Finding the Wolf Tone: Acoustic analysis of the resonance properties of the violoncello

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Feb. 10, 2025 – Mar. 7, 2025
Feb. 16, 2025

Submitted to:
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WPI-ME5304

This project aims to perform analysis on the acoustic resonance properties of the cello with the goal of detecting, isolating, and counteracting the wolf tone frequency. The wolf tone is a consequence of interference between sound waves traveling along the string and vibrations of the cello body. Specifically at resonance frequencies of the cello body, the amplified vibrations are strong enough to cause audible variations. These tones commonly occur around F#$_3$ on a cello, roughly 185Hz, and can be counteracted by placing a small weight on the string between the bridge and tailpiece. Therefore, to prevent the wolf tone frequency, three steps must be taken: finding resonance patterns of the cello using scanning laser doppler vibrometry (SLDV) and time-averaged holographic interferometry, placing the tuned mass damper (counter-vibration weight) in the correct position on the string, and repeating the experiment to find possible shifts in resonance. Steps taken since the project started include a preliminary SLDV scan and further research into damper placement. Also, having received feedback on holographic interferometry, the proposed interferometry setup has changed to reflect increased focus on the bridge. The preliminary SLDV scan presented a full body analysis of resonance from 0 to 5 kHz with 800 frequency divisions and 4 sample complex averaging, however, with large noise-to-sample ratio due to low amplitudes. Several peaks were present and resonant frequencies 2.56875, 2.74375, 2.80625, 3.4625, and 4.37125 kHz were the primarily monitored frequencies. These frequencies are outside the range of the wolf frequency, but provide an example of resonance characteristics for comparison in a secondary SLDV scan with an amplifier. The second scan will also have more frequency divisions within a smaller range of 0 to 1 kHz. The amplifier will assist in reducing the noise-to-sample ratio at lower frequencies seen in the preliminary SLDV as a high noise floor. Next steps also include taking holographic interferometry measurements. Since the initial proposal, no measurement has been taken due to the interferometer not being set up for student use at the time. With specific focus on the cello bridge, the proposed setup has changed to having the cello lay flat on the table and analyzing light reflected off solely the bridge. Further progress and changes can be made after a preliminary interferometry scan. Resonant features of the bridge are shown through small fringe displacements implying large displacement. After finding the resonant frequencies in the range of 100 to 300 Hz, we have determined the position of the tuned mass damper must be placed on an antinode between the bridge and tailpiece. Given a resonant frequency, the mode, n, can be found. Antinodes would then be halfway between n divisions of the string. In conclusion, progress has included taking a preliminary SLDV measurement and identifying resonance as well as correlating resonant frequency to damper position. Next steps include taking a detailed secondary SLDV scan and interferometry scan. Further steps include placing the damper and retaking measurements.