

Physics of Musical Sound

Class 14: Bowed Strings

Read rest of chapter 10

Quiz today

Look at prob 3 from last quiz

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Modern Western Bowed Strings

- 4 sizes
 - Violin: strings 13", G3, D4, A4, E5
 - Playing range G3-E7 ---C8
 - Viola: strings vary 14-16", C3, G3, D4, A4
 - Playing range C3-D6 ---G6
 - Violoncello: strings 27.5", C2, G2, D3, A3
 - Playing range C2-A5 --A7!
 - Double Bass: strings 43", (C1) E1, A1, D2, G2
 - Playing range (C1) E1-G5 --G6

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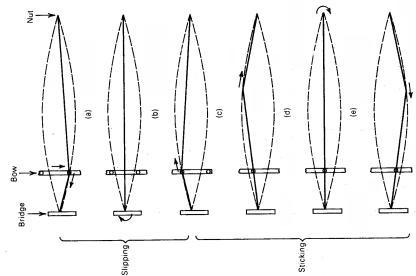
What makes an instrument?

- Essential for all
 - A way to make air move
 - A way to feed energy in to control way air moves
- If **pitched** need to move air in **periodic** way
 - A mechanical system with periodic motions
 - Either operates predominantly on one mode or
 - Modes are predominantly **harmonic**
 - May couple to **resonator** to move more air.

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Stick-Slip Bowing



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Stringed instruments

- Vibrating system=stretched string with clamped ends
 - Harmonic normal modes (remember lab)
 - Frequency controlled by length, tension, and string density
 - Mode n frequency= $\nu v/2L$ and $v^2=T/\mu$
- Needs resonator to be audible
- Energy source plucking, bowing, hammering

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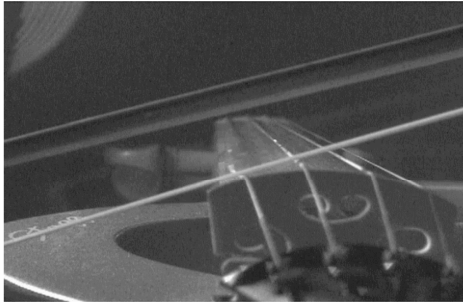
Stick-Slip Bowing



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Stick-Slip Bowing



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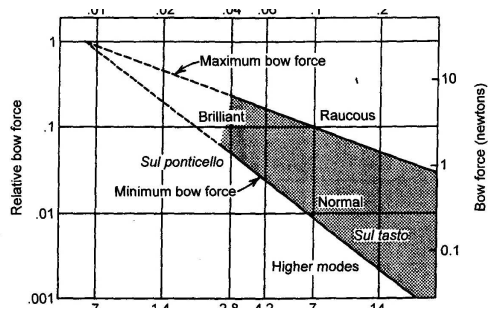
Resonance in 2-D Systems

- Many resonances at many frequencies
 - Lower frequency resonances involve large scale movements of the surface as a whole or only a few sections.
 - The displacement is typically large but the velocity low.
 - Low modes are widely separated in frequency; factors of 1.5 to 3 are common between the fundamental and the first harmonic.
 - Higher frequencies involve smaller scale movements but usually spread over the whole surface.
 - The displacements typically grow smaller as the frequency increases.
 - The modes tend to get closer and closer together in frequency as the mode number increases.

