Garment of Brightness

May the warp be the white light of morning,
May the weft be the red light of evening,
May the fringes be the falling of the rain,
May the border be the standing rainbow.
Thus weave for us a garment of brightness.

*Song of the Sky Loom  (Native American Traditional)*

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**The Interaction of Matter and Electromagnetic Radiation (Light)**

Understanding This is an Important Tool of Astronomy

Light Interacts with matter in several ways…

- Reflection
- Refraction
- Diffraction
- Absorption
- Emission
- Gravitation!

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**Review**

- Light is a form of Electromagnetic Radiation
- Radiation may be described as waves
- Waves are described by their frequency, wavelength, amplitude and speed.

\[ c = f \lambda \]

\[ c = 3 \times 10^8 \text{ m/s} \]
Reflection

Reflection Nebulae

Refraction

Light bends when moving from one substance to another...

Absorption and Emission

Diffraction

Light bends around obstacles...

Observations

Absorption and Emission

Thermal (Blackbody) Radiation Spectra

273 Kelvin = 0 ºC
Two Laws of Thermal Radiation:

1. **Stefan-Boltzmann Law**: Hotter objects emit more power per unit area.
   \[
   \frac{P}{A} = \sigma T^4
   \]
   \[
   \sigma = 5.7 \times 10^{-8} \text{ watts/m}^2 \times \text{K}^4
   \]

2. **Wien’s Law**: Hotter objects emit light that has a higher average energy.
   \[
   \lambda_{\text{max}} = \frac{2.900 \times 10^6 \text{nm}}{T}
   \]

**Practical Example**

Consider a perfect thermal emitter with a temperature of 15000 K. How much power does it emit per unit area? What is the wavelength of maximum intensity?

**Calculation**

\[
\sigma T^4 = 5.7 \times 10^{-8} \times 15000^4 = 2.9 \times 10^9 \text{ W/m}^2
\]

\[
\lambda_{\text{max}} = \frac{2.900 \times 10^6 \text{ nm}}{15000} = 190 \text{ nm}
\]
Why does the sun shine?
- Chemical Burning – insufficient radiation
- Radiative Cooling – only thousands of years
- Gravitational Contraction – only 25 million years

\[ E = mc^2 \]
Stars convert energy into matter.

600 million tons of H $\rightarrow$ 598 million tons of He
IN ONE SECOND
The force of gravity inward and the radiation pressure outward balance each other out.

Gravitational Equilibrium

The total power output of the sun: \(3.8 \times 10^{24}\) watts!!!

Think of your 60 watt light bulb.

1 second of the earth luminosity contains enough energy to meet our needs for roughly 500,000 years!

Only about one two-billionth of that reaches Earth.

Gravitational Equilibrium

91.2% Hydrogen – 8.7% Helium

0.1% Heavier Elements

Spectroscopy

Visible Spectrum

Not at all dark

Roughly the size of the earth

Show the differences in rotation: 27 days equator – 31 days poles

Only about one two-billionth of that reaches Earth.

Luminosity

Granularity of the Solar Surface

Convection
A Solar Prominence

Understanding the sun:

– Light Interacts with Matter
– Spectrum (Energy - Temp - Color)
– E and A Spectra
– Radiation Laws
– Doppler Shift
– Gravitational Equilibrium

Next Time……

STARS, A Mass of Incandescent Gas