Wolf tone frequency: Analysis of resonance properties of a cello through laser metrology

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This project aims to identify the frequency at which wolf tone occurs in a specific cello and the possible effects of compensating for wolf tone. The wolf tone is a consequence of interference between sounds waves traveling along the string and vibration of the cello body. Specifically at the resonance frequency of the cello body, the amplified vibrations are strong enough to cause audible variations. This interference creates a “beating” or “howling” sound uncharacteristic of a cello and is named the wolf tone as a result. Finding the specific frequency and location of dampening to remove the wolf tone can be a grueling task. Since wolf tone is dependent on body resonance, the frequency at which the wolf tone occurs varies across cellos. However, studies have identified that cellos, along with guitars and violins, have three major resonance modes. All three resonance modes are centered around 200 Hz and can safely assumed to be within the range of 100 Hz to 300 Hz. Other resonance modes are too insignificant to cause sound interference. Therefore, I propose the use of two laser metrology techniques to nondestructively identify the wolf tone frequency for a given cello and the effects of compensating the wolf tone using a dampener. The first is scanning laser doppler vibrometry for a full-body frequency analysis. Using scanning laser doppler vibrometry on the cello body can identify the resonance frequencies and patterns through external excitation by a speaker emitting frequencies sweeping from 100 Hz to 300 Hz. Stable patterns and large amplitude variations would be an indication of resonance and likely the cause of the wolf tone. The second method is time averaged holographic interferometry. Like scanning laser doppler vibrometry, this technique will also give a frequency analysis of an excited object. However, this experiment will focus on the bridge of the cello, the point of contact between the strings and cello body, rather than the full body. It is imperative to identify alterations to the wolf tone frequency that result from the bridge interface. By using these two techniques, placing the dampener in the correct location will be significantly easier. After placing the dampener, the two frequency analyses must be repeated. Adding extra weight, the dampener in this case, could shift the resonance of the body, and therefore, the wolf tone frequency as well. Any other resonance properties that may have changed can also be identified by repeating the experiment. The results of both experiments will provide a full indication of both the wolf tone and effects of placing a dampener on the string in regard to body resonance.