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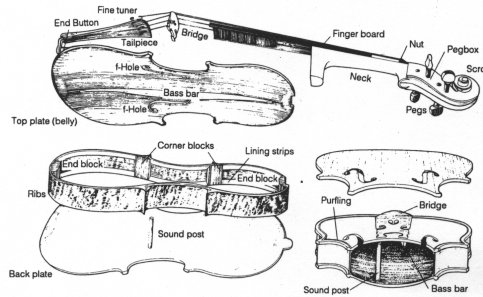
Effects of Bowing



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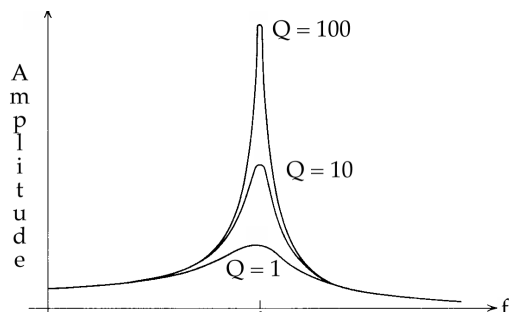
The Violin



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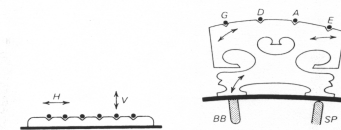
Resonance Curve



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Violin and Guitar Bridges



Guitar bridge
 Low, flat, hard to move.
 Only moves up-down
 Fairly small down-bearing.

Violin bridge
 Tall, flexible, easy to move
 Converts side-side motion of
 String into up-down motion.
 Large down-bearing..

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Violin Body Resonances

- Need a moderate Q.
 - Resonances must be fairly strong to couple sound well to air but
 - Resonances must be somewhat broad to avoid sudden changes in volume from note to note.
- Location and width of lowest mode is crucial to a good sound.
 - Need lowest mode down near the violins lowest frequency, G3, 196Hz.
 - Need that mode to support most of the low notes as the next resonance is not til 400-500Hz.

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Violin Body Resonances

- Overall loudness of a note is determined by the response of many body modes to many partials.
 - A good violin should not vary in loudness more than about 10dB across the playable range.
 - The smoother the response curve is the more even will be tone of the violin.
 - Some variation from note to note is desirable as adding individuality to the notes and to the instrument.

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Violin Body Modes

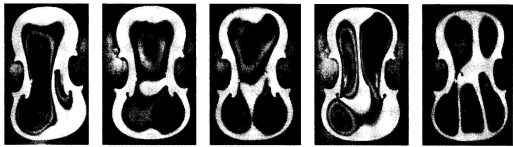


FIGURE 11.4 Vibration of a violin top plate (including bass bar and artificial sound post), studied with the technique of hologram interferometry. The light and dark bands form contour maps of vibration amplitudes. These vibration modes occurred at frequencies 540, 775, 800, 980, and 1110 Hz. Both the mode shapes and their frequencies are changed considerably in the assembled instrument. (Photos provided by E. Jansson, N. Molin, and H. Sundin.)

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Other Bowed Strings

- Other members of the violin family
 - Viola sounds a 5th lower but is only slightly bigger in order to fit under the chin. Weak in its lowest register. Sound is generally darker as highest resonances are weaker than in the smaller violin.
 - Cello sounds 1 octave below the viola. Is a little smaller for its pitch than the violin but not as much as the viola. Size limited by finger range rather than ability to stick it under your chin.
 - Double bass sounds a 6th-8th lower than cello. Quite a bit less than 2x as big so weak in lowest notes. Strings arranged in 4ths to allow for finger range.

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Violin Body Resonances

- Need resonances to extend up above 10kHz even though highest playable note is only 2-3kHz.
 - The characteristic violin sound depends on the presence of many upper partials. Those high frequencies must be transmitted to air efficiently for the violin to sound like a violin.
 - The upper resonances must not be too different in strength or the violin sound will be too colored by a particular range of frequencies.

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Hutchins Octet



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Other Bowed Strings

- Older family the viols use a slightly different body shape and scale. Strung with gut at lower tension so weaker, thinner sound. Are fretted like a guitar.
- The fiddle is not a different instrument, only a different style of playing. You can play a Stradivarius as a fiddle but the style is designed for cheaper instruments!
- Various non-Western bowed strings including the Rebab that is a prominent member of Javanese Gamelans.

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The Chuniri



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The Baryton



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The Erhu



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