Monday Feb. 14

Syllabus and class notes are at: www.as.utexas.edu
go to courses, AST301 – Introduction to Astronomy – Lacy

The first exam is Friday, Feb. 18
It will cover Chapters 1-6.

Reading for this week: Chapter 7 (especially 7.3)

If you want help on anything covered in the course, come to discussion session Thursday at 6:00 in RLM 15.216B.

Topics for last week and today

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.

Proportionalities

The circumference of a circle is $C = 2 \pi r$.

Because there is a C on the left and an r on the right (with no powers on them), we can write $C \alpha r$.

This means that if one circle has twice the radius of another, its circumference is twice as large.

Note that proportionalities are always used to compare two objects or two situations.

Quiz

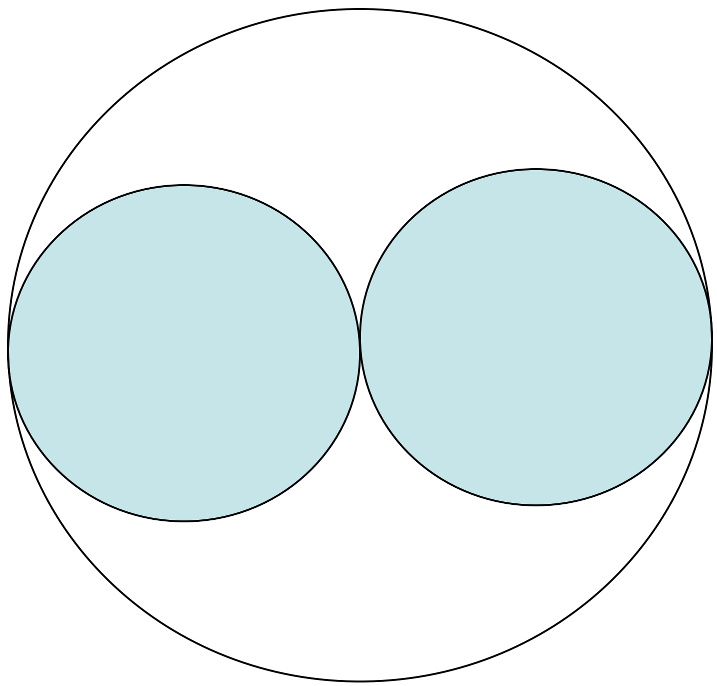
How does the circumference of the big circle compare to that of one of the small circles?

A. _ as big

B. the same

C. twice as big

D. four times as big



Quiz

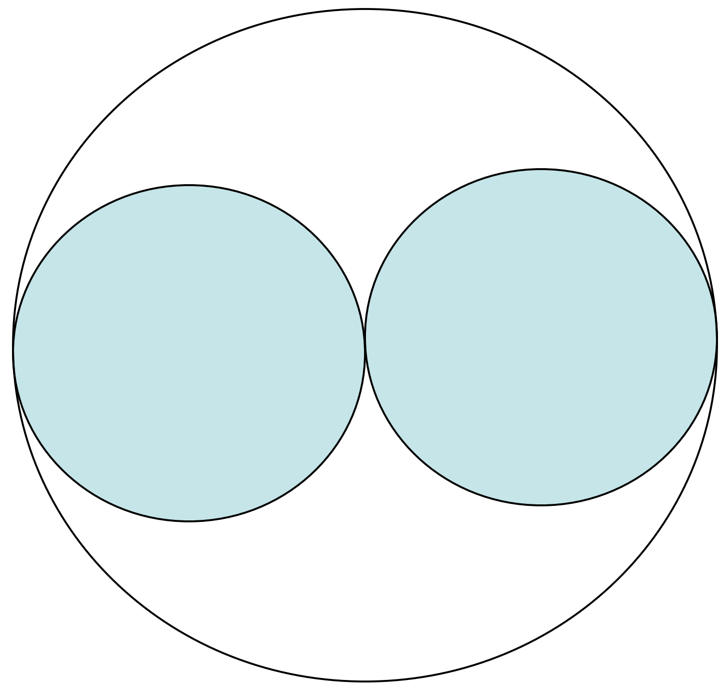
How does the area of the big circle compare to that of one of the small circles?

