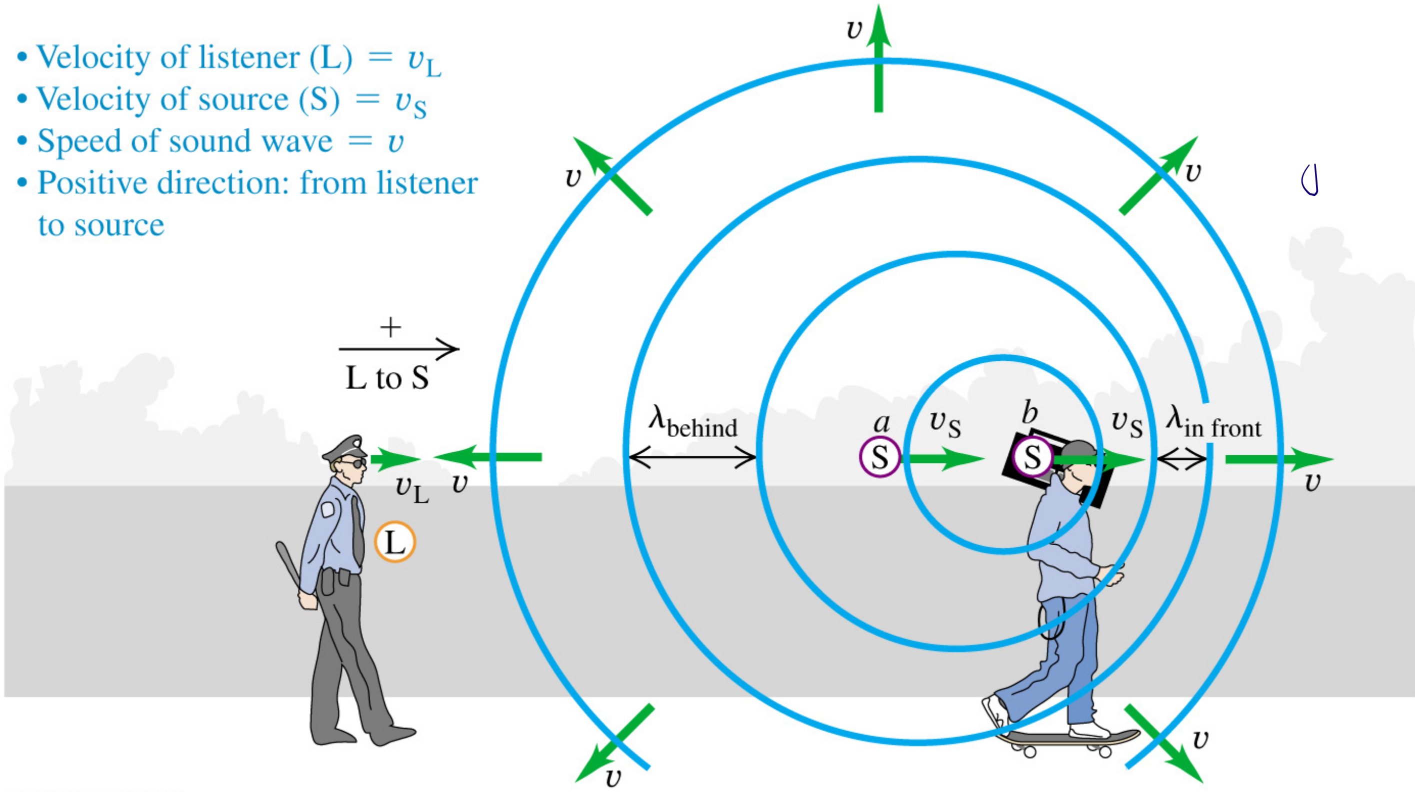
16.8 The Doppler Effect

1) Sound waves from a moving source



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S = Source

L = listener

f_S = frequency emitted by source

f_L = frequency detected by listener

v_S = speed of the source

v = speed of the waves

here $f_L < f_S$ (waves are spread out).

