



## Concept:

The white ball represents the center of a galaxy. The colored balls represent stars revolving around the galactic center. The amount of red/blue seen represents the degree to which the spectrum is Doppler shifted. A star's spectrum is shifted toward the *blue* as the star *approaches* the observer because its wavelength is compressed. As the star *recedes* from the observer, the spectrum shifts toward the *red* since its wavelength is extended. A useful mnemonic device is “red for recede”.

The Doppler shifted frequency for light with observer and source moving *toward* and (*away from*) each other with relative speed  $v$  are given, respectively by

$$f_{\text{observer}} = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} f_{\text{source}} \quad \text{and} \quad f_{\text{observer}} = \sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}} f_{\text{source}}$$

The effect clearly becomes more pronounced as the relative speed  $v$ , approaches the speed of light,  $c$ .

## Procedure:

1. Verify that the white ball is securely attached to the rotator base and the colored balls are arranged as shown in the top-left picture.
2. Toggle the rotation direction switch to counter-clockwise (CCW).
3. Turn the rotation speed knob clockwise to turn the powered rotator on and adjust its speed.
4. Use the switch on the power strip (not shown) to turn the motor on and off – to avoid being hit by the revolving balls.

## Equipment:

1. Powered Rotator
2. Large Styrofoam Ball
3. Small Red/Blue Styrofoam Balls with Dowel Arms (2)