

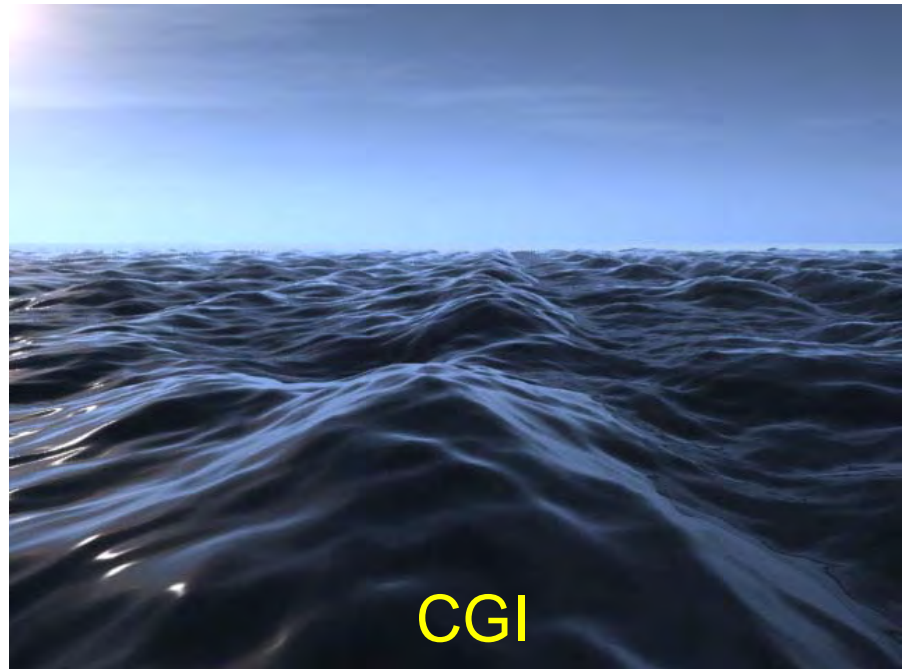
Waves & Spectra



National Science Foundation
WHERE DISCOVERIES BEGIN

Realistic Waves

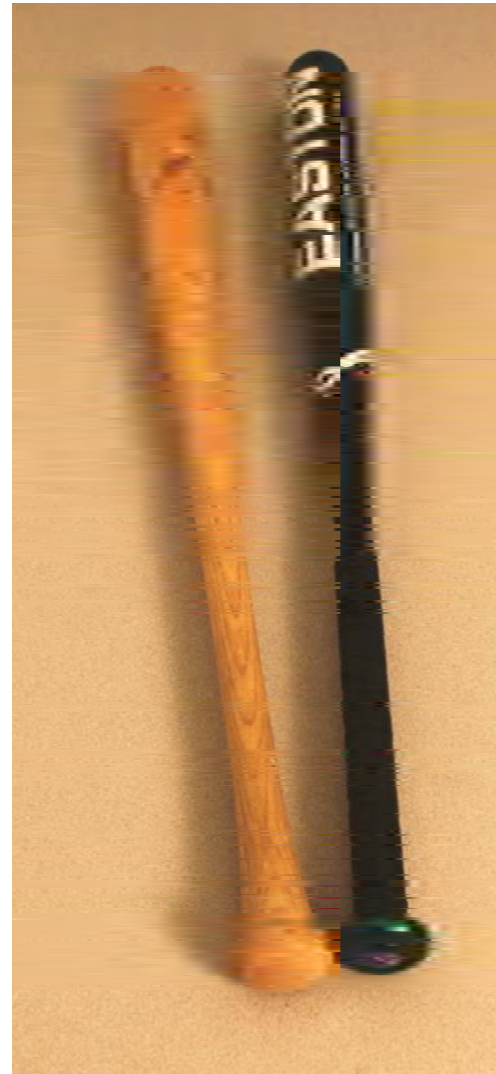
Fake waves are easy to spot but identifying and fixing the problem isn't easy.



Natural Frequencies

Metal baseball bat
and wooden bat
sound very different
when dropped to
the floor.

Objects of different
materials and
shapes vibrate at
their own set of
natural frequencies.



