ASTRONOMY 1102 – 1

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Answers to HW2, Fall 1999

1) Problems 8 and 9: *The Doppler Effect*
$\lambda_{\rm rest} = 121.6$ nm for the transition from level 2 to 1 in H.
Here are the observations and the calculations

Star A

$\lambda_{\rm obs} = 120.5$ nm, shorter than $\lambda_{\rm rest}$, so it is a blueshift. $\Delta\lambda = \lambda_{\rm obs} - \lambda_{\rm rest} = -1.1$ nm, so $v/c = \Delta\lambda/\lambda_{\rm rest} = -0.009$, and the star is approaching us with a *radial* velocity of $v = -2714$ km/s (the negative sign indicates approach).

Star B

$\lambda_{\rm obs} = 121.2$ nm, shorter than $\lambda_{\rm rest}$, so it is a blueshift. $\Delta\lambda = \lambda_{\rm obs} - \lambda_{\rm rest} = -0.4$ nm, $v/c = \Delta\lambda/\lambda_{\rm rest} = -0.0033$, $v = -987$ km/s.

Star C

$\lambda_{\rm obs} = 121.9$ nm, longer than $\lambda_{\rm rest}$, so it is a redshift. $\Delta\lambda = \lambda_{\rm obs} - \lambda_{\rm rest} = +0.3$ nm, so $v/c = \Delta\lambda/\lambda_{\rm rest} = 0.0025$, and the star is moving away from us with a *radial* velocity of $v = +740$ km/s (the positive sign – which can be omitted – indicates recession).

Star D

$\lambda_{\rm obs} = 122.9$ nm, longer than $\lambda_{\rm rest}$, so it is a redshift. $\Delta\lambda = \lambda_{\rm obs} - \lambda_{\rm rest} = +1.3$ nm, $v/c = \Delta\lambda/\lambda_{\rm rest} = 0.0107$, $v = +3207$ km/s.

Problem 11: *Understanding Light Bulbs*
$\lambda_{\rm max} = 2.9 \times 10^6 {\rm nm}/3 \times 10^3 = 967$ nm. This is longer than the longest visible wavelength (700 nm), so it is in the infrared band. So most of the energy emitted by a hot filament at this temperature is in the infrared. That's why the bulb gets hot. Overall, it is redder than the sun because the light it emits has a higher proportion of red than the light emitted by the sun (at approximately double the temperature). Objects indoors, illuminated by an incandescent bulb reflect light that is redder than outdoors (sun). The sensitivity of indoors film must be adjusted accordingly. Fluorescent tubes emit in spectral lines with little or no continuous spectrum. So most of the energy is in visible lines rather than in the infrered (IR), so they are more efficient. So if a 15 W compact fluorescent bulb emits as much light as a 75 W bulb, it is 5 times more efficient. Consider also their useful life or lifetime.

2) In a quasar, a line of $\lambda_{\rm rest} = 400$ nm is observed at $\lambda_{\rm obs} = 500$ nm (redshift). Therefore $\Delta\lambda = \lambda_{\rm obs} - \lambda_{\rm rest} = +100$ nm, so $v/c = \Delta\lambda/\lambda_{\rm rest} = 1/4$, and the quasar is moving away from us with a *radial* velocity of $v = 3/4 \times 10^5$ km/s $= 7.5 \times 10^4$ km/s.

3) Along line of sight 1 you are looking at atoms in the cloud that are excited by the radiation of the hot star. You see them when they return to the ground state by emitting photons at the wavelengths corresponding to the atomic levels of those atoms. So you only see emission lines, and this is an *emission line spectrum.*

Along line of sight 2 you are looking at the star (which emits mostly a contiunous spectrum similar to a blackbody at the effective temperature of the star) *through* a cloud which absorbs only on certain wavelengths (the saem wavelengths as you see in the emission spectrum above). Since the cloud removes light at those wavelengths, you see what is left over: a bright continuum with dark lines in it, and this is an *absorption line spectrum.*