PHYS 301 Problems in Doppler Effect for Light Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The Doppler shifted frequency (*f*) for a source emitting light waves of frequency *f*0 and moving with relative radial speed *v* (speed parameter *β* = *v*/*c*) is given by:

$f=f\_{0}\sqrt{\frac{1-β}{1+β}}$ (source and detector separating)
$f=f\_{0}\sqrt{\frac{1+β}{1-β}}$ (source and detector moving toward)

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| For speeds much less than *c*, the above equations becomes, http://edugen.wiley.com/edugen/courses/crs4957/common/art/pixel.gif |
| http://edugen.wiley.com/edugen/courses/crs4957/halliday9118/halliday9088c37/math/math060.gif |    |
| http://edugen.wiley.com/edugen/courses/crs4957/common/art/pixel.gif |

where *Δλ* (= *λ* - *λ*0) is the *Doppler shift* in wavelength due to the motion.

1. A spaceship is moving away from Earth at speed 0.20*c*. A source on the rear of the ship emits light at wavelength 450 nm according to someone on the ship. What (a) wavelength and (b) color (blue, green, yellow, or red) are detected by someone on Earth watching the ship?

2. Figure below shows curves of intensity versus wavelength for light reaching us from interstellar gas on two opposite sides of [galaxy M87](http://astronomy.swin.edu.au/~gmackie/DarkStar/alpha.html). One curve peaks at 499.8 nm, the other at 501.6 nm. The gas orbits the core of the galaxy at a radius *r* = 100 light-years, moving toward us on one side of the core and moving away from us on the opposite side.

1. What is the speed of the gas relative to us (and rela­ tive to the galaxy's core)?
2. The gas orbits the core of the galaxy because the gas experiences a gravitational force due to the mass *M* of the core. What is that mass in multiples of the Sun's mass *Ms* ( = 1.99 X 1030 kg)?