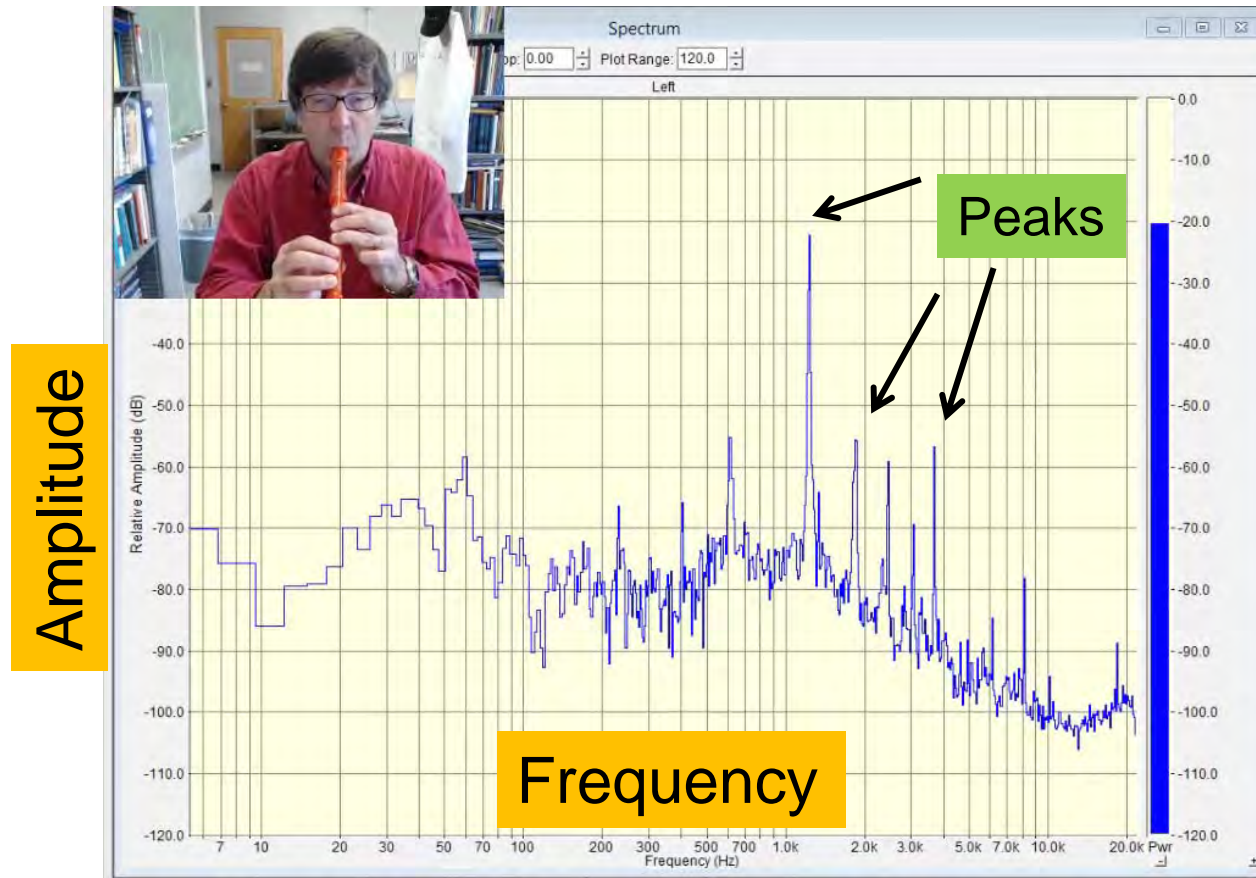
Natural Frequencies

Close your eyes and listen carefully to the sounds

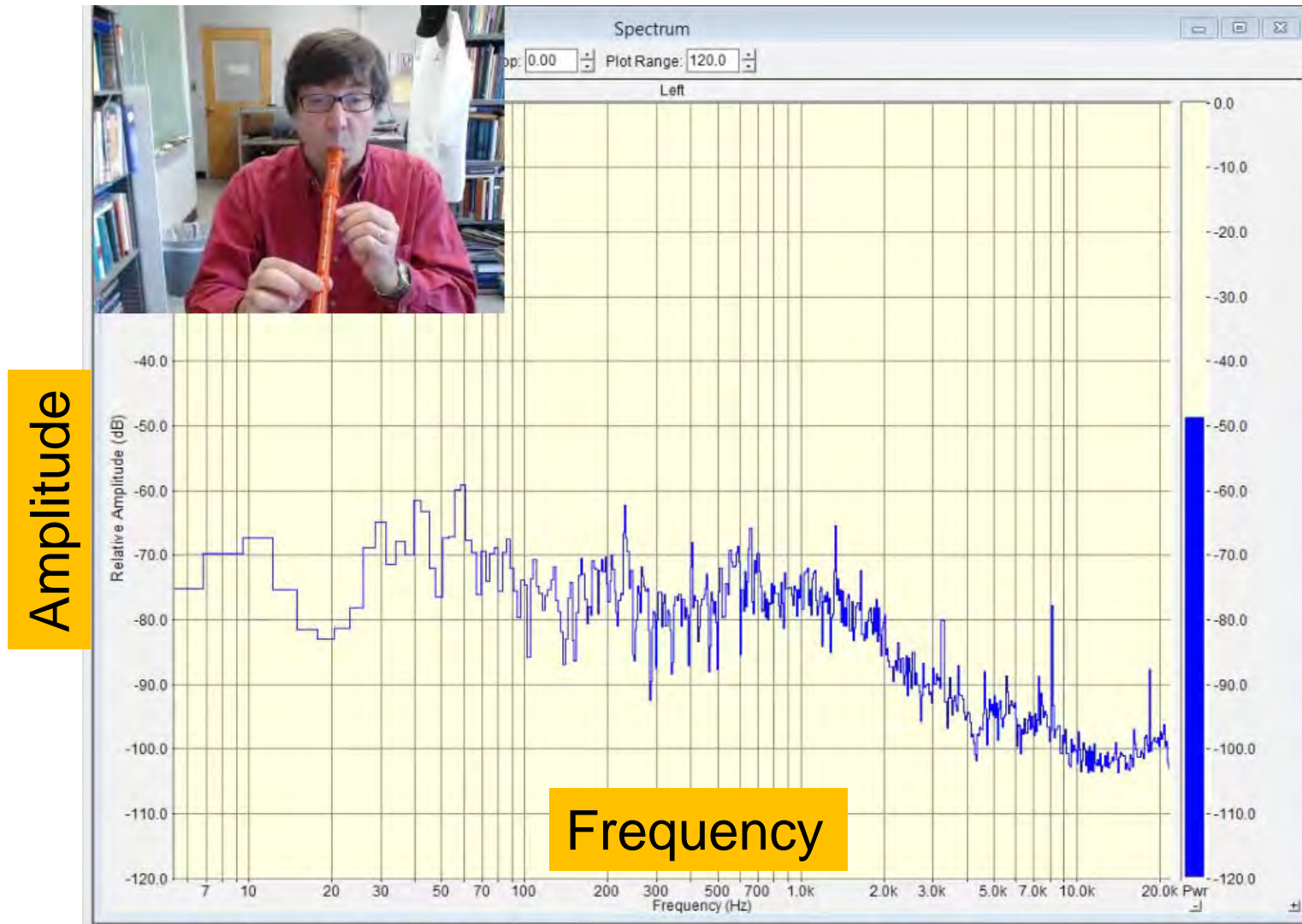


