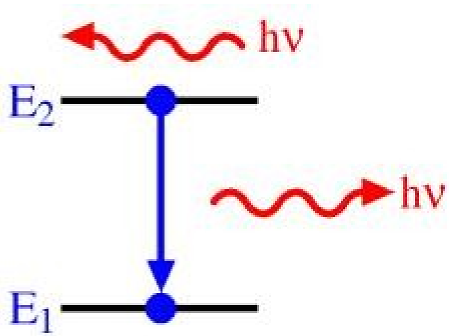
Data: Bob Kurucz et al (SAO); Image: Nigel Sharp. NOAO; Telescope: KPNO-McMath

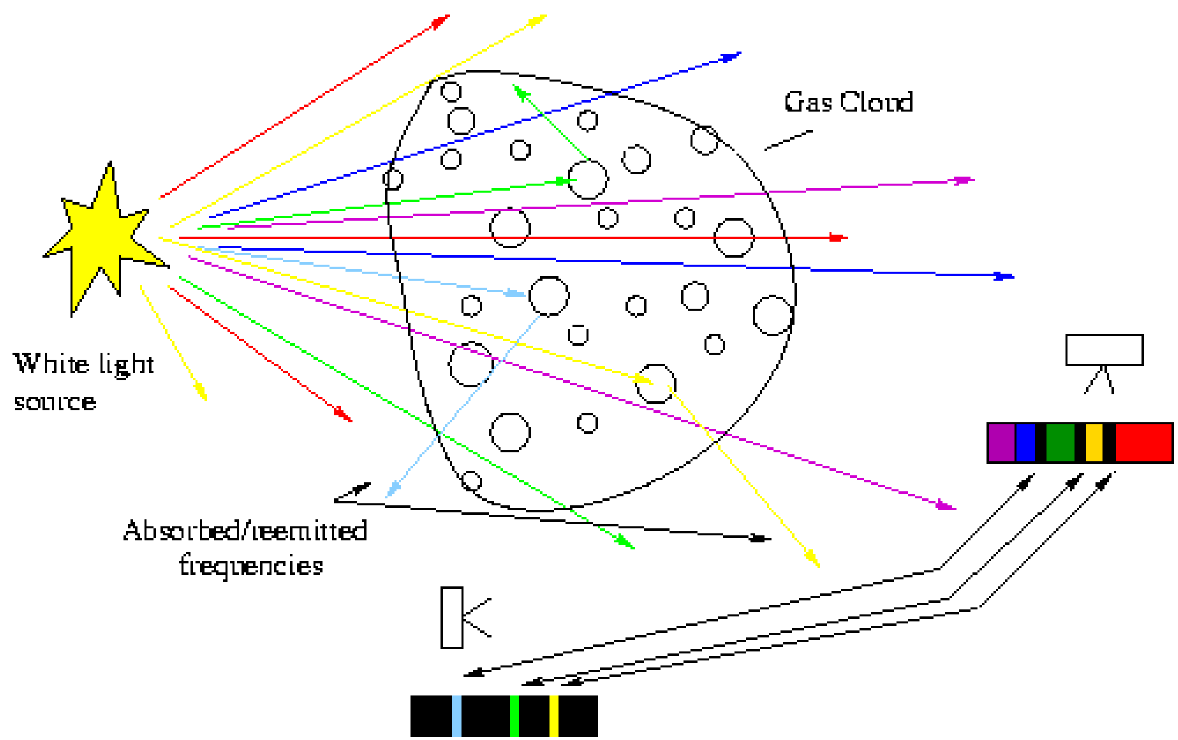
Solar spectrum, 2960-13000 Angstroms



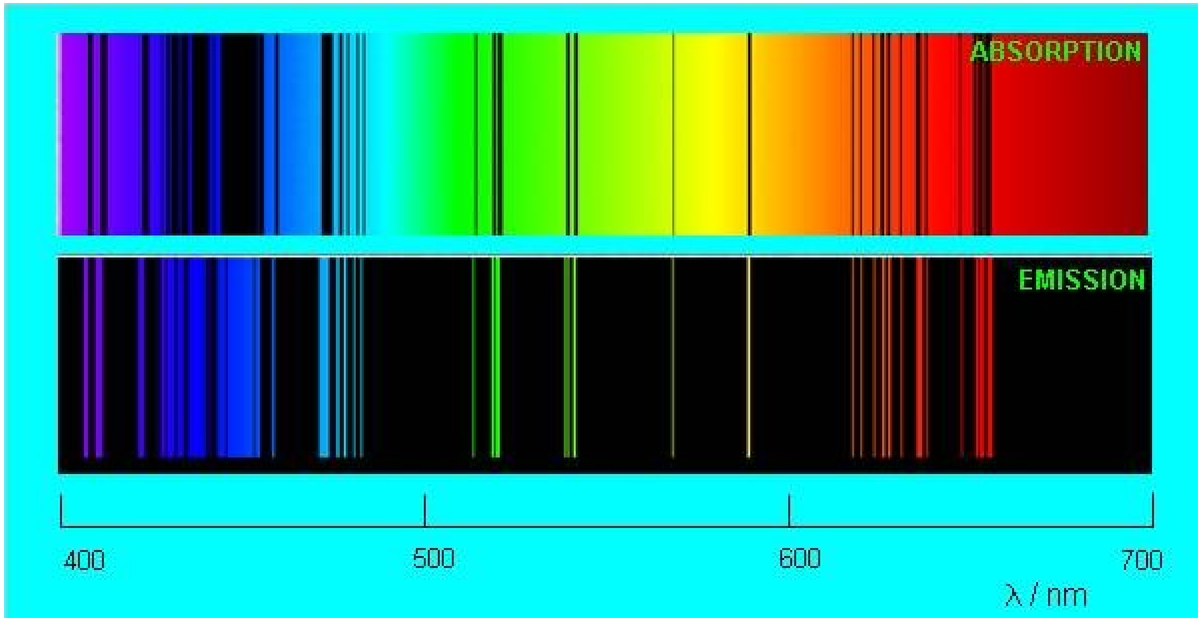