A. twice as big

B. four times as big

C. six times as big

D. eight times as big



Quiz

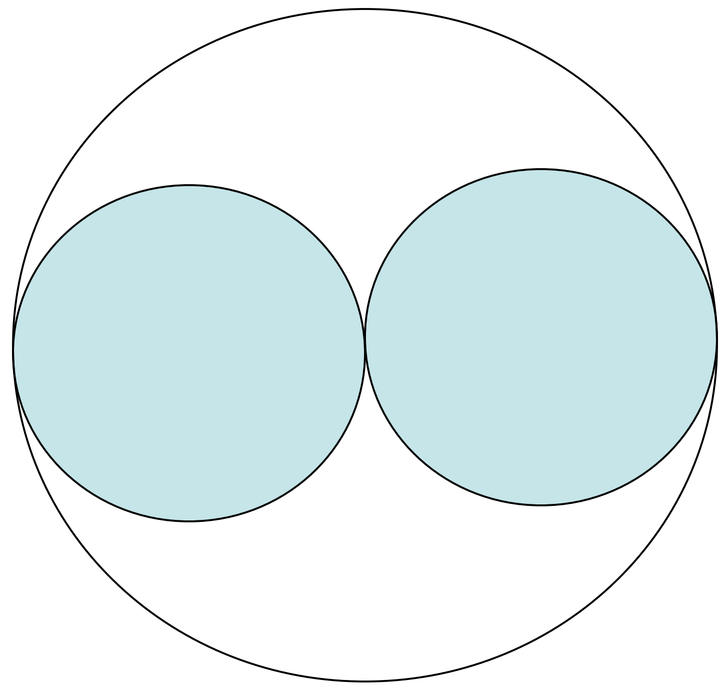
How does the volume of a sphere whose outline is shown by the big circle compare to that of a sphere outlined by one of the small circles?

A. twice as big

B. four times as big

C. six times as big

D. eight times as big



Volumes

The volume of a sphere is given by: $V = 4/3 \pi r^3$.

But you don't have to know that for this class.

You only have to know that there is an r^3 in the formula, because all volumes go as width cubed.

The diameter of Jupiter is about 1/10 that of the Sun.

How do their volumes compare?

They are made of the same stuff, packed about equally tightly.

How do their masses compare?

Energy and Power

Energy is a measure of how hot something is, or how fast it is moving, or how high it is, or if you burned it how much heat it would generate.

The Joule is one unit of energy. The calorie is another.

Power is the rate of flow of energy.

That is, how much energy goes into an object each second.

A 100 Watt light bulb uses 100 Joules of electrical energy each second. That electrical energy is converted into 100 Joules of light and heat energy each second.

One Watt is one Joule per second.

Power emitted by a hot object

The formula for the power emitted by a hot object is:

$P = (\text{surface area}) \times \sigma T^4$

σ is called the Stefan-Boltzmann constant, but you don't have to know that for this course.

I will always ask you questions comparing two objects.

Then you can write $P \propto T^4$. (If they have the same areas.)

This formula means that if one object is 3 times hotter than another, it emits $3^4 = 81$ times as much power.

Or if it is 1/3 the temperature of another it emits $(1/3)^4 = 1/81$ as much power.

Quiz

If Vega (the brightest star in the summer sky) has twice the surface temperature of the Sun, and if they have the same size, how does the light power emitted by Vega compare to that emitted by the Sun?

A. Vega emits twice as much

B. four times as much

C. eight times as much

D. sixteen times as much

Quiz

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Would you have gotten it right if I had said the Sun's temperature is 6000K and Vega's temperature is 12,000K?

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.

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:

$$\lambda = h / mv,$$

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

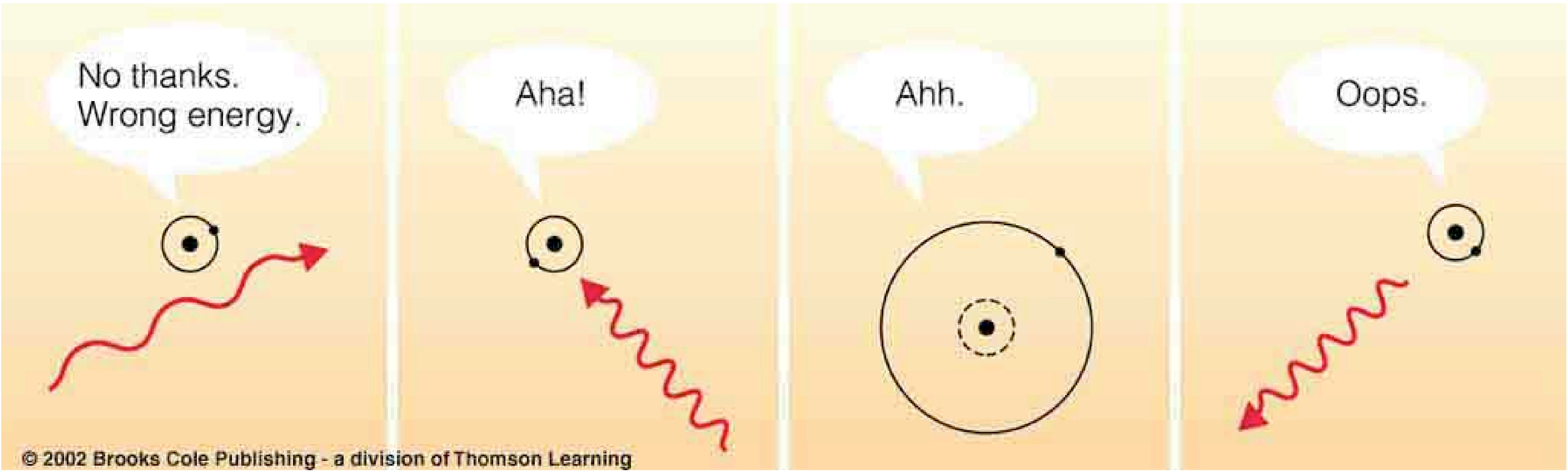
In an atom, an electron must orbit at a distance from the nucleus so that an integral number of probability waves fit around its orbit.

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

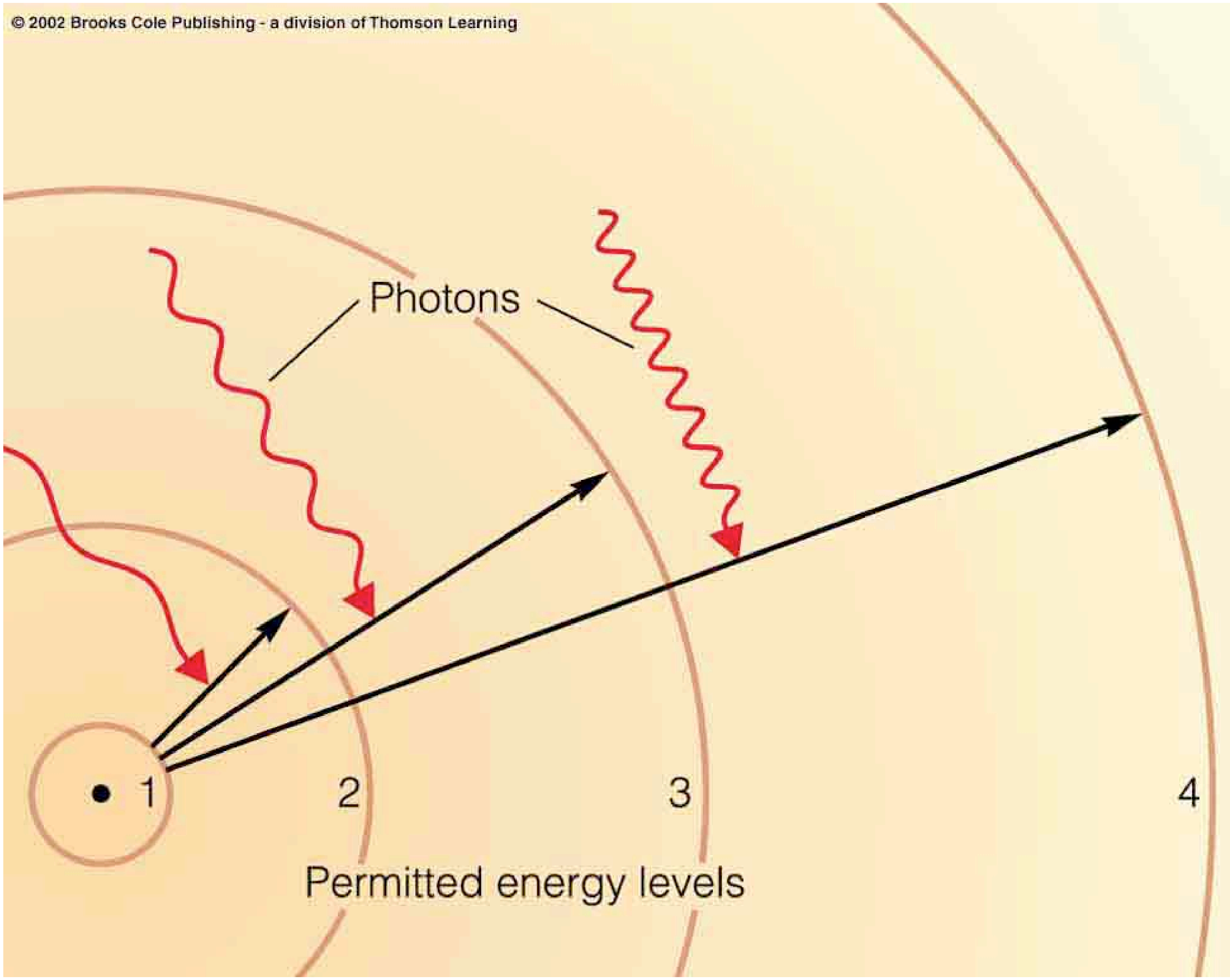
Emission and absorption of light by atoms