Wave Spectrum

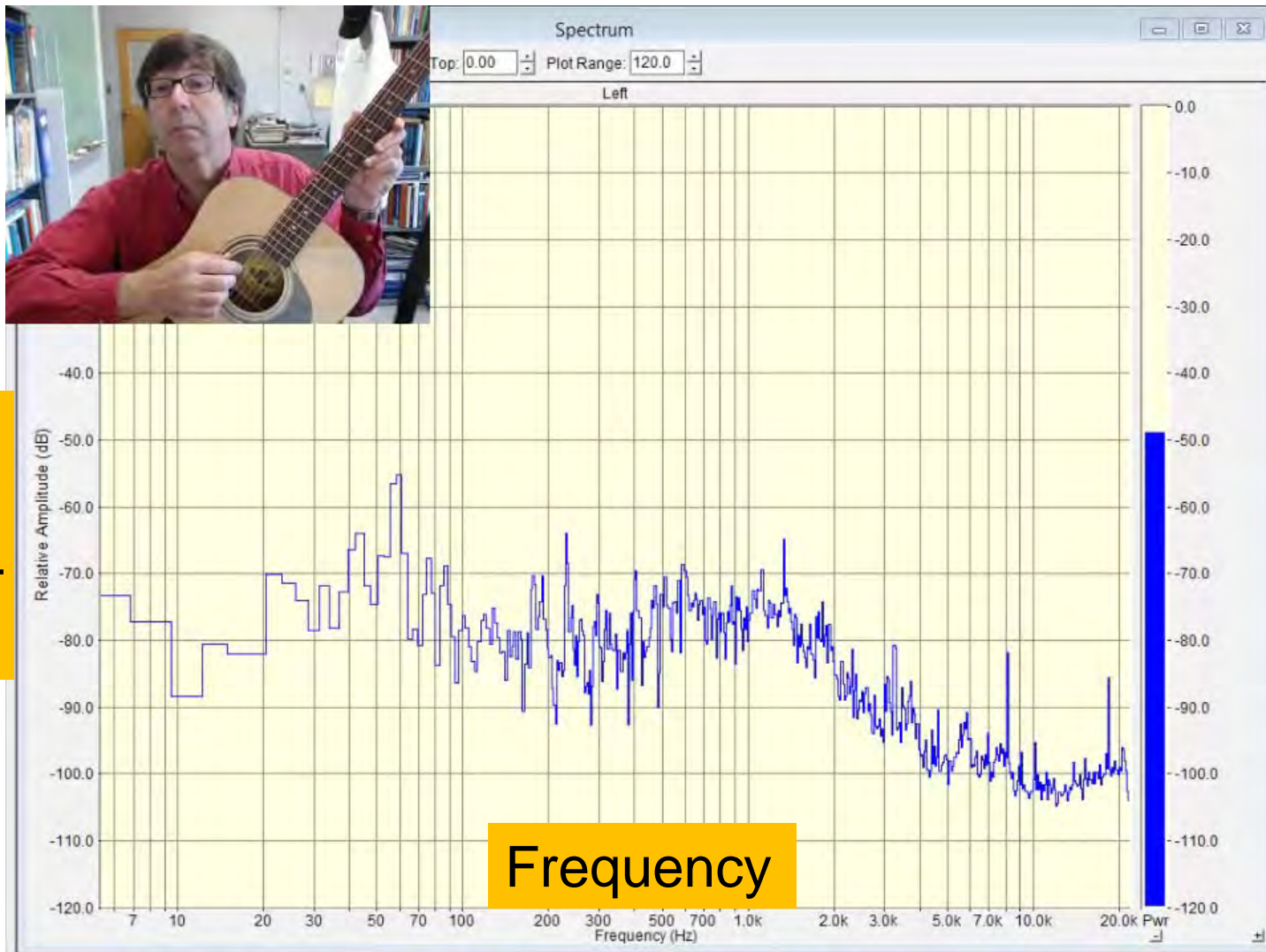
A spectral analyzer measures the different frequencies present in a wave spectrum.



