Supplementary Recordings of Banjo and Resonator Guitar

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(Dated: April 28, 2024)

Two recordings complement recent work. One is a particularly fine-sounding flat plastic substitute for the aluminum cone of a resonator guitar. The other presents the sounds of taps on a banjo head, by itself, i.e., without strings. The repeated taps produce a sound akin to a cymbal, in addition to the expected thump-thump-thump. This had been identified as one of the two major sources of inharmonic partials in string plucks on the banjo.

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I. BACKGROUND

The purpose of this note is to enter two sound files into the record that are very relevant to work posted in the past year regarding banjos and resonator guitars, which can be found at https://www.its.caltech.edu/∼politzer/. The common themes are the role of inharmonic partials to produce distinctive sounds and the mechanisms that generate those sounds.

II. BANJO HEAD TAPS

Banjos apparently lead all plucked instruments in the strength of inharmonic partials. The sound of the collection of those partials on their own is quite "metallic." And it is suggested that the metallic component of the sound is what prompts the descriptor "ring." To be sure, there are other aspects of banjo sound that distinguish it, say, from acoustic guitar. Sounds are relatively loud, short-lived, and come with distinct formants. (These features can be quantified and their physics origins identified.[1])

Inharmonic partials must originate from something other than the resonant modes of the plucked string itself – at least if it is a decent string. In ref. [2], head modes and modes of the unplucked strings, excited by the sudden onset of the pluck, are shown to produce the inharmonic partials.

A. Banjo Supplement: pure banjo head sound

A recording from 2016[3] offers a dramatic version of the metallic sound produced by the modes of a banjo head. In particular, the sound clip features sequences of taps starting at the center and moving out to the rim on four different 11″ pots with the same type of heads, at the same tension. (These are pots without strings — i.e., drums.)

The sequences feature the expected "thud, thud, thud." However in addition, there is a weaker sound whose amplitude increases and sound becomes more cymbal-like as the taps go from center to edge.

https://www.its.caltech.edu/∼politzer/bacon/four-heads-center-to-rim-wide-open.mp3

III. RESONATOR GUITAR WITH A FLAT PLASTIC "CONE"

John Dopyera was tasked with designing a louder guitar. He succeeded. The key feature of his design is that string vibration is transferred to a very thin aluminum cone (or cones) rather than directly to the guitar top, as is done with wood-toped acoustic guitars. The continued enthusiasm for the instrument today, nearly 100 years after its invention, is due largely to its distinct timbre. Spectrograms of individual plucks reveal that the characteristic timbre comes from inharmonic partials. In contrast, wood-topped sound is overwhelmingly harmonic.[5] (Banjo remains the inharmonic king – so much so that some banjo players are keen to tone that down.[6])

At least some builders have long known that the resonator cones need not be thin aluminum nor need they be cone shaped. The aluminum cone substitute need only be comparably light and relatively free to move (i.e., compared to a solid wood sound board). Ref. [7] offers sound files of resonator guitars equipped with paper stock cones and even plastic disks that previously served as lids to food take-out containers. All sound somewhat different. Of course, players have preferences. Even in the world of spun aluminum cones, some players are adamant about the sonic differences produced by different designs.

A. Resonator Guitar Supplement: a better plastic lid

The cleanest sounding cone or cone substitute will more up and down under the force of the strings without, itself, flexing — at least for a substantial range of frequencies. With any design, at high enough frequencies, the normal modes of the cone will appear and destroy the frequency smoothness of the transduction. (For acoustic speakers, this phenomenon is known as "break-up.")

In FIG. 1, the "better" lid has no crinkles and does not bottom out against the wood structural member beneath under the tension of the strings. It sits on a ring of dense red felt of cross section $\frac{3}{8}'' \times \frac{3}{4}''$.

