Friday, Sep. 26

Syllabus, class notes, and homeworks are at:
www.as.utexas.edu → courses → AST 301, Lacy

Reading for next week: chapter 7

Put your homework in the baskets in back and pick up a new one for next week.

The Wednesday help session is in GRG 424 at 5:00 (for the entire semester).

1. Star A has a magnitude of 4 (it is a 4th magnitude star). Star B has a magnitude of 5. What does this tell me about how these two stars compare?
Star A (with the smaller magnitude) appears brighter. It is 2.5 times brighter (one magnitude).

2. I have sketched below the big dipper and Polaris as they will appear at 9:00 tonight. Make a sketch showing how they will appear 6 hours later, at 3:00 AM.
The celestial sphere pivots by 90° counter-clockwise about Polaris in 6 hours.
The dipper would be below Polaris and rotated by 90°.

3. a) Describe the motion of the Sun across the sky during a day in September in Quito, Ecuador (on the equator).
You look due east to watch it rise on the equinox (a bit north of east earlier in September). It then passes directly overhead and sets due west.

b) Describe the motion of the Sun across the sky during a day in June in Quito.
Say how the Sun's motion in June differs from its motion in September.
It rises north of east, passes north of overhead, and sets in the northwest.

4. a) The Moon was full on Monday. What will its phase be on Monday of next week?
Third quarter. (half lit)

b) When will the Moon rise on Monday of next week?
Around midnight.

c) I think I saw the Moon while walking into campus this morning. Do you believe me? Roughly where in the sky should the Moon have been at 8:00 this morning? Should it have been up, given its phase now?
It is 4 days after the full moon, so it should have risen about 3 hours after sunset, and it doesn't set until about 3 hours after sunrise, so it should have been up. It should have been west of overhead.

5. Newton said that the force of the Earth's gravity on a 2 kg ball is twice that on a 1 kg ball. But when I drop the two balls they fall at the same rate (with the same acceleration). How would Newton explain this? Why didn't the greater force of gravity on the 2 kg ball make it fall faster?
Newton's 2nd law says $a = F/m$, or the acceleration is proportional to force and inversely proportional to mass. So although the force is twice as large on the 2 kg mass, since its mass is also twice as large the acceleration (and its speed as it falls) is the same as for the 1 kg mass. (Double F and double m, and a stays the same since $2/2=1$.)

6. I've drawn below the Earth and Moon, and the path of the Moon as it goes around the Earth (looking down on the north pole of the Earth). Put arrows on the drawing showing the direction of rotation of the Earth and the direction of revolution of the Moon. Using this drawing, figure out whether the Moon moves in a prograde or retrograde direction. Explain in a couple of sentences how you figured it out.
The Moon orbits the Earth in the counterclockwise direction. This is the prograde direction. Note that the rotation of the Earth does not matter. Retrograde and prograde motion refer to how things move relative to the stars, not how they move across our sky during a night.

Topics for this week

What is a photon? What is an electromagnetic wave?

How are the photon and wave pictures of light related?

Make a sketch of an atom, showing its parts.

How do the wave properties of electrons result in only certain electron orbits being allowed in an atom?

How does the fact that only certain electron orbits can occur result in photons of only certain wavelengths being emitted?

Describe emission and absorption line spectra and the conditions under which each occurs.

Describe black body radiation and the relations between temperature and the power emitted and the wavelengths of light emitted.

Describe the Doppler shift.