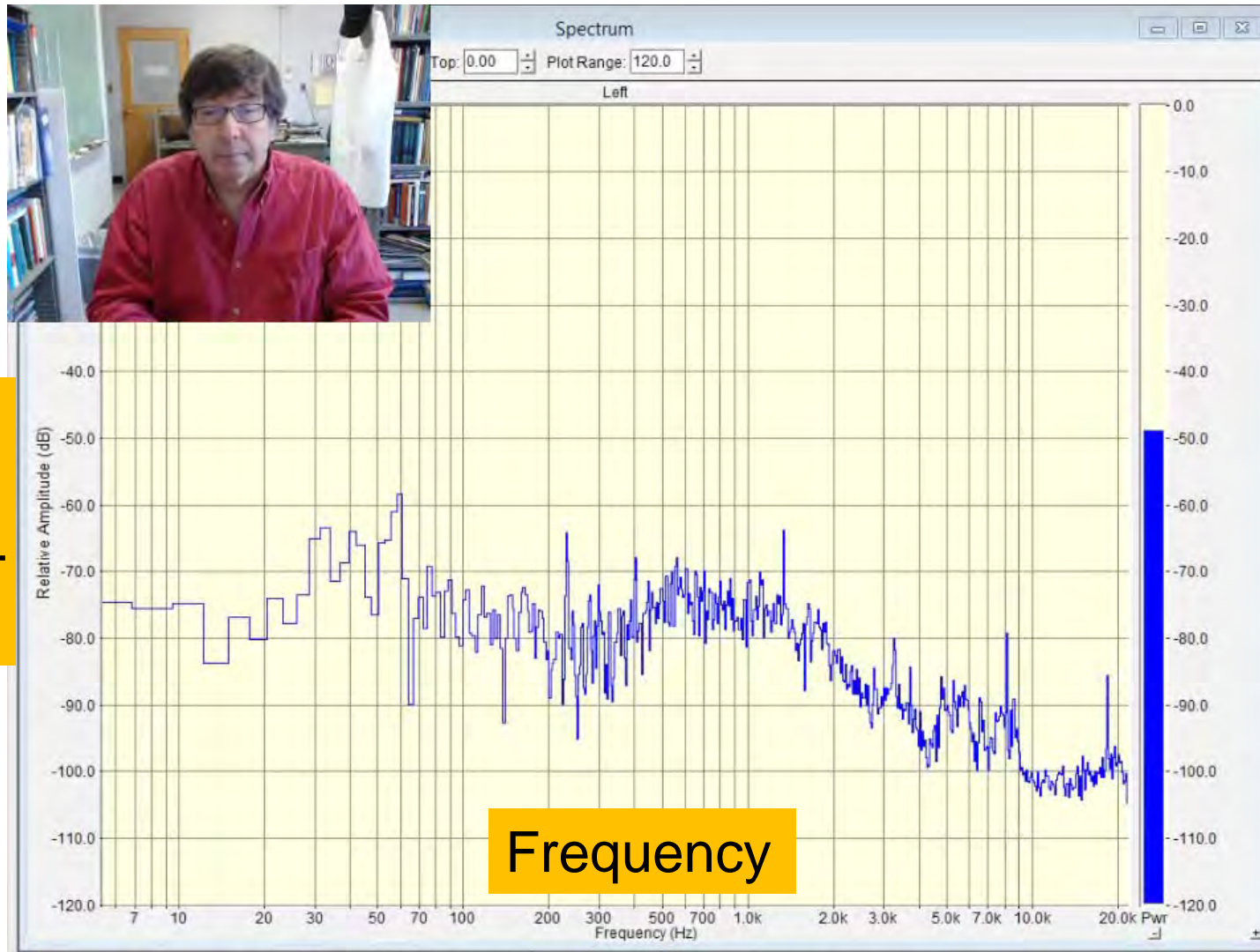
Musical Instruments



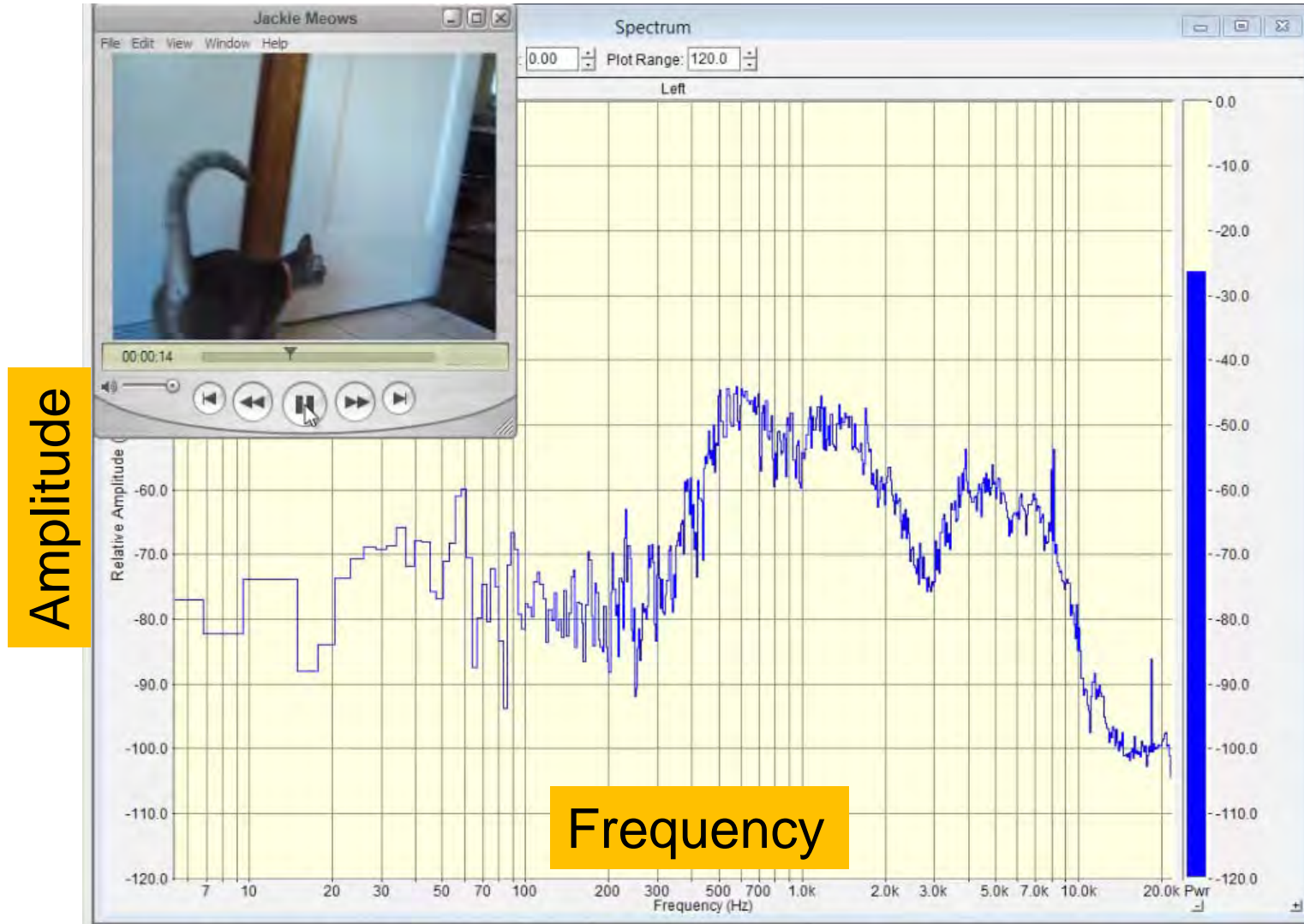
Musical Instruments



Simple Instruments



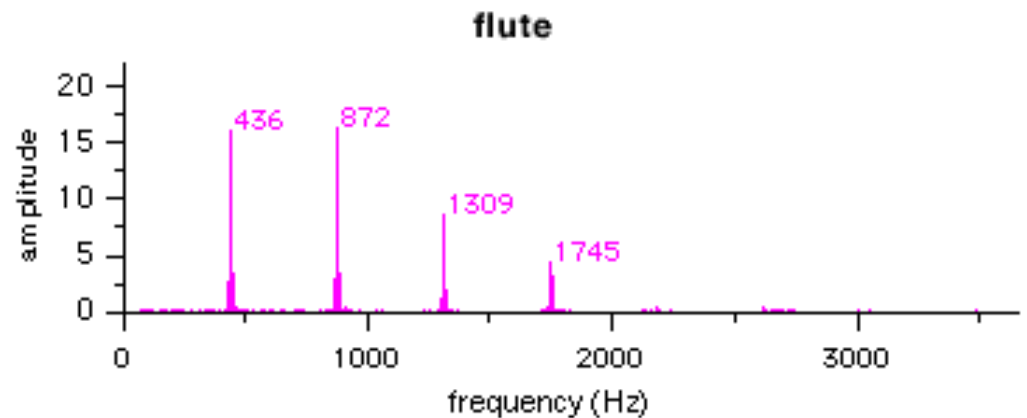
Human & Animal Sounds



Musical Spectra

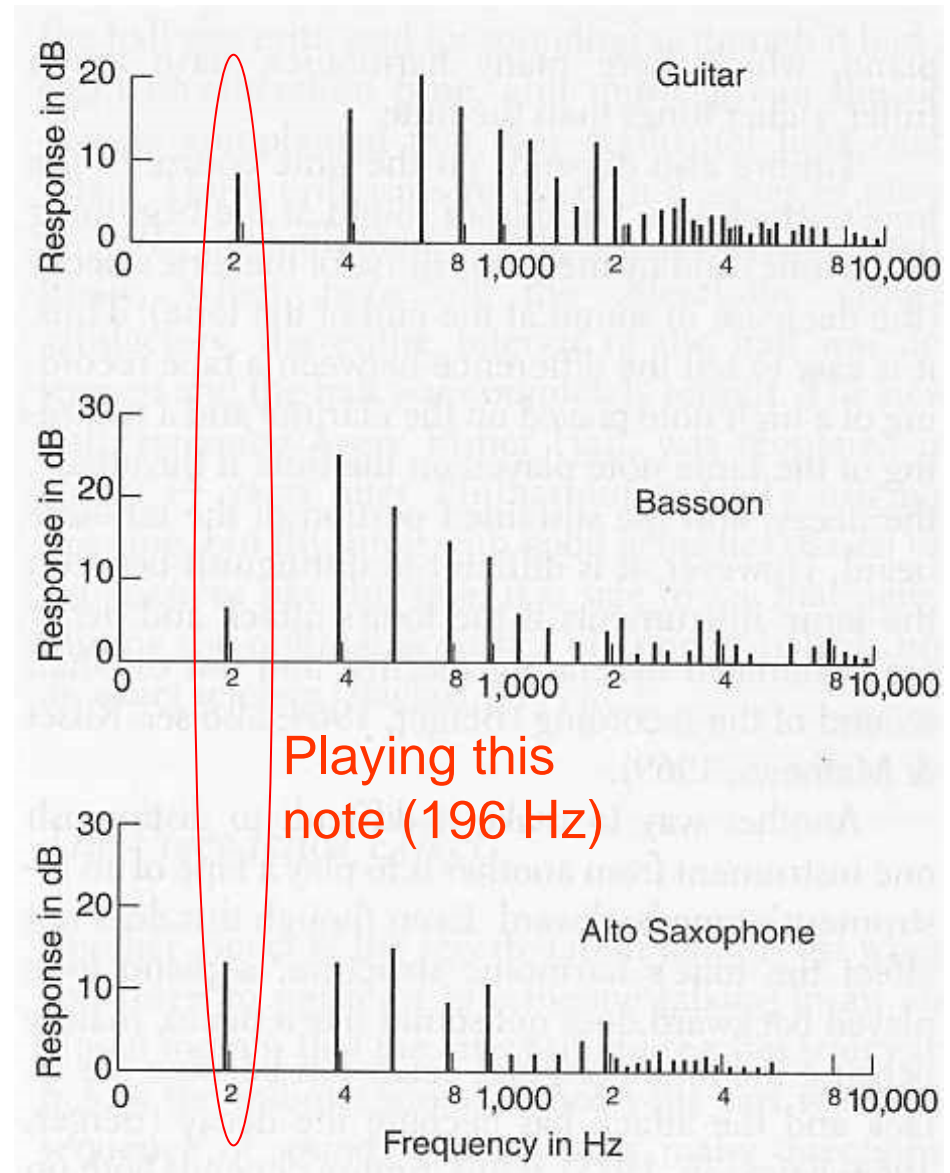
A musical instrument playing a single note produces not just that note's frequency but others as well, mostly overtones.

The frequencies produced by a flute playing an A (slightly flat) show that the fundamental (436 Hz) and the harmonic (872 Hz) have almost the same amplitude.



Timbre

The unique spectrum of frequencies for a musical instrument gives that instrument a unique signature, which is called the instrument's **timbre**, also called tone color.



Ocean Waves

Spectrum of ocean waves changes in different weather conditions, from calm to storms.