Light passes through a gas made of atoms

Each atom “likes” certain colors – it swallows them, and then re-emits them in a random direction





What we can learn from a spectrum:



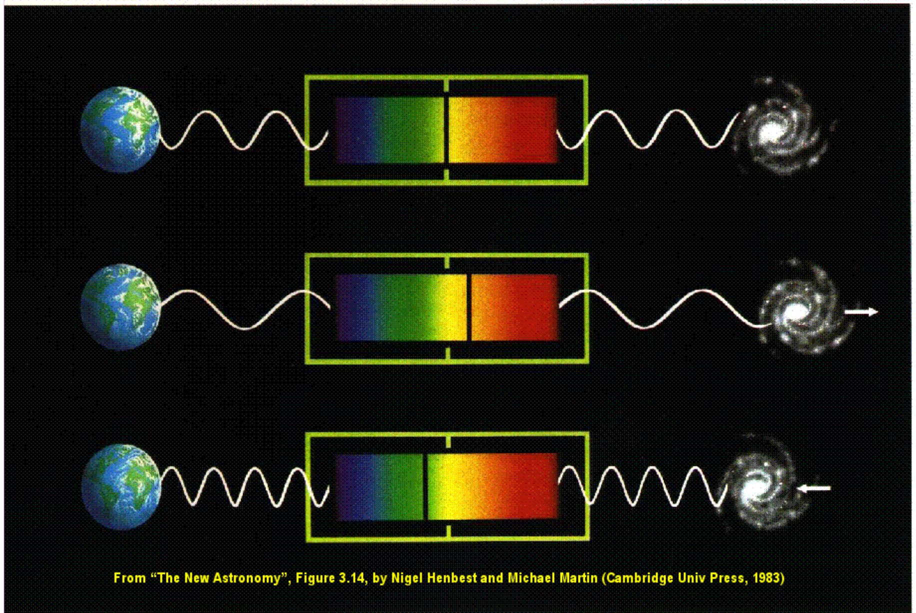
What is the light source made of?