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.



Doppler shift

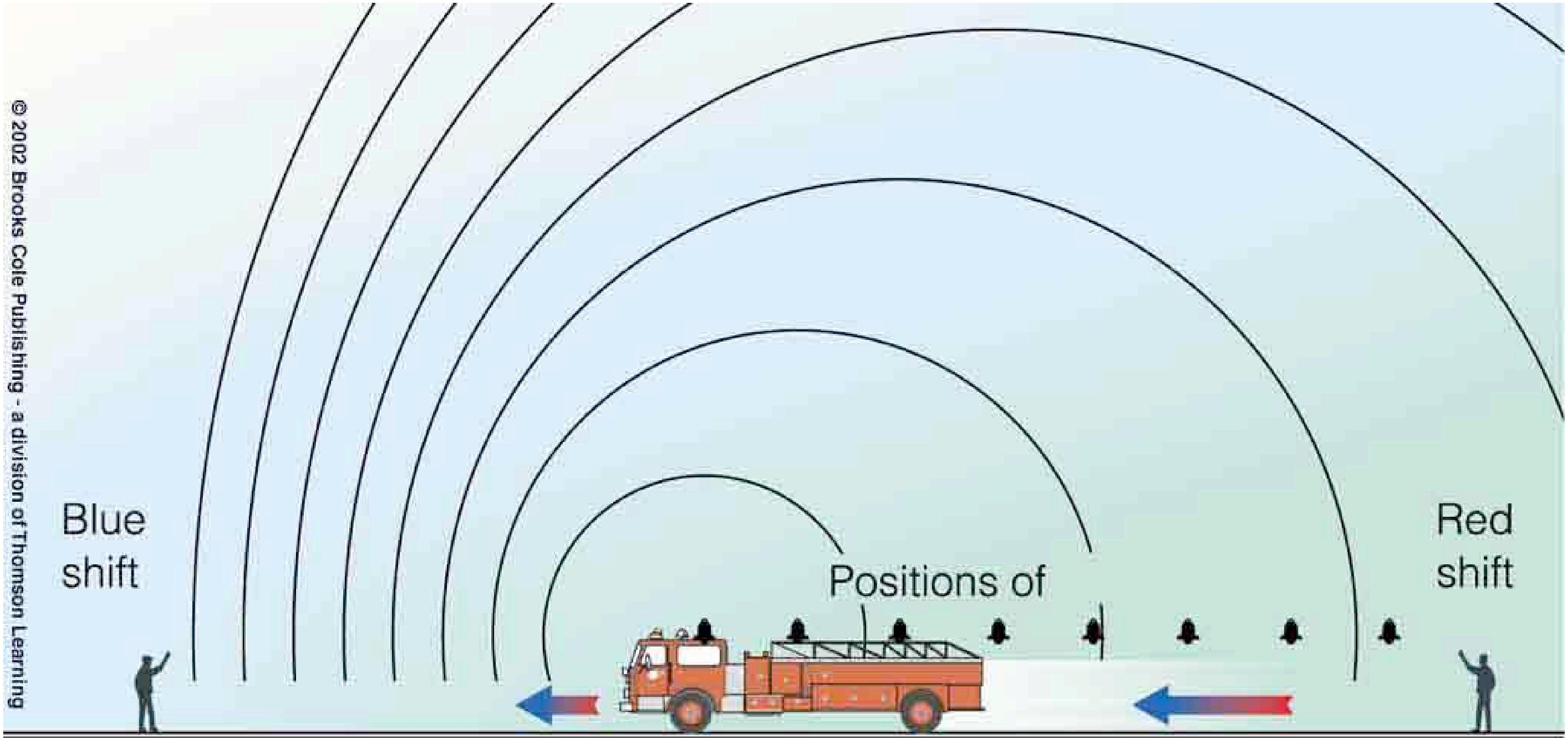
If an object emitting light (or sound) waves is moving relative to an observer, the observed wavelength is different from that emitted.