Beaufort Force 2



BEAUFORT FORCE 2
WIND SPEED: 4-6 KNOTS

SEA: WAVE HEIGHT .2-.3M (.5-1FT), SMALL WAVELETS, CRESTS HAVE A GLASSY APPEARANCE AND DO NOT BREAK

Beaufort Force 6



BEAUFORT FORCE 6
WIND SPEED: 22-27 KNOTS

SEA: WAVE HEIGHT 3-4M (9.5-13 FT), LARGER WAVES BEGIN TO FORM, SPRAY IS PRESENT, WHITE FOAM CRESTS ARE EVERYWHERE

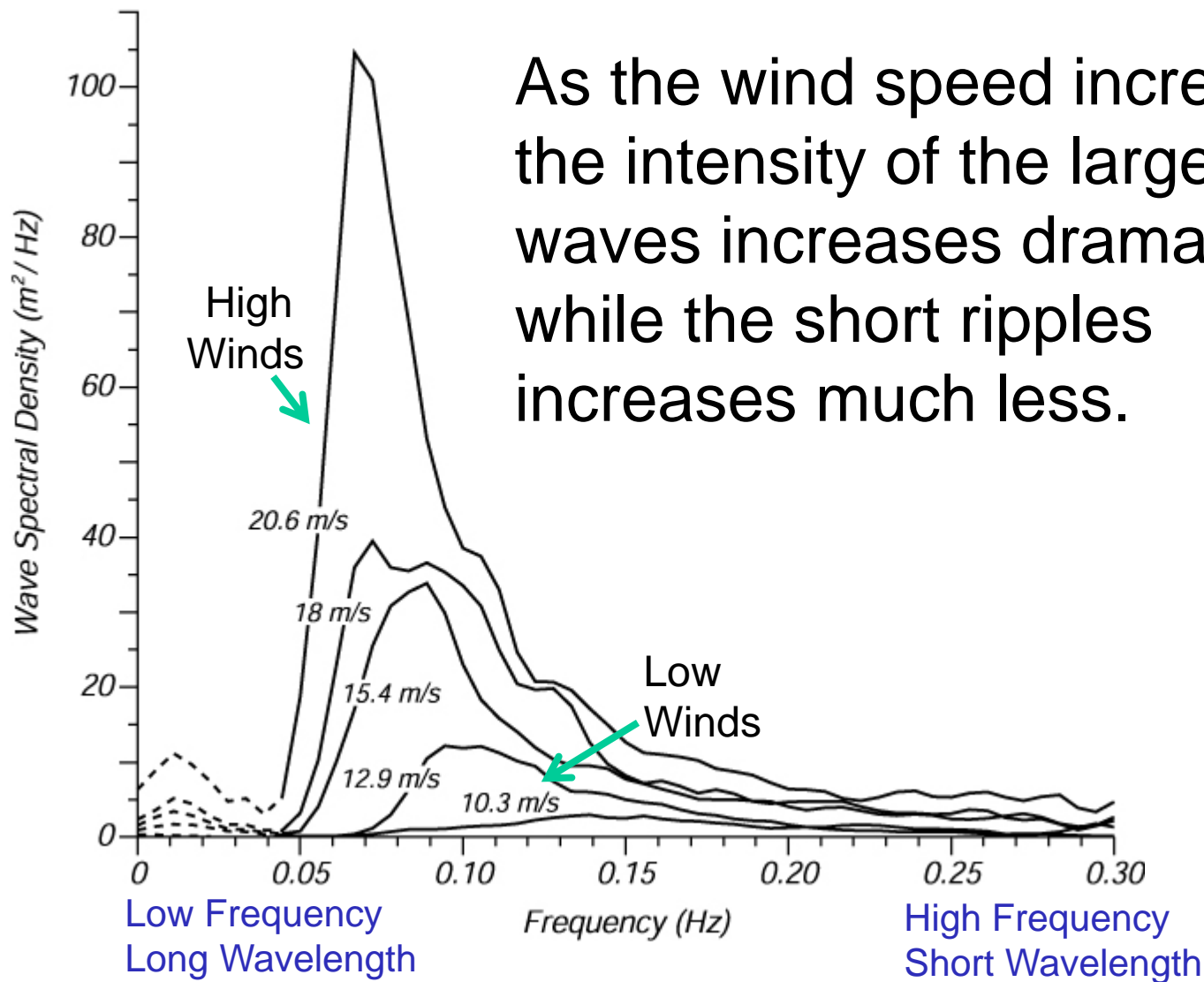
Beaufort Force 11



BEAUFORT FORCE 11
WIND SPEED: 56-63 KNOTS

SEA: WAVE HEIGHT 11.5-16M (37-52FT), EXCEPTIONALLY HIGH WAVES, SMALL-MEDIUM SIZED SHIPS MAY BE LOST TO VIEW BEHIND THE WAVES. SEA COMPLETELY COVERED WITH LONG WHITE PATCHES OF FOAM LYING ALONG WIND DIRECTION. EVERYWHERE, THE EDGES OF WAVE CRESTS ARE BLOWN INTO FROTH.

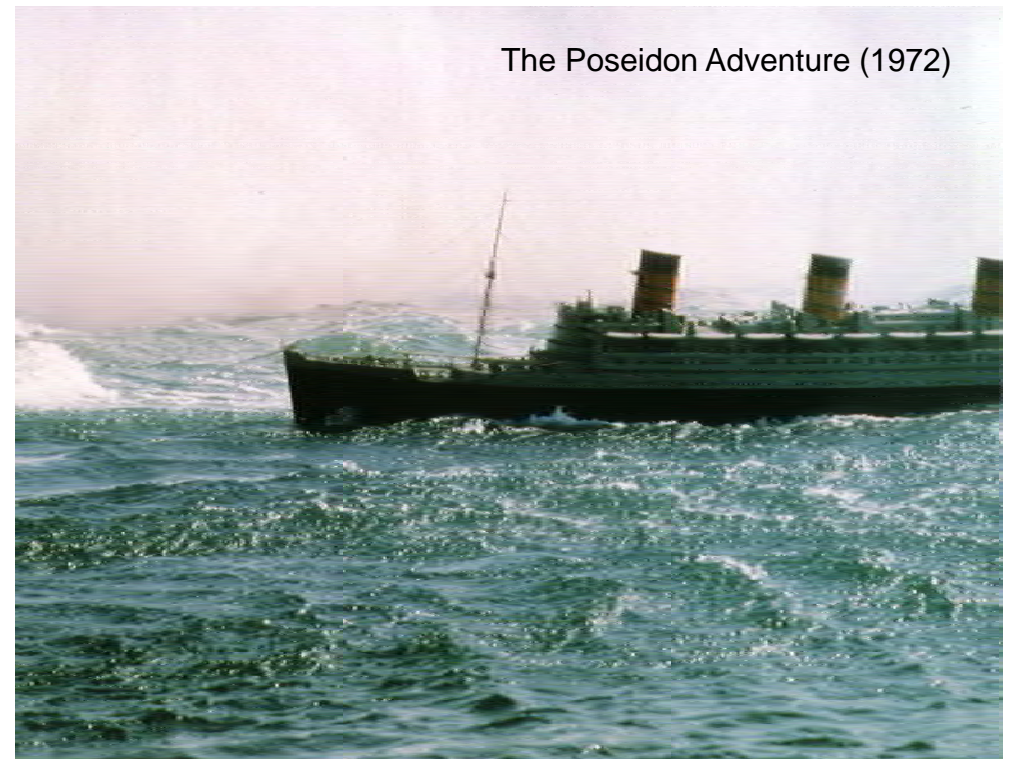
Ocean Wave Spectrum



As the wind speed increases, the intensity of the large surge waves increases dramatically while the short ripples increases much less.

