http://concam.net

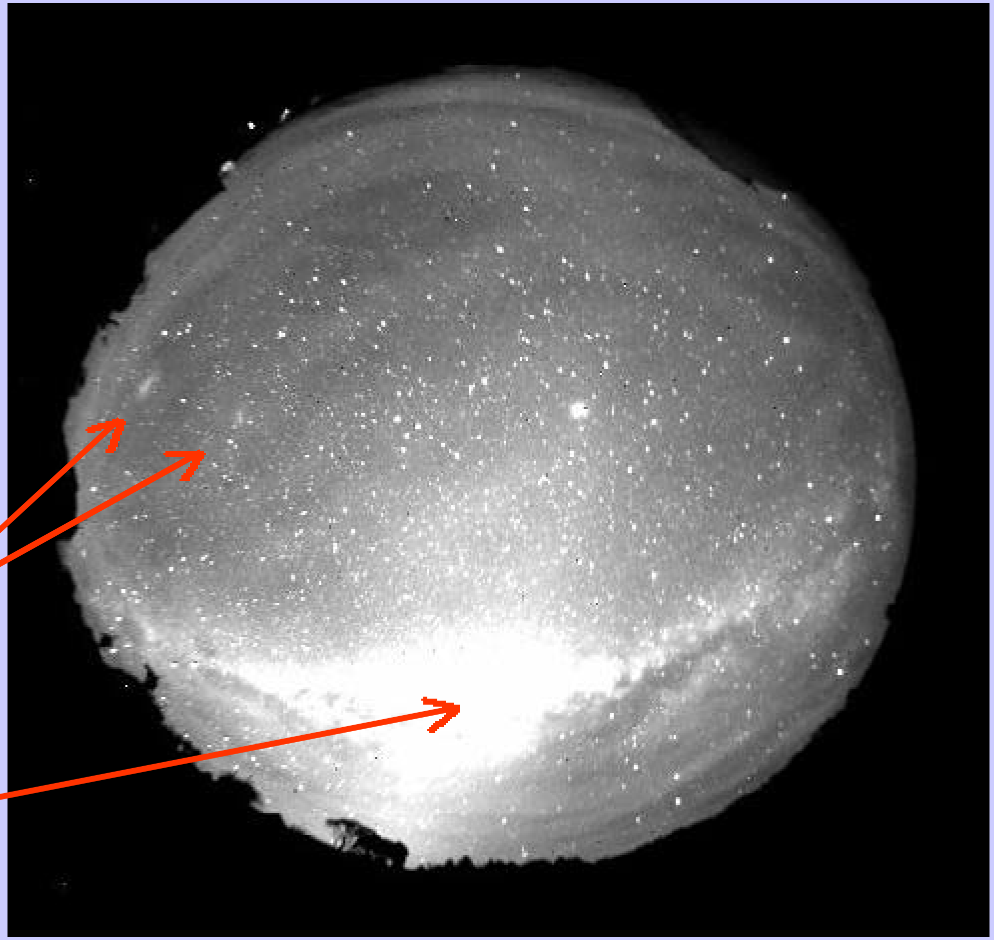
Continuous sky images.
fish-eye lens + CCD.

7 observatories

Sky from Australia:

Magellenic Clouds

Milky Way centre



Magnitudes

- Hipparcos (2nd century BC)
  stars visible by eye:
  1st mag = brightest
  6th mag = faintest
- Herschel (1780s) 1st mag stars are
  100 times brighter than 6th mag stars.
- 1800s -- eye responds to flux ratios

true flux	1	:	10	:	100
perceived	1	:	2	:	3

Apparent Magnitude (measures apparent brightness)

- Pogson (1856)
  . ***apparent magnitude:***

$$m = -2.5\log(F / F_0)$$

$$F = F_0 \times 10^{-(m/2.5)}$$

$$F_0 = \text{flux of } 0 \text{ mag star (Vega)}$$

Naked Eye Stars

- brightest: Sirius (mag -1.5)
- bright mag -1   1 star

bright	mag -1	1 star
.	0	3
.	1	11
.	2	40
.	3	150
.	4	500
.	5	1600
faint	mag 6	4800 stars