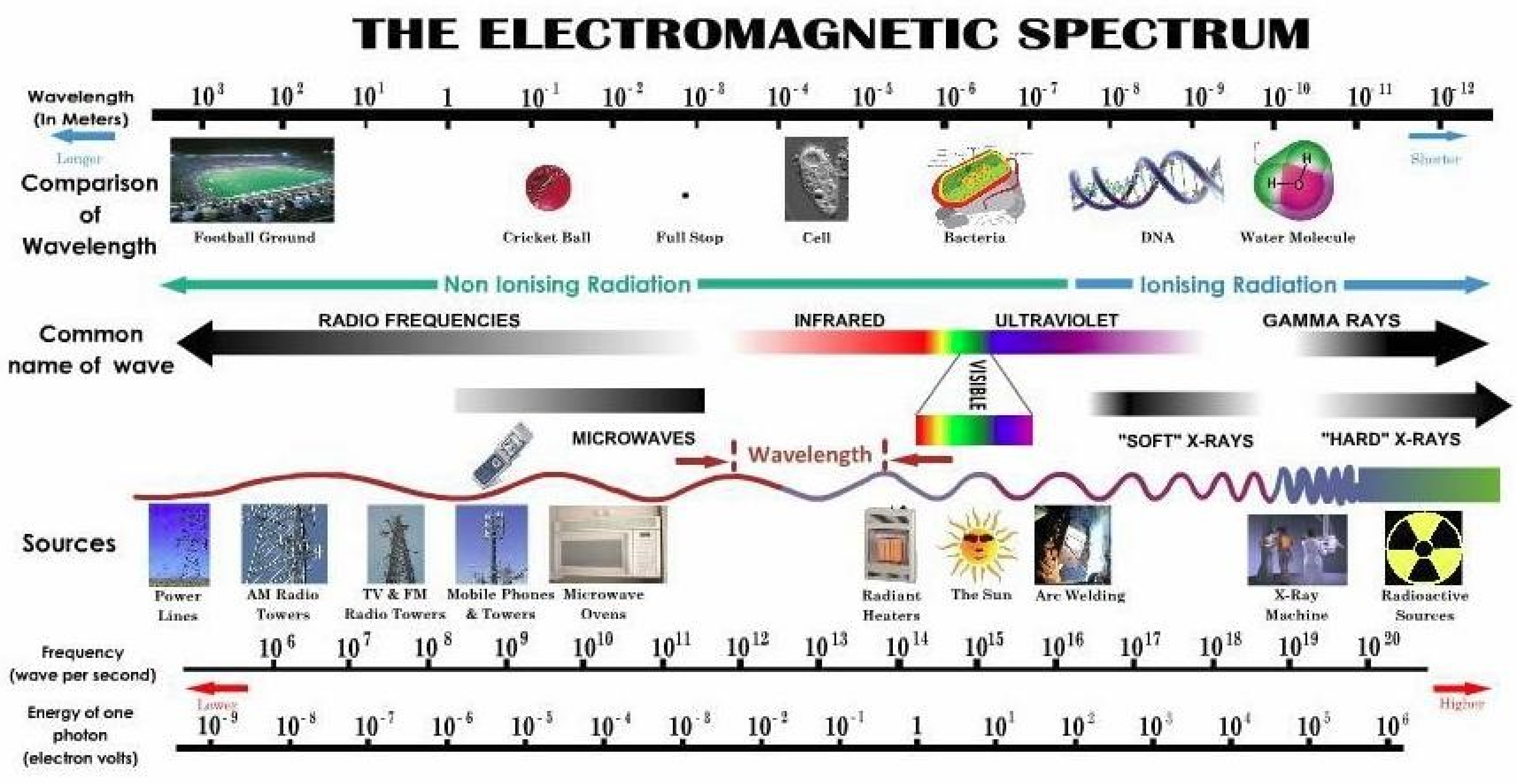
- this is the “fingerprint' of sodium

What are the physical conditions like?

- relative brightness and thickness of different lines indicates temperature and density

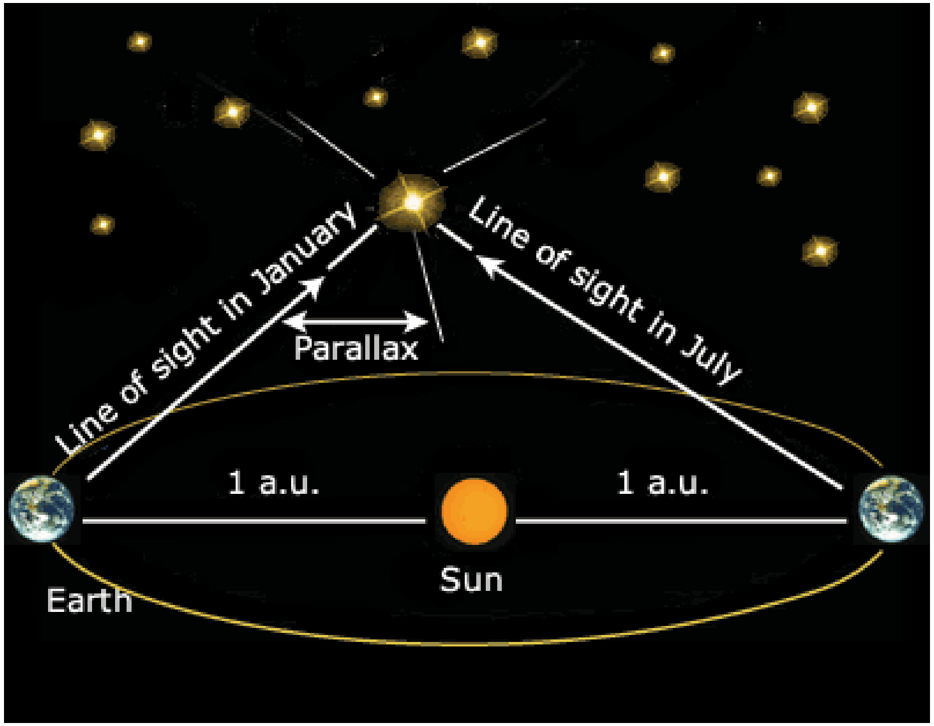
How fast is it moving?
“Doppler Shift” stretches or squeezes the spectrum: read off the speed