Waves and Scale Models

It is very difficult to make water waves look realistic using scale models due to the effects of surface tension, viscosity, etc.



Clash of the Titans (1981)

Notice how fake the waves looks because the spectrum and the timing are wrong.



Tidal wave scenes were created with scale models.

Clash of the Titans (2009)

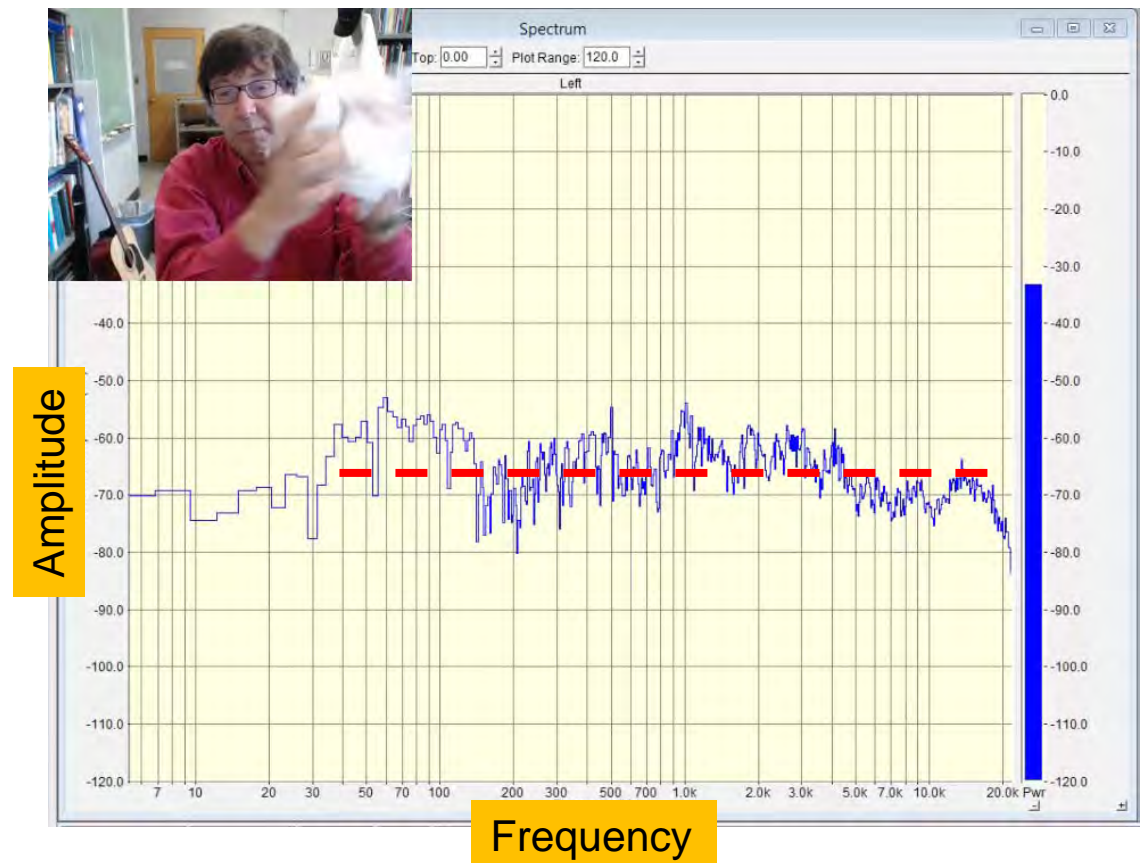
With modern CGI and a good understanding of physics it's possible to make believable waves.



Noises

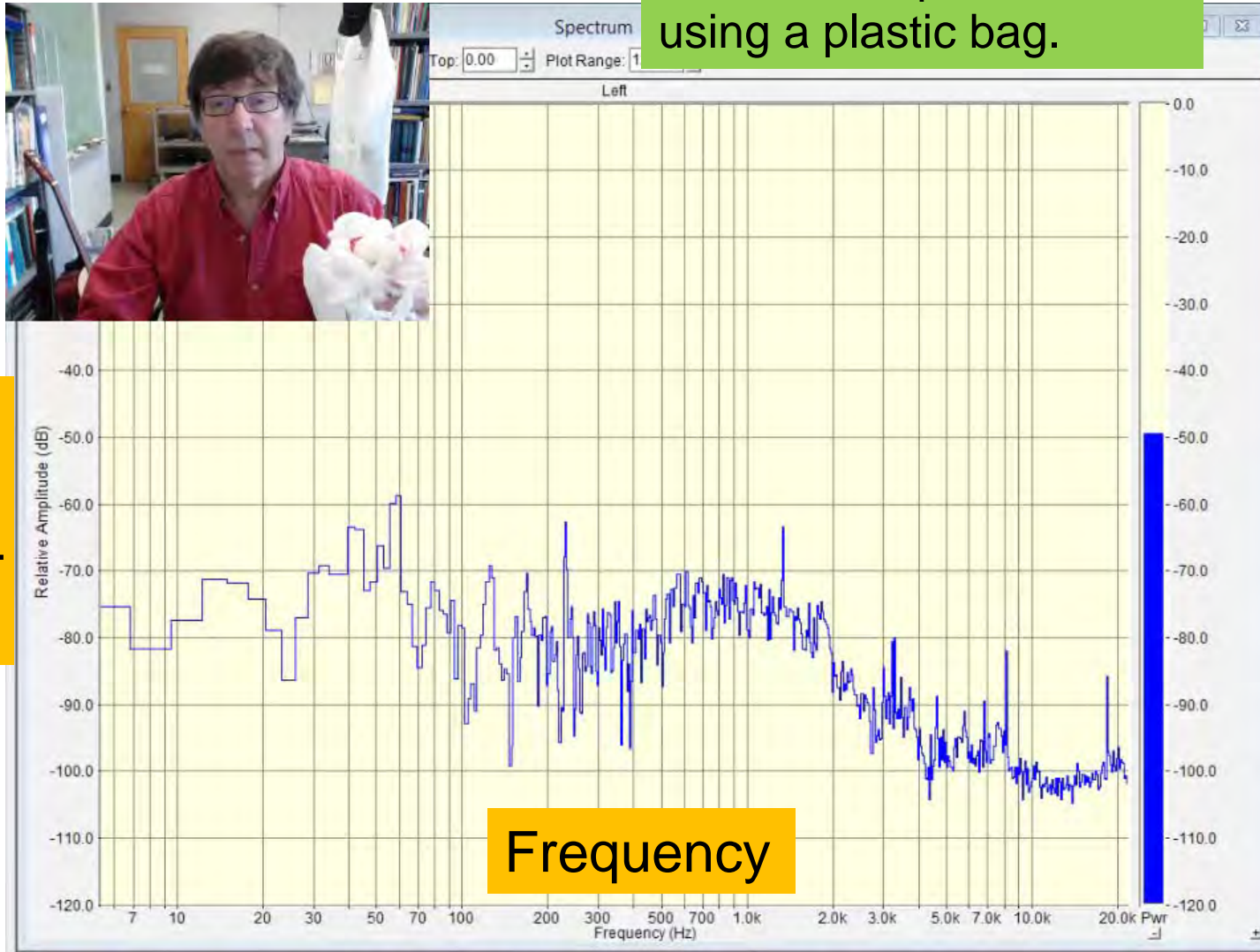
White noise has a spectrum with uniform intensity over a broad range of frequencies.

