Investigating Hot Gases near a Black Hole

Temperature (Kelvin)	Color (nm)
9,000	400 (violet)
7,000	500 (yellow)
6,000	600 (orange)
5,000	700 (red)
4,000	900 (infrared)
T	???

As gas falls into a black hole, friction makes it get hotter and hotter. Just as turning up the temperature on your stove makes its color change from dull-red to brilliant yellow, as a gas heats up, the light it produces also changes its color. Photographers and scientists define colors by the wavelengths of light that they correspond to in the 'visible' part of the electromagnetic spectrum. Wavelengths are measured in nanometers, where 1 nanometer is 1 billionth of a meter. Temperatures are measured in Kelvins where 0 Kelvin is Absolute Zero (- 273^{o} Celsius).

The table above compares the color and temperature of a gas at five different distances from a black hole that has 10 times the mass of our sun.

Problem 1 – What is the formula that gives, W, the wavelength of the light in nanometers, given the temperature, T, of the gas in Kelvins?

Problem 2 - Suppose that an astronomer detected light from the gas near a black hole that had a wavelength of Ultraviolet-B (UV-B) radiation at a wavelength of 200 nm. What is the temperature of the gas at this location?

Problem 3 – Gas that is very close to a black hole can be so hot that it shines brightly in x-ray light with a wavelength of W = 3.6 nm. What is the temperature of this gas?

Problem 1 – What is the formula that gives, W, the wavelength of the light in nanometers, given the temperature, T, of the gas in Kelvins?

Answer: This is actually a test of whether the student can recognize that as the temperature increases, W decreases, so the relationship is an **inverse relationship** between W and T.

If T = 6,000 K we have W = 600 nm, so **W = 3,600,000 / T**

Problem 2 - Suppose that an astronomer detected light from the gas near a black hole that had a wavelength of Ultraviolet-B (UV-B) radiation at a wavelength of 200 nm. What is the temperature of the gas at this location?

Answer: Students have to solve 200 = 3,600,000 / T to get T = 3,600,000/200 so **T = 18,000 K**.

Problem 3 – Gas that is very close to a black hole can be so hot that it shines brightly in x-ray light with a wavelength of W = 3.6 nm. What is the temperature of this gas?

Answer: W = 3,600,000/T so T = 3,600,000/W and for W = 3.6 nm, we have T = 3,600,000/3.6 so **T = 1 million K**.