Measuring Star Temperatures

Careful measurements of a star's light spectrum gives astronomers clues about its temperature. For example, incandescent bodies that have a red glow are 'cool' while bodies with a yellow or blue color are 'hot'. This can be made more precise by measuring very carefully exactly how much light a star produces at many different wavelengths.

In 1900, physicist Max Planck worked out the mathematical details for how to exactly predict a body's spectrum once its temperature is known. The curve is therefore called a Planck 'black body' curve. It represents the brightness at different wavelengths of the light emitted from a perfectly absorbing 'black' body at a particular temperature.

From the mathematical properties of the Planck Curve, it is possible to determine a relationship between the temperature of the body and the wavelength where most of its light occurs - the peak in the curve. This relationship is called the Wein Displacement Law and looks like this:

$$\text{Temperature} = \frac{2897}{\text{Wavelength}}$$

Where the temperature will be in units of Kelvin degrees, and the wavelength will be in units of micrometers.

The lower plot is the spectrum of the white dwarf star 40 Eridani B. The horizontal axis is in units of Angstroms. (10,000 Angstroms = 1 micrometer)

**Problem 1** - Based on the overall shape of the curve, and the wavelength where most of the light is being emitted, use the Wein Displacement Law to determine the temperature of 40 Eridani B.

**Problem 2** - What would be the peak wavelengths of the following stars in A) Angstroms; B) nanometers?

A) Antares ....................... 3,100 K  
B) Zeta Orionis............... 30,000 K  
C) Vega ......................... 9,300 K  
D) Regulus...................... 13,000 K  
E) Canopus...................... 7,300 K  
F) OTS-44 brown dwarf... 2,300 K

Note:

1 micron = 10,000 Angstroms  
1 nanometer = 10 Angstroms
Answer Key:

**Problem 1** - Based on the overall shape of the curve, and the wavelength where most of the light is being emitted, use the Wein Displacement Law to determine the temperature of the white dwarf star 40 Eridani B.

Answer: The peak of the curve is near 4600 Angstroms or 0.46 micrometers. The temperature is $2897 / 0.46 = 6280$ K.

**Problem 2** - What would be the peak wavelengths of the following stars in Angstroms:

- A) Antares occurs at $2897 / 3100 = 0.9$ microns or 9000 Angstroms
- B) Zeta Orionis is at $2897 / 30000 = 0.10$ microns or 1000 Angstroms
- C) Vega is at $9300$ K = 0.31 microns or 3100 Angstroms
- D) Regulus is at $13000$ K = 0.22 microns or 2200 Angstroms
- E) Canopus is at $7300$ K = 0.39 microns or 3900 Angstroms
- F) OTS-44 brown dwarf is at $2300$ K = 1.2 microns or 12000 Angstroms

What would be the peak wavelengths of the following stars in nanometers?

- A) Antares: 9000 Angstroms = 900 nanometers
- B) Zeta Orionis: 1000 Angstroms = 100 nanometers
- C) Vega: 3100 Angstroms = 310 nanometers
- D) Regulus: 2200 Angstroms = 220 nanometers
- E) Canopus: 3900 Angstroms = 390 nanometers
- F) OTS-44 brown dwarf: 12000 Angstroms = 1200 nanometers.