This type of noise is said to be “white”, in analogy with the spectrum of white light, which also has (roughly) uniform intensity over all visible frequencies.



White Noise

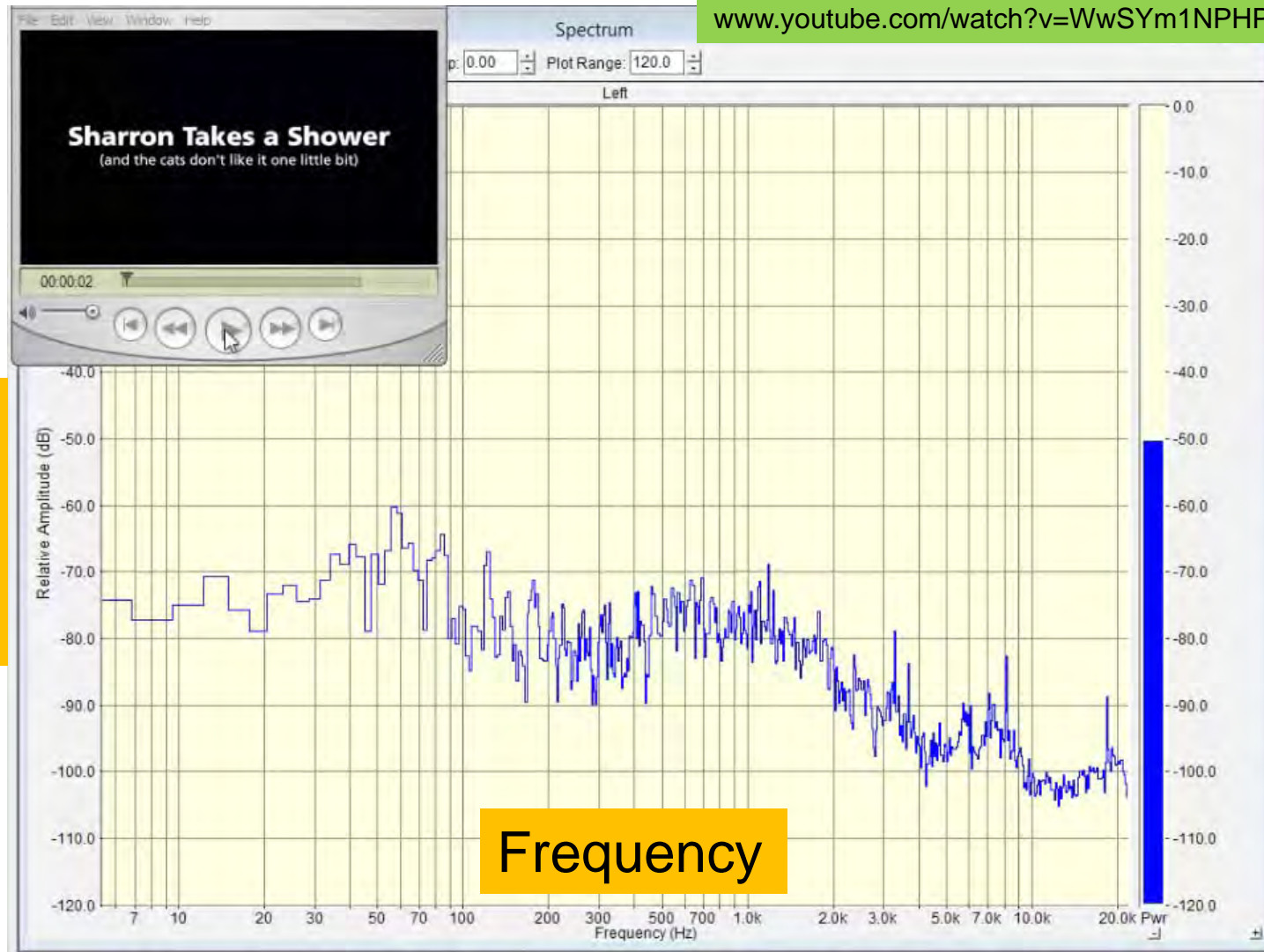
White noise produced using a plastic bag.



Siamese Cat Noises

www.youtube.com/watch?v=WwSYm1NPHP4

Amplitude



Summary

- Objects of different materials and shapes vibrate at their own set of natural frequencies.
- A spectral analyzer measures the different frequencies present in a wave spectrum.
- Musical instruments have a spectra “signature” called the timbre, also known as tone color.
- Ocean waves and other natural wave phenomena also have spectral signatures.
- Spectral signature varies with material properties and with scale.