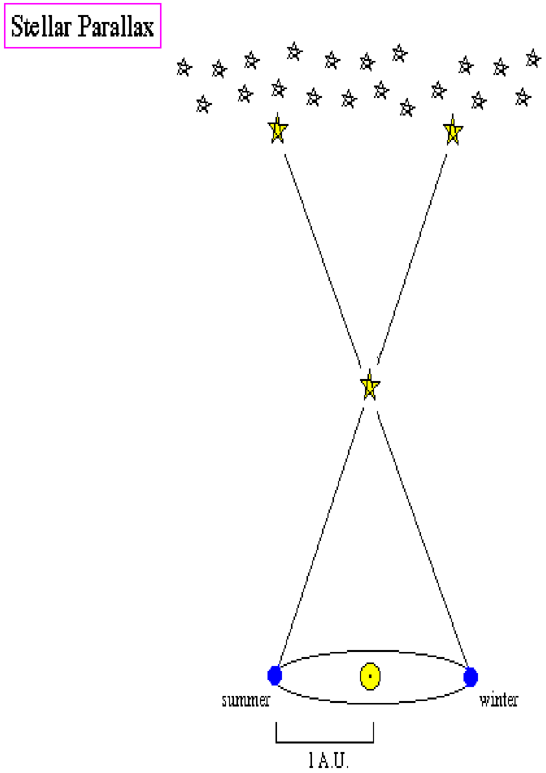



THE ELECTROMAGNETIC SPECTRUM
Wavelength (In Meters)
10^3 10^2 10^1 1 10^-1 10^-2 10^-3 10^-4 10^-5 10^-6 10^-7 10^-8 10^-9 10^-10 10^-11 10^-12
Longer
Shorter
Comparison of Wavelength
Football Ground
Cricket Ball
Full Stop
Cell
Bacteria
DNA
Water Molecule
Non Ionising Radiation
Ionising Radiation
Common name of wave
RADIO FREQUENCIES
INFRARED
ULTRAVIOLET
GAMMA RAYS
VISIBLE
MICROWAVES
Wavelength
"SOFT" X-RAYS
"HARD" X-RAYS
Sources
Power Lines
AM Radio Towers
TV & FM Radio Towers
Mobile Phones & Towers
Microwave Ovens
Radiant Heaters
The Sun
Arc Welding
X-Ray Machine
Radioactive Sources
Frequency (wave per second)
10^6 10^7 10^8 10^9 10^10 10^11 10^12 10^13 10^14 10^15 10^16 10^17 10^18 10^19 10^20
Lower
Higher
Energy of one photon (electron volts)
10^-9 10^-8 10^-7 10^-6 10^-5 10^-4 10^-3 10^-2 10^-1 1 10^1 10^2 10^3 10^4 10^5 10^6

Distances to the stars, step 1: parallax

This is just surveying like on Earth, basic trig.



