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Problem 2.50 (R)

We have to find the wavelength shift, if any, in the Doppler effect for the sodium D_2 line (5890 A^0) emitted from a source moving in a circle with constant speed 0.1 c measured by an observer fixed at the centre of the circle.

Solution:

As the source is moving in a circle with respect to an observer at the centre of the circle the line of sight is at 90^0 to the relative motion. In this case there will be transverse Doppler effect. If a source moving with velocity v transverse to the direction of observation emits waves of frequency v_0 the observed frequency will be

$$v = v_0\sqrt{1 - v^2/c^2},$$

or

$$\lambda = \frac{\lambda_0}{\sqrt{1 - v^2/c^2}}.$$

In our problem $v = 0.1\,c$ and $\lambda_0 = 5890\text{ A}^0$. The wavelength of the sodium D_2 line observed at the centre of the circle will be

$$\lambda = \frac{5890}{\sqrt{1-0.01}}\text{ A}^0 = 5919.6\text{ A}^\circ.$$

Therefore, shift in the wavelength will be 29.7 A^0.