Magnitude Difference (measures brightness ratio)

$$m_1 - m_2 = -2.5 \log(F_1 / F_2)$$

$m_1 > m_2$ $\quad F_1 < F_2$

$m_1 - m_2$	F_2 / F_1	
5	100	
10	10^4	
1	$\sqrt[5]{100} \cong$	2.512
0.1	≈ 1.1	(10%)
0.01	≈ 1.01	(1%)

Apparent Magnitude

- Sun m = -26.8
- full moon -12.5
- venus -4
- Sirius -1.5
- Vega 0.0
- faintest galaxies detected by HST +30

$25 \text{ mag} = 10^{10}$

$30 \text{ mag} = 10^{12}$

Absolute Magnitude (measures true brightness)

- *m* = apparent mag at distance *d.*
- *M* = aparent mag at 10 pc.

$$F(10\ \mathrm{pc}) = F(d) \times \left(\frac{d}{10\ \mathrm{pc}}\right)^2$$

$$M = -2.5\log\left(F(10\ pc)/F_0\right)$$

$$= m - 5\log(d/10\ \mathrm{pc})$$

- *d* known (e.g. parallax) for nearby stars.

Absolute Magnitude

- *m* = apparent mag at true distance d.
- *M* = aparent mag at 10 pc.
- *d* known (parallax) for nearby stars

star	*m*	*M*	*d*(pc)
Vega	0.0	+0.5	8.1
Sirius	-1.5	+1.4	2.7
Sun	-26.8	+4.5	1/206265

- Which star is truly brighter?

Distance Modulus (measures distance)

$$m - M = 5\log\left(d/10\ \text{pc}\right)$$
$$= 5\log\left(d/\text{pc}\right) - 5$$

Electromagnetic Radiation (EMR)

- ***EMR = Light*** *(of any wavelength)*
- speed of light in vacuum (slower in air, glass,…)

$$c = 3\times10^{8}\,\mathrm{m/s}$$

- ***wave properties*** (interference,diffraction)
  . frequency = speed / wavelength
  . Hz = cycles/s = (m/s) / m