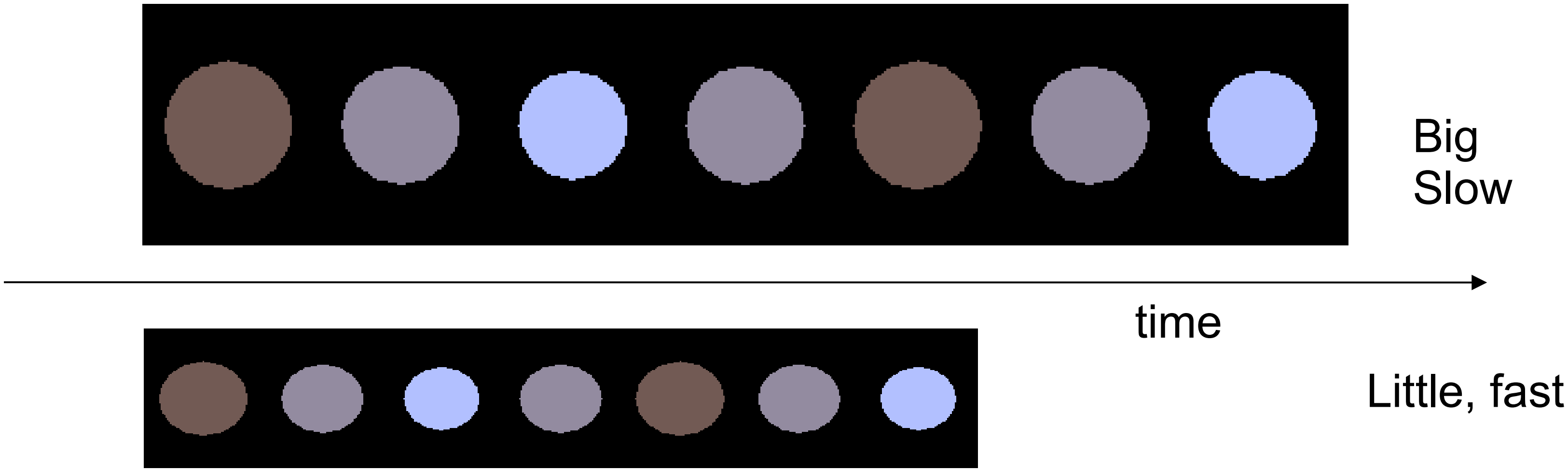


parallax is the apparent change of position of a nearby star with respect to background stars due to the motion of the Earth around the Sun

Lets you measure distance to nearby stars as long as there are more distant ones behind it to compare against

Only works for nearby stars; shift is too small for distant ones

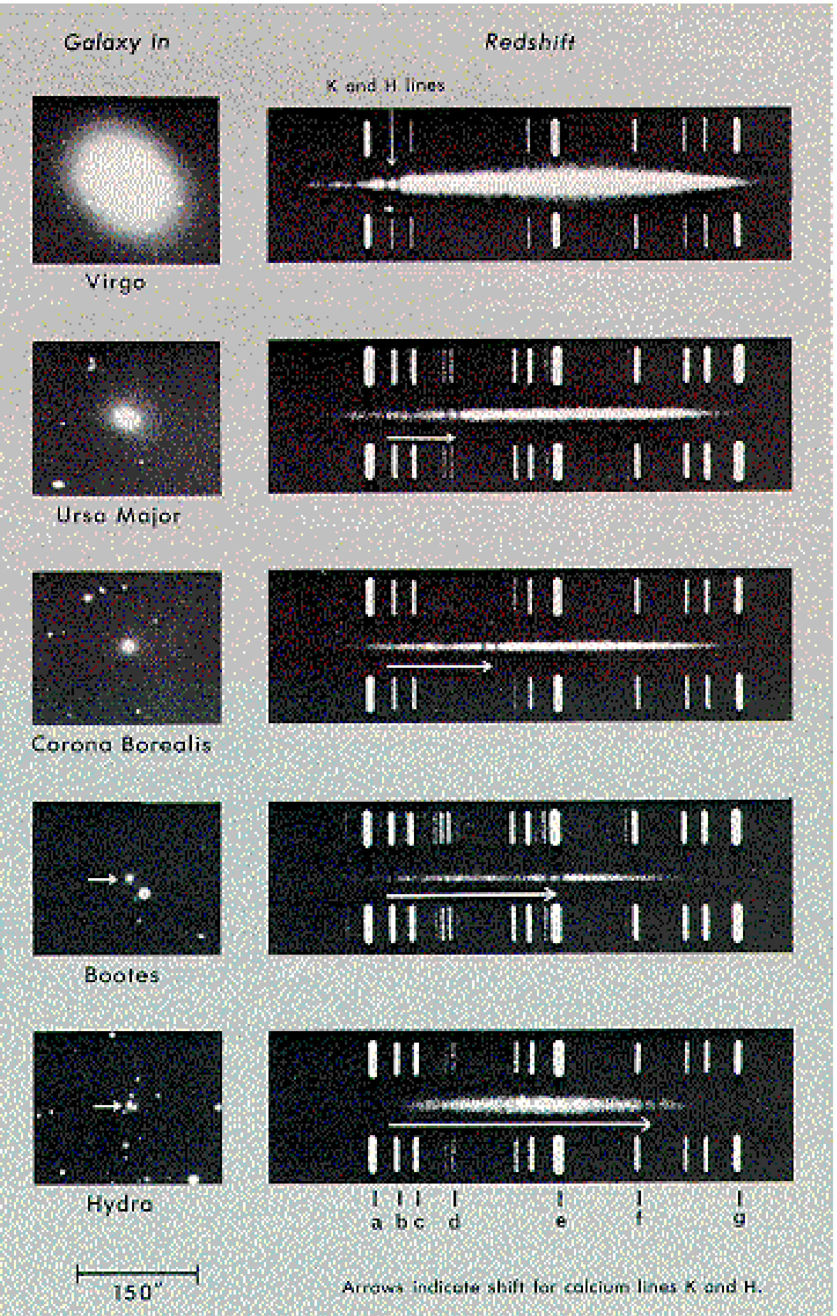
Distance to the stars, step 2: “Standard candles”