If the emitter moves toward the observer (or the observer moves toward the emitter) the observed wavelength is shorter than the emitted wavelength.

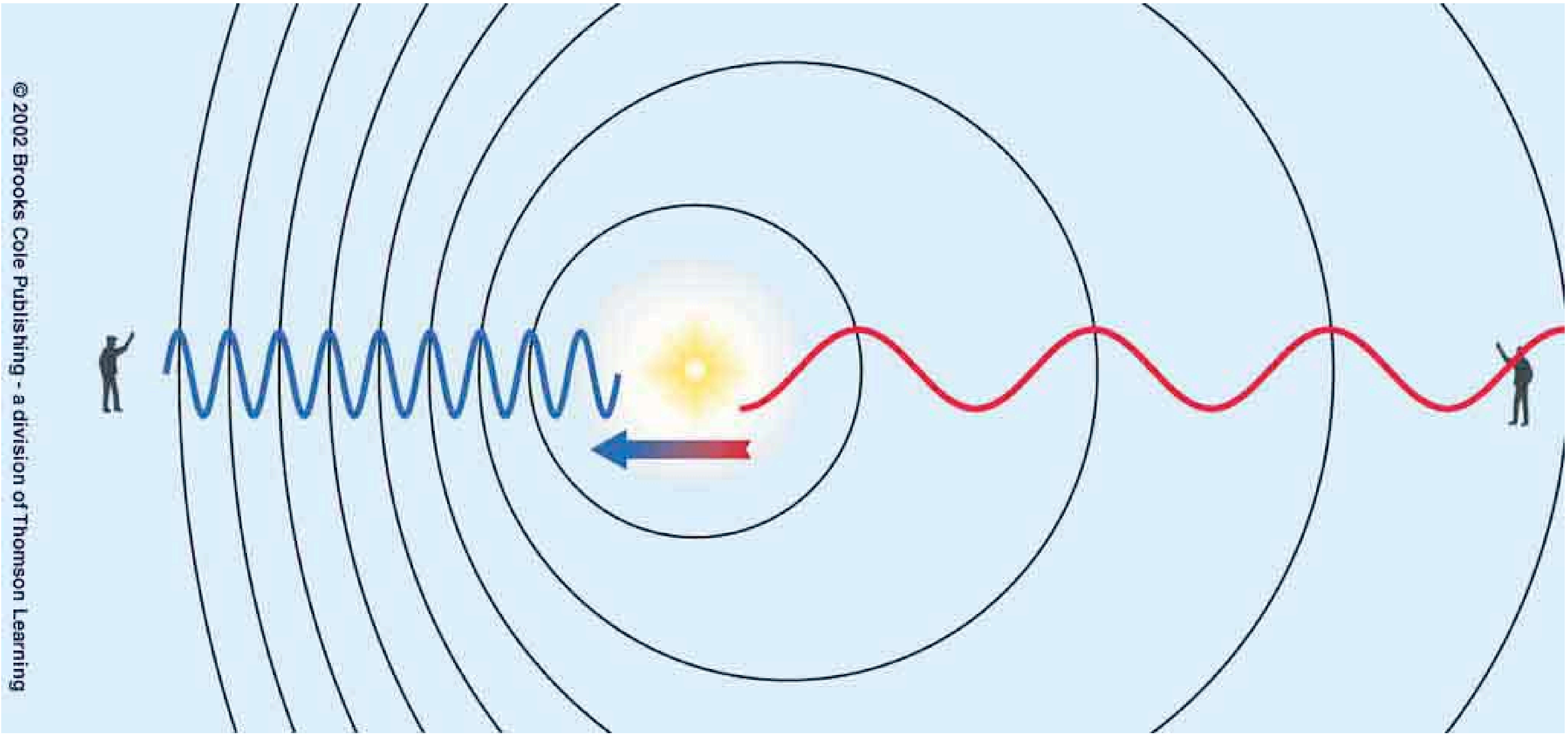
If the emitter moves away from the observer, the observed wavelength is longer than the emitted wavelength.

If the motion is small compared to the speed of the wave (the speed of light for light waves) the formula for the shift in wavelength is:

$$(\lambda_{observed}-\lambda_{emitted}) / \lambda_{emitted} = v / c$$



Blue
shift
Positions of
Red
shift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