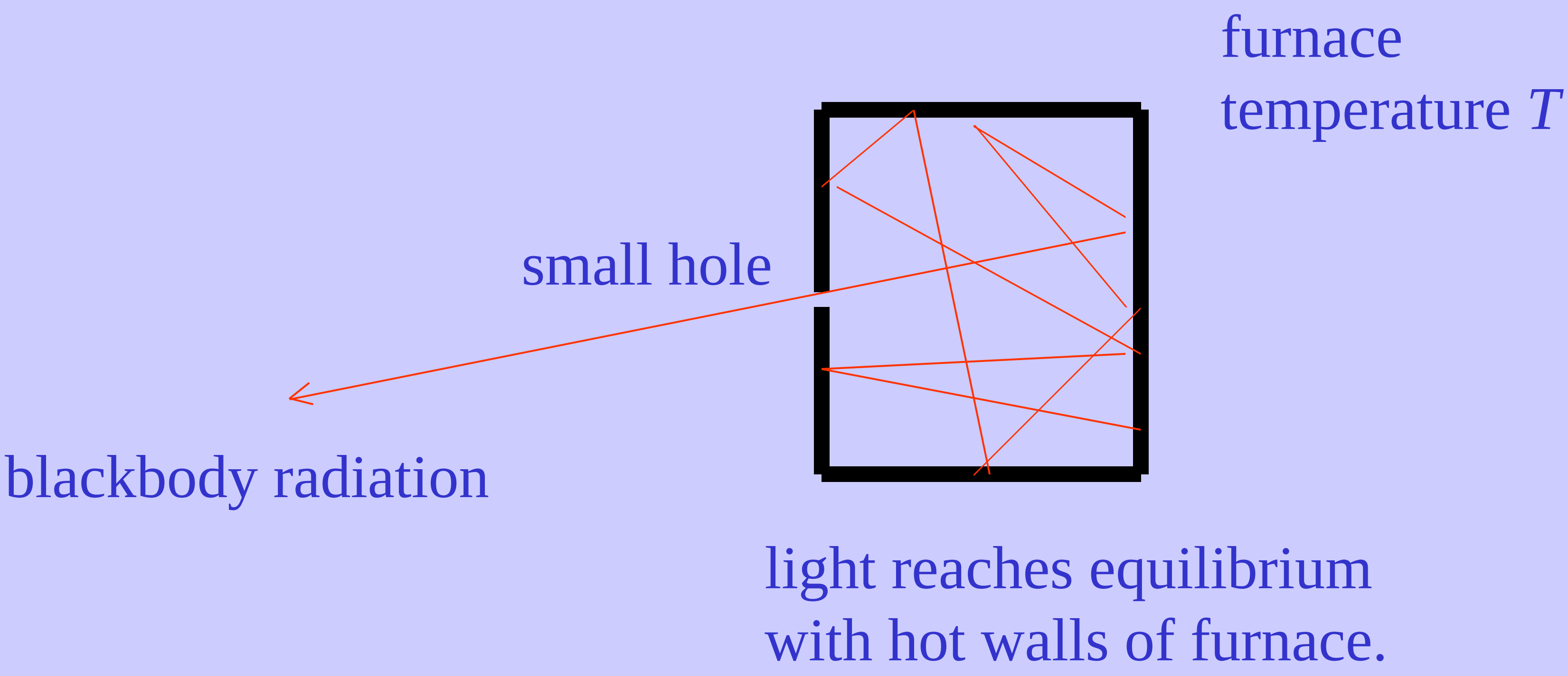
$$f = c / l$$

- ***particle properties*** (photons)
  . discovery by Planck (1900)
  . photon energy :
  . *h* = Planck’s constant (6.6x10^(-34) Joule/Hz)