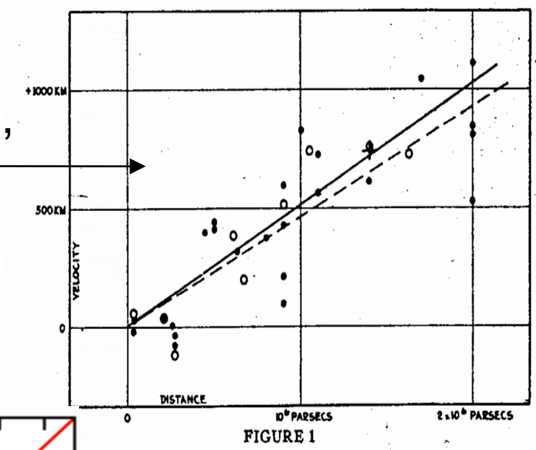
Cepheid stars are unstable: they oscillate – big/cool, small/hot

The bigger, more luminous ones take longer to pulsate than the smaller, feebler ones: use a stopwatch, get the wattage! Compare the wattage and the apparent brightness, get the distance!

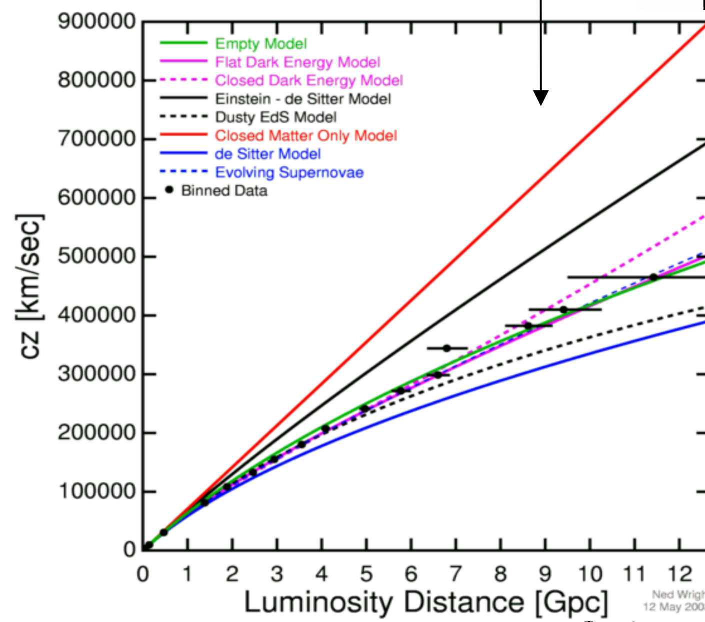