Spectra of gasses and solids

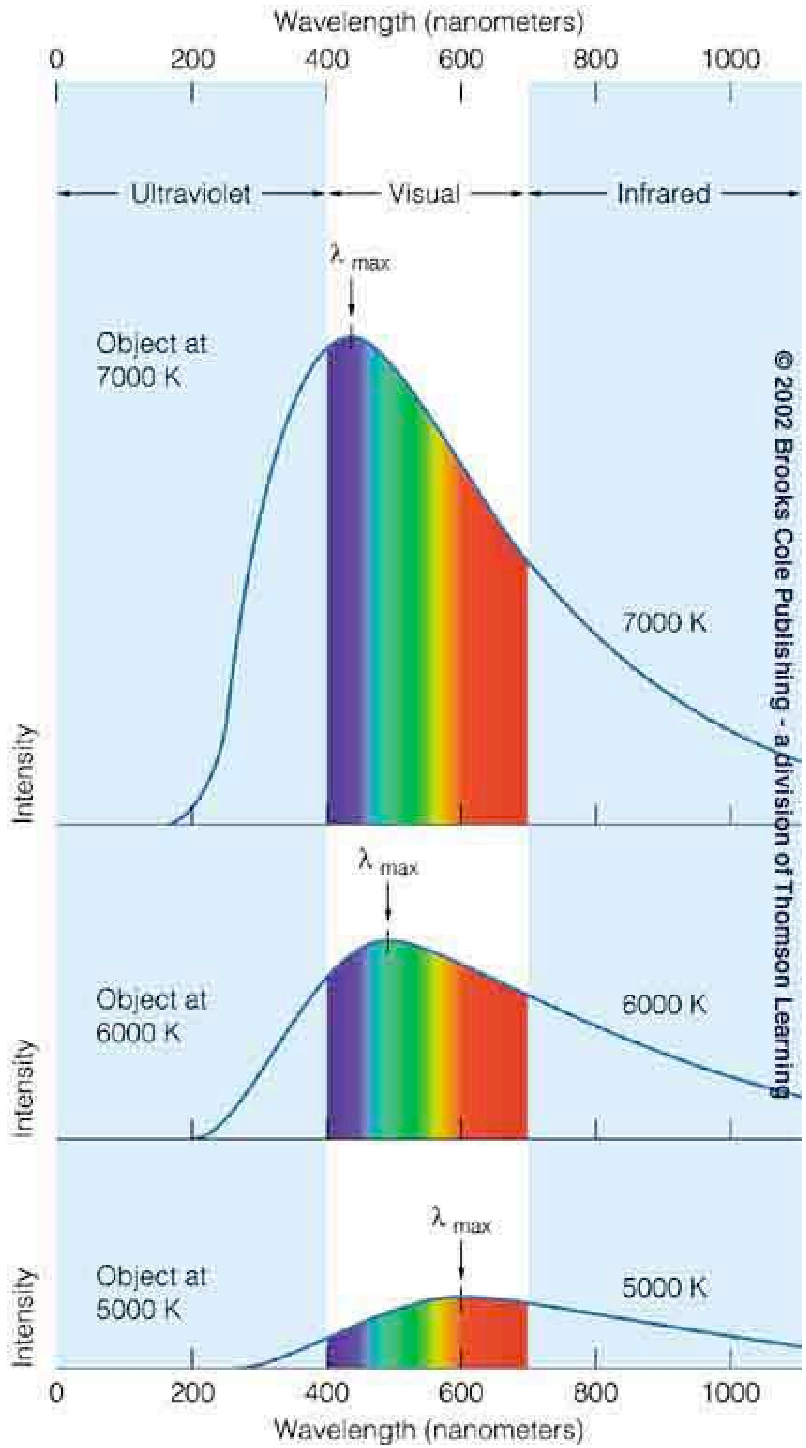
When solids are heated they emit all wavelengths of light (a continuous spectrum).

How bright the light at different wavelengths is depends on the temperature of the solid. Hotter solids emit more light of all wavelengths, but they especially emit more short wavelength (blue and violet) light.

When gasses are heated they emit only certain wavelengths of light (an emission line spectrum).

Different gasses emit different wavelengths.

A cool object (gas or solid) can absorb some of the light passing through it.


Wavelength (nanometers)
0
200
400
600
800
1000
Ultraviolet
Visual
Infrared
λ max
Object at
7000 K
7000 K
Intensity
λ max
Object at
6000 K
6000 K
Intensity
λ max
Object at
5000 K
5000 K
Intensity
0
200
400
600
800
1000
Wavelength (nanometers)

Hot solids – continuous spectra

The temperature of an object is a measure of how much energy its atoms have.

Since atoms in hotter objects have more energy, they can emit photons with more energy than cooler objects can.