$$E = h\ f$$

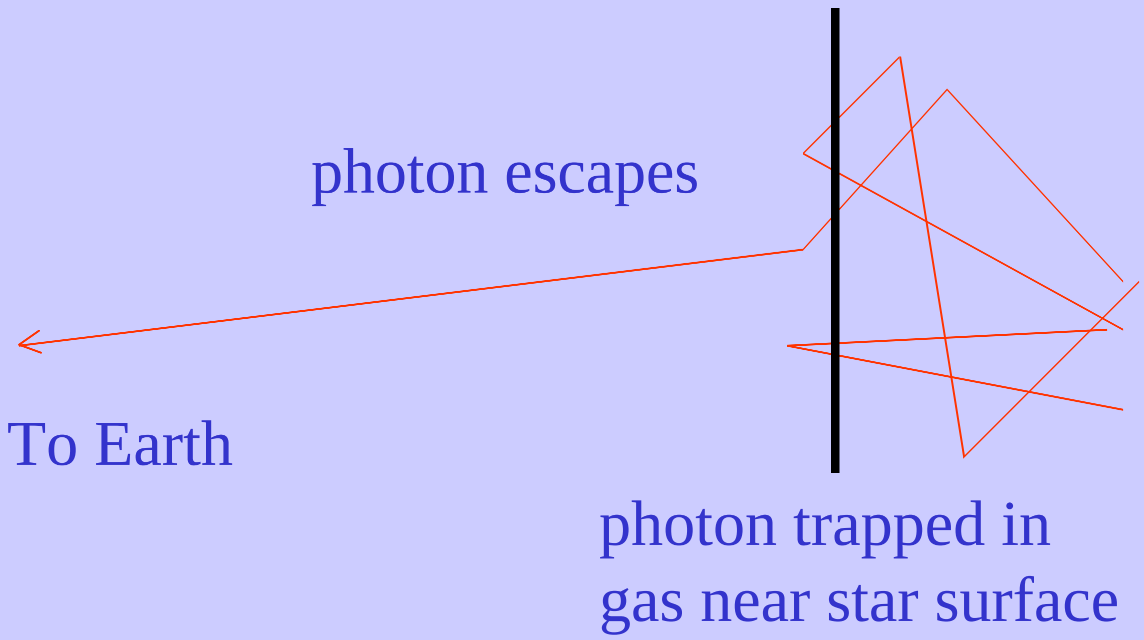
Thermal (Blackbody) radiation

- ***Characterised by temperature T.***



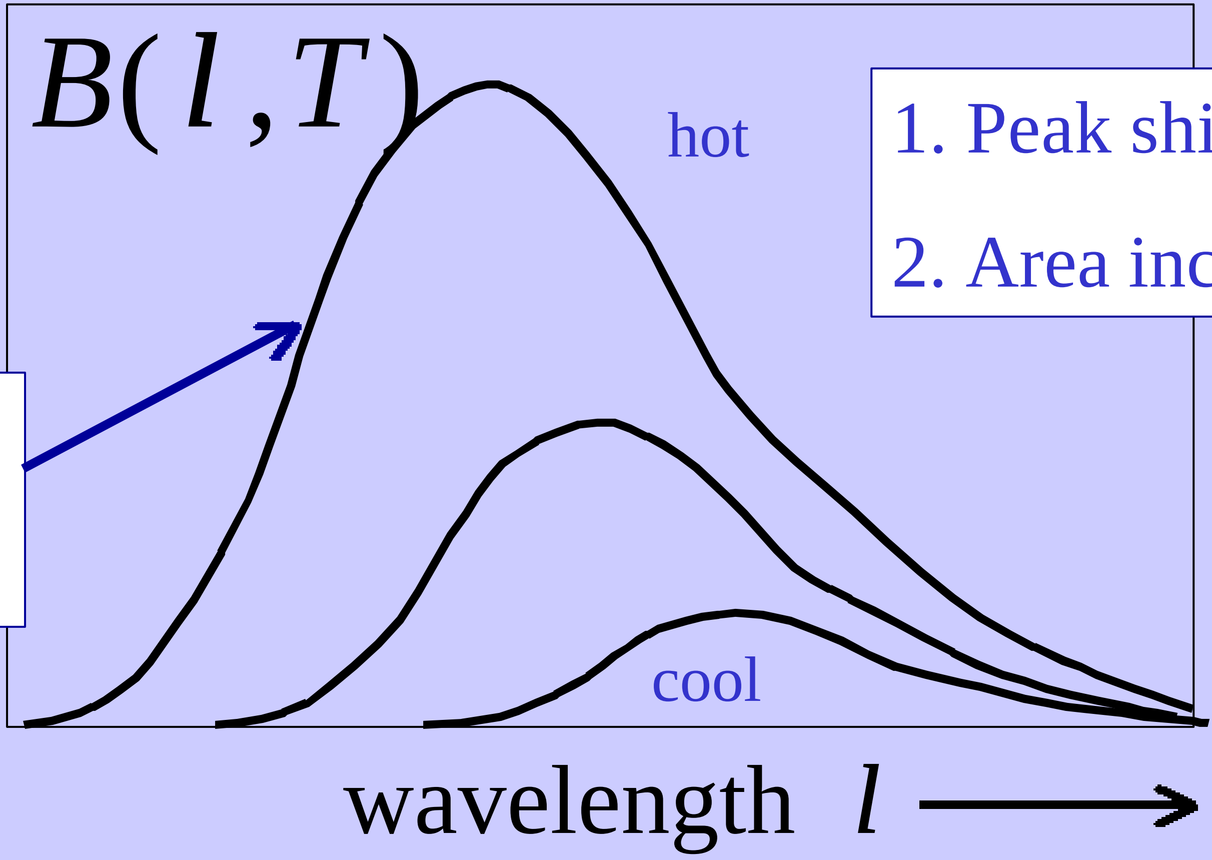
Stellar Spectra

- Resemble blackbody spectra
- temperature *T* at star surface
- (hotter interior invisible)



Blackbody Spectra

Planck function (1900)