Moving Source:

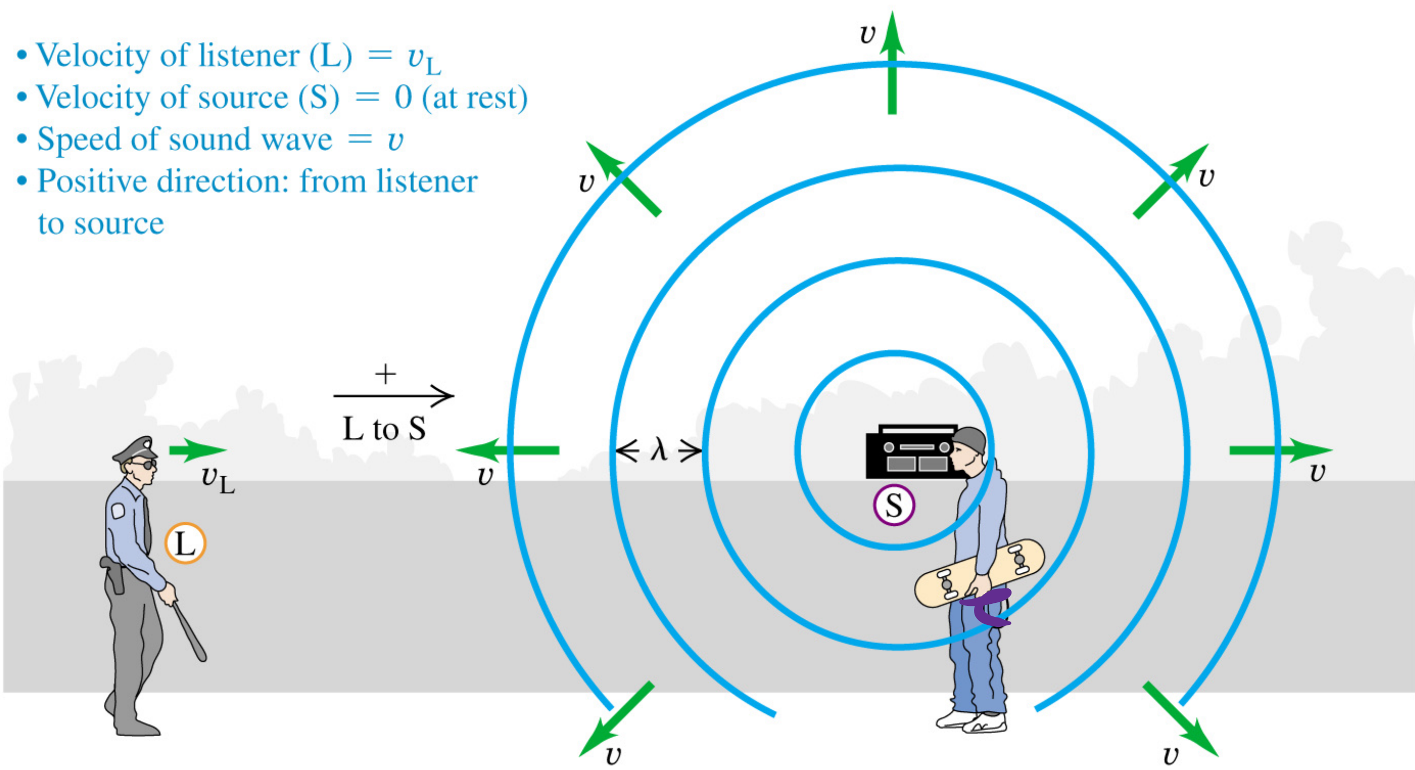
$$f_L = \left(\frac{v}{v \pm v_s}\right) f_s$$

which do you pick – + or – ?

Pick – if $f_L > f_s$ (approaching)

Pick + if $f_L < f_s$ (receeding)

Moving Listener



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$$f_L = \left(\frac{v \pm v_L}{v}\right) f_s$$

which do you pick − + or − ?

Pick + if $f_L > f_s$ (approaching)

Pick − if $f_L < f_s$ (receeding)

Example: Ch16 - doppler - 1

combined

$$f_L = \left(\frac{v \pm v_L}{v \mp v_s}\right) f_s$$

Aside: for double Doppler shift, if

$v_{source} \ll v_{sound}$

$$\Delta f \approx \pm 2 \frac{v_{source}}{v_{sound}} .$$

How to detect it? Beats!

Electromagnetic waves

no medium!

speed = c for all observers = constant

$$f_L = \sqrt{\frac{c-u}{c+u}}\, f_S$$

where u = relative speed.

For $u \ll c$, these reduce to the above equations.