(When an atom emits a photon the photon energy comes from the atom, so an atom can't emit a photon with more energy than the atom had.)

So hot objects emit high energy photons, or short wavelength light.

Since l a $1/E_{photon}$ and E_{photon} ~ E_{atom} a T, l a 1/T

They also emit more photons that cooler objects do.

The rule is the amount of power emitted (energy emitted each second) is $P_{emitted}$ a T^4

Emission line spectra

Hot gas emits light of only certain wavelengths.

If a source emitting a continuous spectrum lies behind cool gas, the gas absorbs some of the light, and it absorbs the same wavelengths of light that it would emit if hot.

To understand why gasses act this way, we need to understand more about how electrons orbit in atoms.

What is an atom?

A hydrogen atom has one proton at its center, with one electron orbiting around the proton.

The proton has a positive electrical charge.

The electron has a negative charge and is about 2000 times less massive than the proton.

Opposite charges attract, with a force law like that for gravity, so we expect the electron orbit to obey laws like Kepler's laws.

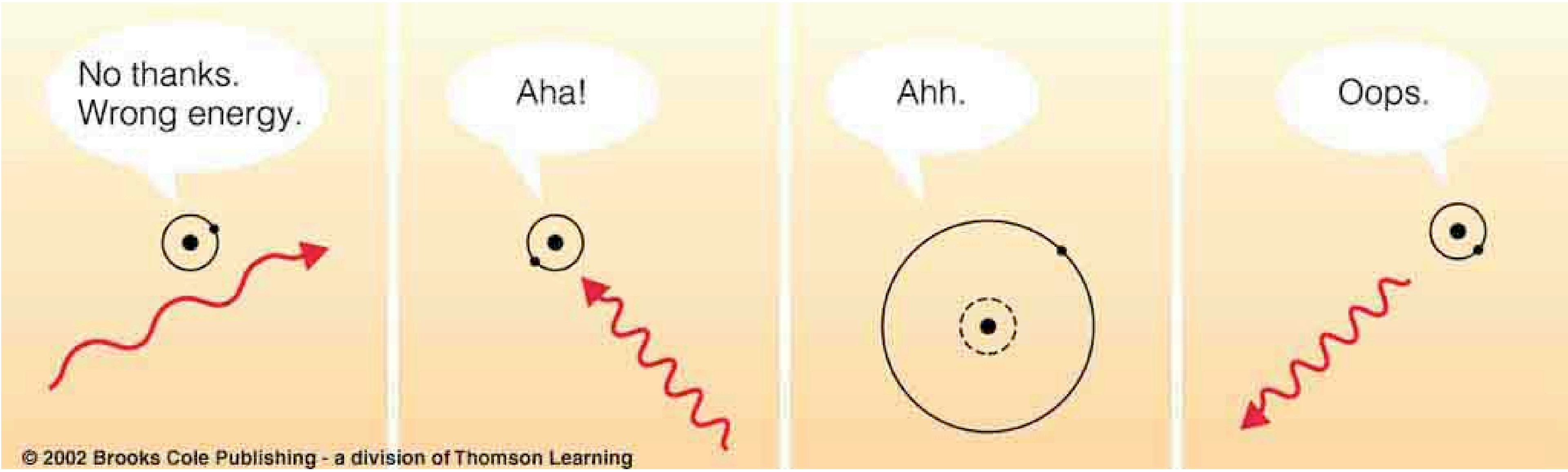
Other atoms have additional protons in their nuclei and additional electrons orbiting around their nuclei.

The also have neutrons (electrically neutral particles with masses similar to proton masses) in their nuclei.