Distances, step 3: Dr. Hubble

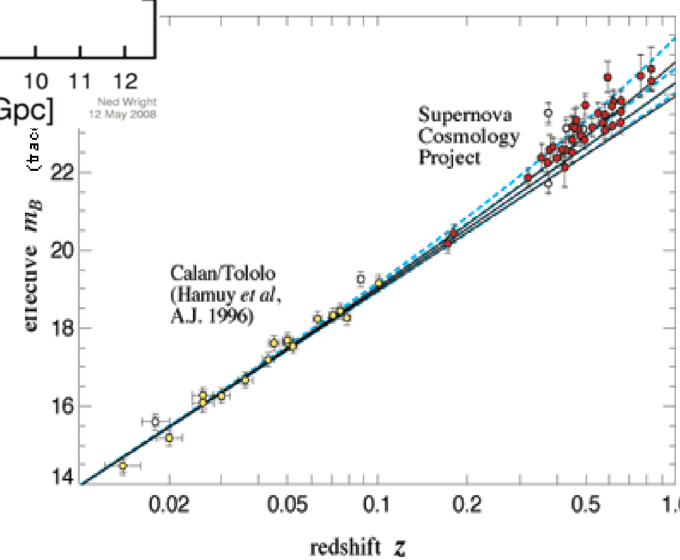


Hubble: to 13 Mpc (he thought only 2!), 1000 km/s

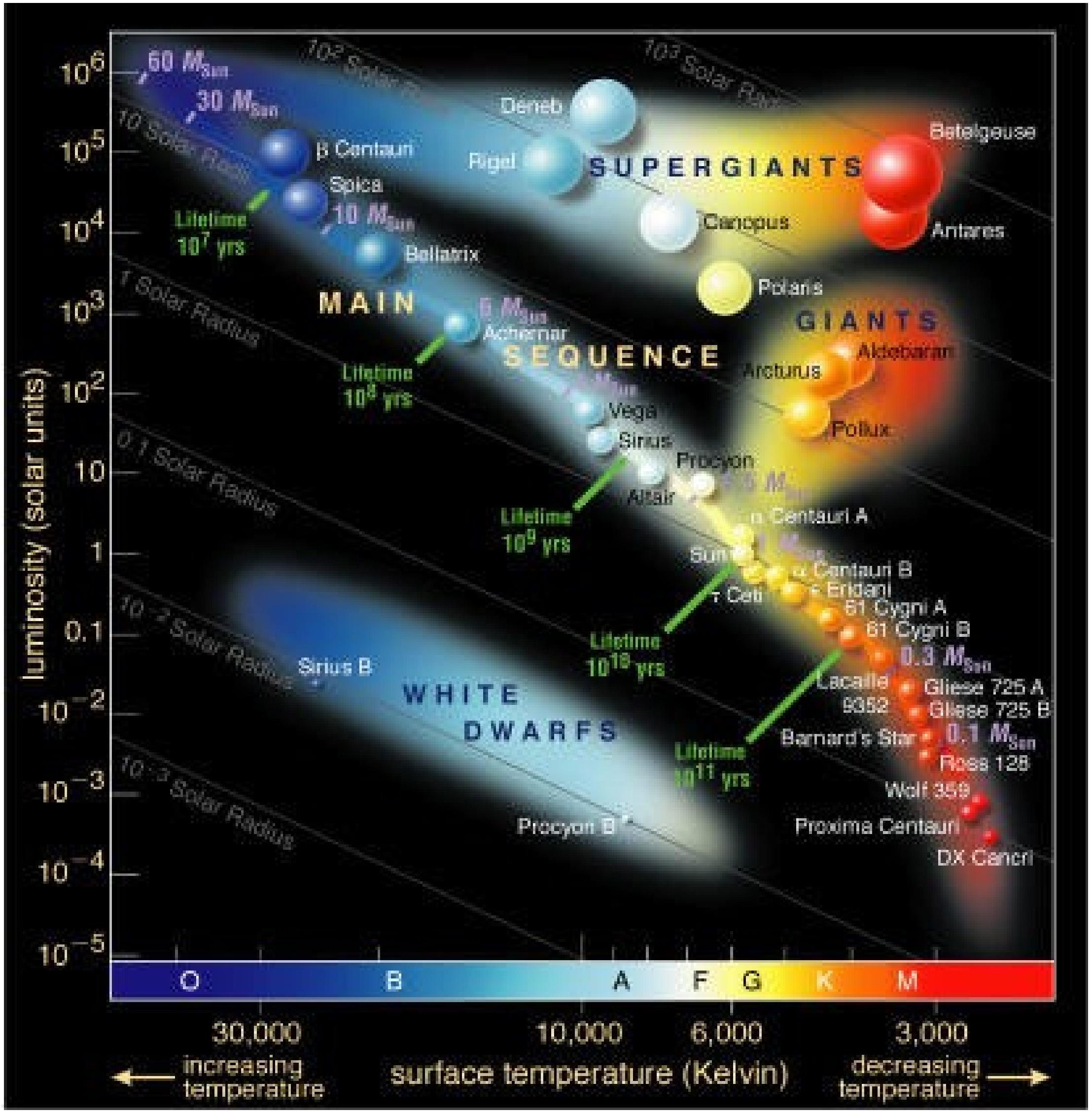


Wright 2008: to 12000 Mpc, 500 000 km/s

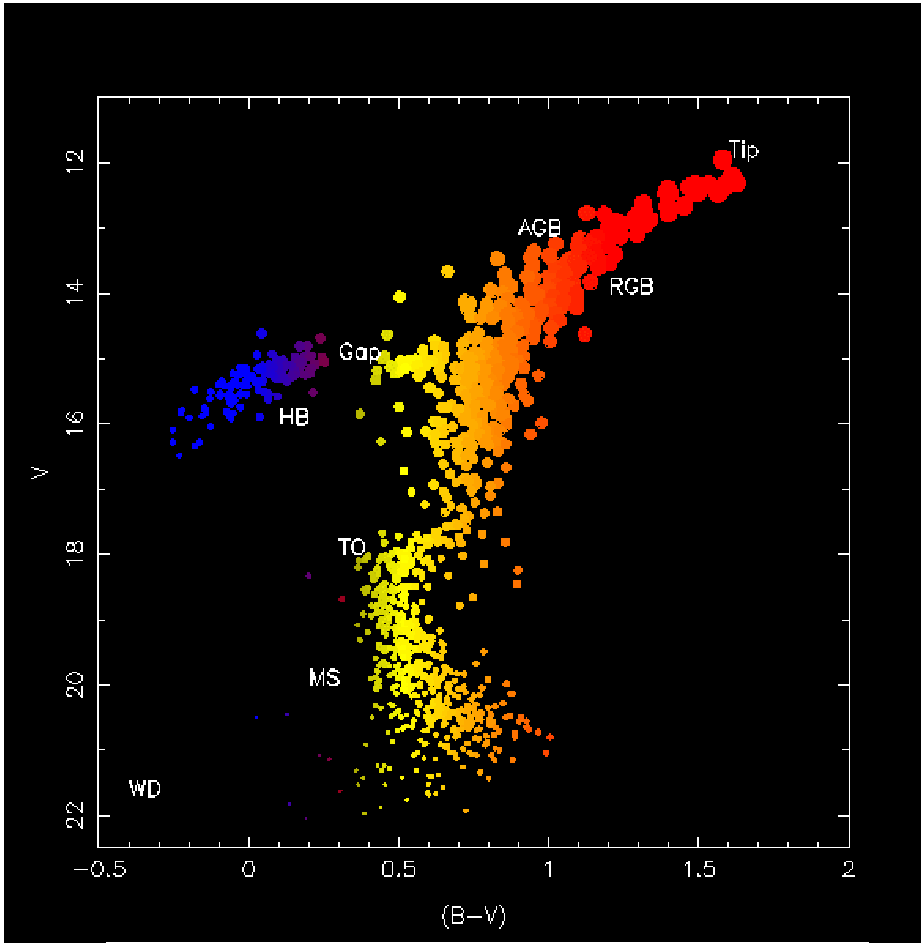


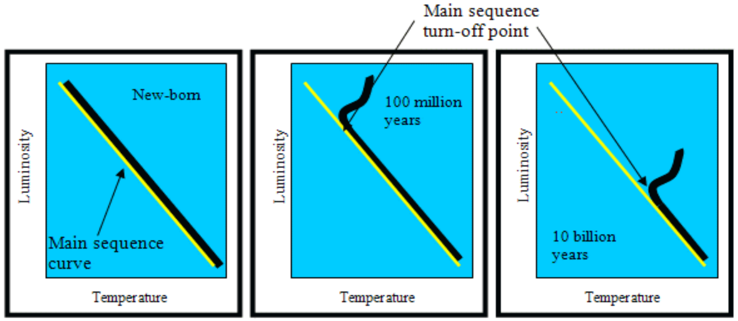


The Hertzprung-Russell diagram: the stellar family tree