1. Peak shifts

2. Area increases

First clue to quantum mechanics

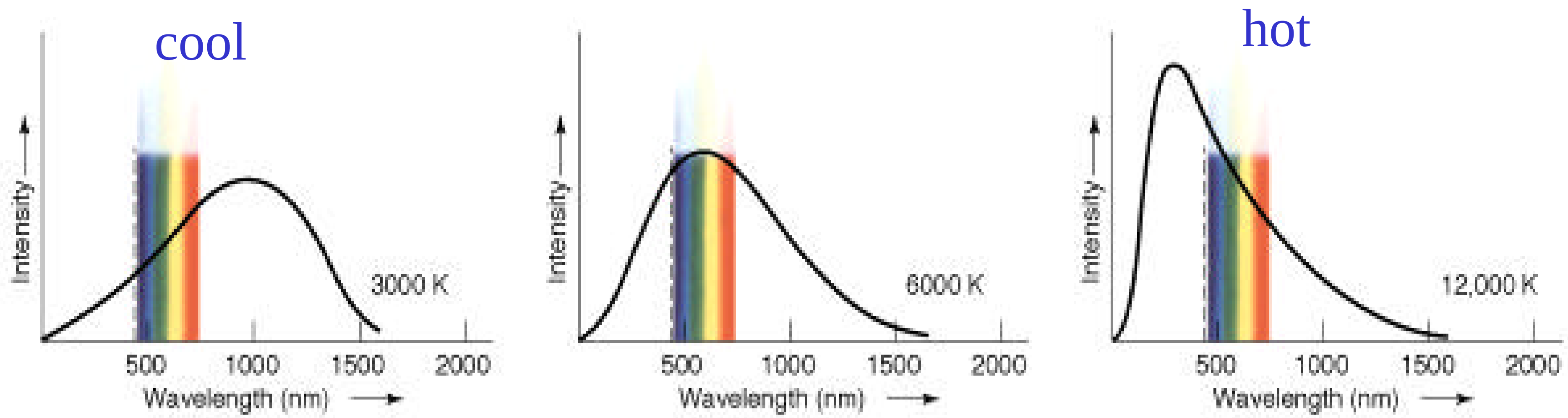
Wien's Law

$$l_{\mathrm{max}} T = \mathrm{constant}$$

$$\approx 0.003 \mathrm{~m~K}$$

$$\left(\frac{l_{\mathrm{max}}}{300 \mathrm{~nm}} \right) \approx \left(\frac{10^4 \mathrm{~K}}{T} \right)$$

Star Colours



a This star looks red

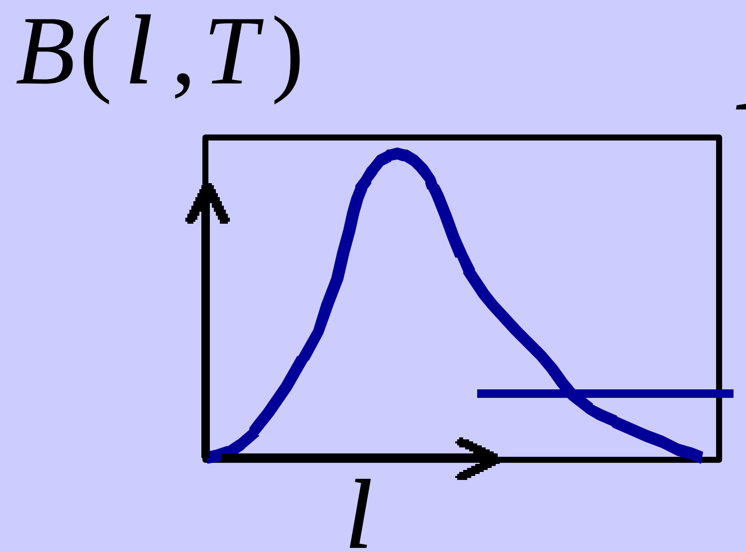
b This star looks yellow-white

c This star looks blue

Wien's Law in action

- Sun: $T \approx 6000$ K, $\lambda_{max} \approx 500$ nm
  - intensity peak at visible wavelength
  - looks yellow or white to us
- hot star: $T = 12000$ K, $\lambda_{max} \approx 250$ nm
  - ultraviolet peak, looks blue
- cool star: $T = 3000$ K, $\lambda_{max} \approx 1000$ nm
  - infrared peak, looks very red

Blackbody Flux



Area increases with T.

$$B(T) = s\ T^4$$

$$\text{units}: \quad \frac{\text{energy}}{\text{time area}} \qquad \frac{\mathrm{W}}{\mathrm{m}^2} = \left(\frac{\mathrm{W}}{\mathrm{m}^2\,\mathrm{K}^4} \right) \left(\mathrm{K}^4 \right)$$

Stefan Boltzmann constant

$$s = 5.7 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$$

Review

magnitudes : $m = -2.5 \log (F / F_0)$

$$M = m - 5 \log (d / 10 \text{ pc})$$

light speed : $c = 3 \times 10^8 \text{ m / s}$

frequency : $f = c / l$

photon energy : $E = h \ f$

blackbody peak : $\left(\dfrac{l_{\text{max}}}{300 \text{ nm}} \right) \approx \left(\dfrac{10^4 \text{ K}}{T} \right)$

flux : $B(T) = s \ T^4$