This is a sound sample of the newer lid:

https://www.its.caltech.edu/∼politzer/more-partials-mp3s/KCJones-red-felt-clear-lid.mp3

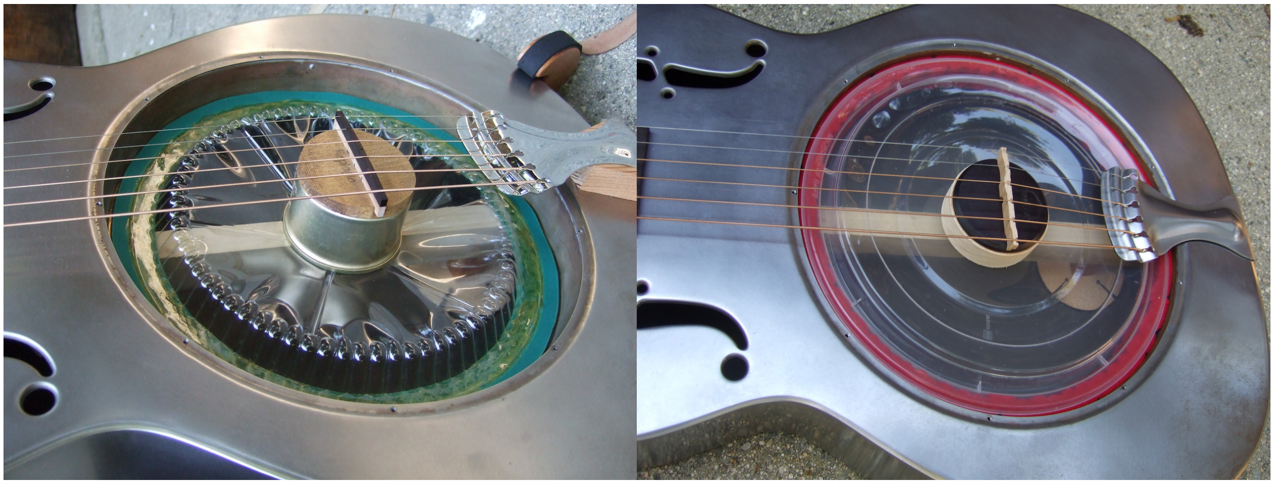

FIG. 1: PETE #1 lid from ref. [7] (left) and a "better" lid for the recording below

In contrast, this is the recording from ref. [7] (albeit different recording space and mic placement):

https://www.its.caltech.edu/∼politzer/paper-cone/KC-volume-adjusted/steel-PETE+7dB.mp3

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[1] J. Woodhouse, D. Politzer, H. Mansour: a technical exposition is available as open-access as *Acoustics of the Banjo: measurements and sound synthesis & theoretical and numerical modeling*, Acta Acustica, **5**, 15 and 16 (2021) https://doi.org/10.1051/aacus/2021009 and https://doi.org/10.1051/aacus/2021008); *Pickers' Guide to* Acoustics of the Banjo, HDP: 21 – 01, http://www.its.caltech.edu/∼politzer – APRIL 2021 is an informal account of some of the salient results.

[2] *Inharmonic Partials and Banjo Ring*, HDP: 24 - 06, https://www.its.caltech.edu/∼politzer/banjo-ring/inharmonic-partials-banjo-ring.pdf

[3] *A Bacon Tone Ring on an Open-Back Banjo*, HDP: 2016 - 01, https://www.its.caltech.edu/∼politzer/bacon/bacon-ring.pdf The relevant text on page 3 describing the selected recording reads,

`"In the following sound clip, each of the four rims has the same model new head,`
`tightened to the same tension. Each rim is suspended from an eyebolt screwed into`
`the coordinator rod, in place of a neck. The backs are left wide open to the air.`

`For each, you hear a sequence of taps that start at the center and move gradually out to the rim. The order of the pots is: 1) an old wood rim, 2) an old wood rim fitted with a 1/4″ diameter brass ring, 3) a new wood rim, and 4) a new wood rim fitted with a Bacon tone ring."`

"Old" and "new" are original 13-ply and modern 3-ply Deering Goodtime rims.

[4] *Resonator Guitar Synthesis*, HDP: 23 - 04, https://www.its.caltech.edu/∼politzer/pluck-synthesis/pluck-synthesis.pdf

[5] *An Investigation of Resonator Guitar Sound*, HDP: 23 - 01, https://www.its.caltech.edu/∼politzer/resonator-guitar/resonator-guitar.pdf

[6] https://banjobolster.com

[7] *Resonator Guitar Physics Clue from a Paper Cone*, HDP: 23 - 03 - rev'd , https://www.its.caltech.edu/∼politzer/paper-cone/paper-cone.pdf