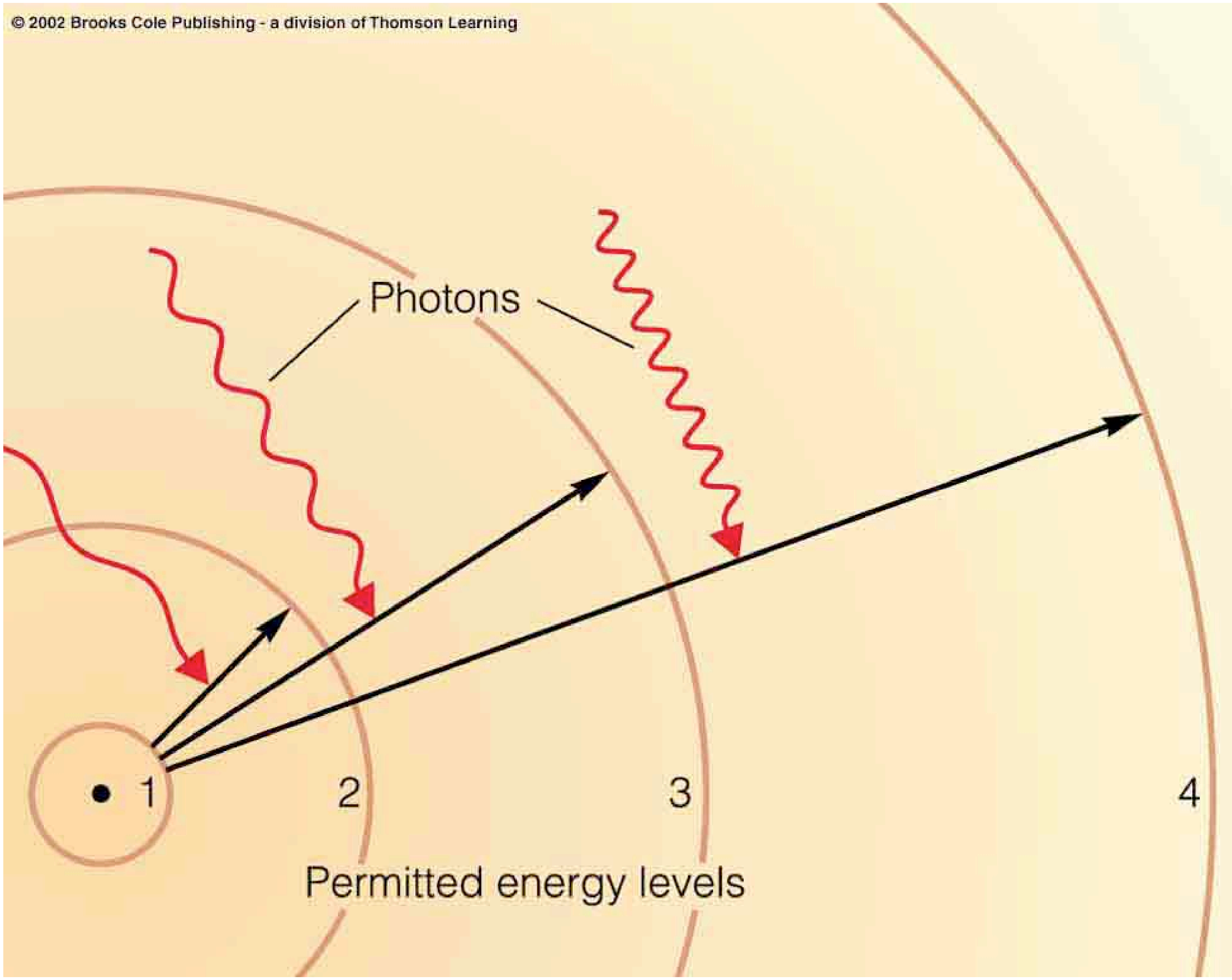
Emission and absorption of light by atoms

When an atom absorbs light, the photon energy must equal the energy needed to make an electron jump from a small orbit to a bigger one.

When an atom emits light, a photon is created, and the energy of the photon must equal the energy lost by the atom when an electron jumps from one orbit to another.



A big jump for an electron requires a high energy photon, or short wavelength light.



Electron waves

We normally think of electrons as particles.

But like photons, they have both wave and particle properties.

The height of the wave describes the probability of finding the electron in different places.

The wavelength of the probability wave is related to the electron speed, v, by:

$$l = h / mv,$$

where h is Planck's constant and m is the electron mass.

In an atom, an electron must orbit at a distance from the nucleus so that an integral number of probability waves fit around its orbit.

This causes only certain electron speeds or energies to be allowed.