Globular cluster M5: 13 Gyr old

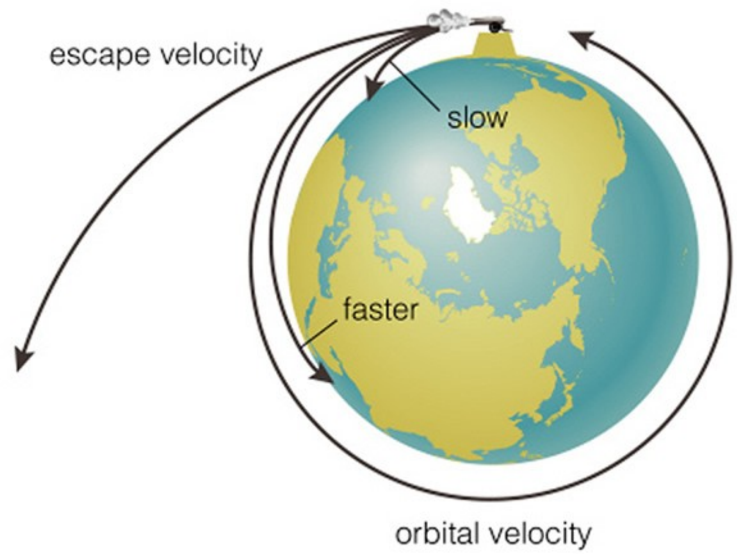


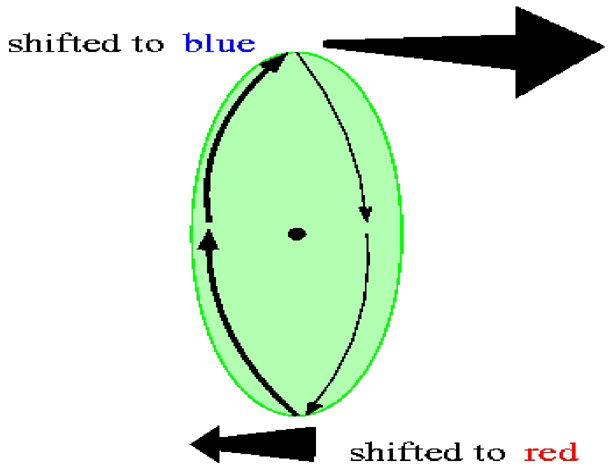


Weighing things in space: What's the Mass?

Bigger gravity: tugs more: things fall toward it faster

Measure speed of object orbiting it – faster the speed, the more gravity there must be.





$$v^2 = \frac{GM}{R}$$