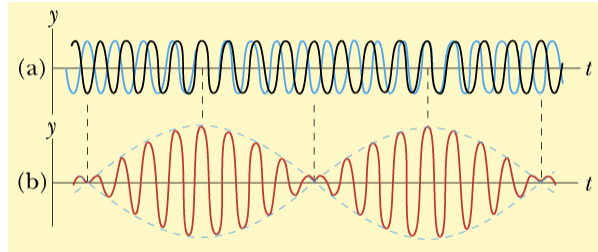


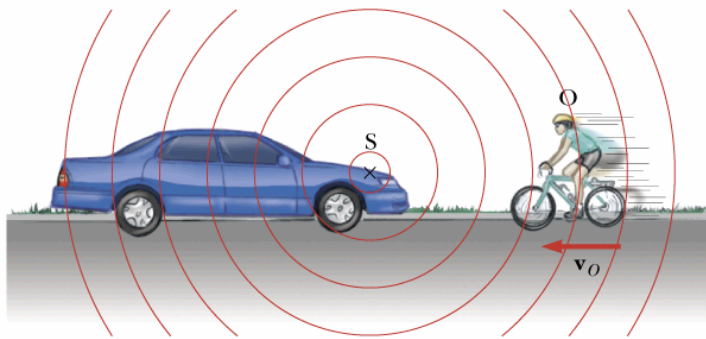
## Beats (lecture 10)



- Occur when two waves with equal amplitude and slightly different frequencies interfere
- Periodic constructive and destructive interference causes variations in loudness called **beats**
- The frequency of loudness variation or beat frequency is given by

$$f_{beat} = f_1 - f_2$$

## The Doppler Effect – Moving Listener

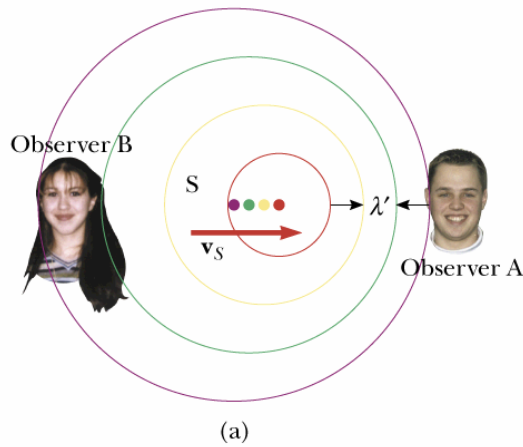


E.g., Parked car sounding the horn;

$$f_o = \frac{v + v_o}{\lambda} = \left(1 + \frac{v_o}{v}\right) f_s$$

The cyclist hears frequency  $f_o$  as he approaches with speed  $v_o$

## Moving Source and Moving Listener



$$f_L = \frac{v + v_L}{v + v_S} f_S$$

This expresses the frequency heard by the listener in terms of the frequency of the source

It includes all possibilities for motion of source and listener (relative to the medium) along the line joining them

## Shock Waves

