Why Does a Guitar Need a Body to Make Sound?

Ra Inta, Texas Tech University
Making guitars...
The Experimental Instruments

Engelmann Spruce

Sitka Spruce

Western Red Cedar
... and measuring guitars

WESTERN RED CEDAR, XBL (LOWER BOUGHT)
“I’ve seen guitars without bodies”

Electric guitars don’t count!
The Helmholtz resonator

\[ f_H = \frac{c}{2\pi} \sqrt{\frac{S}{Vl}} \]
Where is the ‘throat’ of the resonator?
It’s the end ‘correction’!

\[
\ell' = \left( \frac{8}{3\pi} \right) R \sim 0.85R
\]

Here: \( R = 48.0 \text{ mm} \)
So: \( \ell' \sim 41 \text{ mm (each side)} \)
Helmholtz resonance of this guitar

Volume: 16.60 litres = 1.66×10^{-2} m^3

Radius of soundhole: 48.0 mm

Calculated $f_H$: 122.1 Hz

Measured $f_H$: 120.0 Hz
Coupled oscillators
A circuit diagram of the guitar!

(a) 

(b) 

\[ F(t) \]

\[ m_p \]

\[ m_h \]

\[ K_p \]

\[ V \]

\[ \frac{F(t)}{A_p} \]

\[ M_p \]

\[ C_p \]

\[ R_p \]

\[ U_p \]

\[ U_v \]

\[ U_h \]

\[ C_v \]

\[ R_v \]

\[ M_h \]

\[ R_h \]
Coupled resonators split frequencies

- $f_\text{r} = 91.5 \text{ Hz}$
- $f_H = 120.0 \text{ Hz}$
- $f_p = 134.1 \text{ Hz}$
- $f_\oplus = 155.0 \text{ Hz}$
Vibrations of the sound-board (top)
Thanks for listening!