GENERAL COMMENTS ON BISSINGER RESEARCH ARTICLES

The articles included here deal with fundamental results from some of the most comprehensively measured *playable* violin vibration and radiation properties. These articles have direct relevance to the violinmaker interested in how the violin makes sound: 1) the fundamental vibrations determined by the materials-shape-construction of the violin expressed in the language of modes, with special emphasis on the "signature modes" in the open string region, and 2) how whole violin modes – corpus and cavity – radiate, again with emphasis on the crucial low-frequency signature modes and their effect on perceived violin sound. These articles were originally written in technical language for a technical journal and reviewed professionally for technical soundness. They provide the underlying scientific basis to understand how the violin creates sound as embodied in the *dynamic filter* model.

General technical comments for all the VIOCADEAS data from plates to playable violin:

- *Chladni patterns* – most makers are familiar with the Chladni patterns used for tuning individual low-lying plate modes; a single frequency tone is adjusted to give a maximal plate response at a certain frequency for a plate suspended over a loudspeaker, bouncing the glitter to the quiet places on the violin plates. Of most importance here are plate modes #2 and #5.
- *Radiativity* – this is the normalized pressure measurement = pressure/driving force. For the VIOCADEAS data it is simply the amount of sound pressure at 1.2 m per unit driving force applied at the bridge.
- *Radiativity profile* – Properly setup traditional violins have very similar radiativity "profiles", i.e., radiativity vs. frequency averaged over 266 points over a sphere around the violin to provide a direct measure of how strongly a violin radiates across a wide frequency range. Profile shapes fall into three major regions: 1) five widely separated "signature mode" peaks in the open string region below 660 Hz, 2) a deep "trough" bottoming near 0.7 kHz, and 3) rising at higher frequencies above the trough to a region with much peak response overlap resulting in three broad structures that suggested a statistical treatment.
- *Mobility profile* – this is the vibrational version of the radiativity profile. Mobility is the velocity per unit driving force.
- *Radiation efficiency* – the VIOCADEAS database uniquely contains simultaneous mobility and radiativity measurements sharing the same driving force. Thus dividing the radiativity profile by the mobility profile cancels out the driving force to provide the amount of sound per unit motion, a ratio leading directly to the radiation efficiency, *the* crucial structural acoustic parameter in the *dynamic filter* model.

Two general areas have dominated research on how the violin creates sound for a very long time:

- *Plate tuning* – fundamental to how the violin vibrates in its assembled state as it directly affects: *i)* violin total mass, *ii)* corpus mode frequencies (especially the 1st corpus bending modes B1$^-$ and B1$^+$ in the open string region near 470 and 545 Hz resp. (but note the strong rib stiffness contribution to the B1 frequencies), and *iii)* the violin's critical frequency near 4 kHz (estimated from the violin's radiation efficiency vs. frequency plot). The frequency placement of B1$^-$ and B1$^+$ relative to the two lowest cavity modes A0 (the always-strongly-radiating Helmholtz resonance near 275 Hz and only mode falling on the G string below D), and A1 (the sometimes-strongly-radiating, lowest longitudinal (lengthwise) cavity mode near 470 Hz) is a major consideration for achieving strong sound production across the open string region.

- *Bridge tuning (*requires *soundpost)* – setup is crucial to achieving the violin's ultimate perceived quality. Soundpost insertion by itself plays an absolutely essential part in good violin sound because it literally transforms the violin's radiative response in the open string region below 660 Hz by its powerful effect on A0 frequency and strength. On the other hand waist trims that modify the bridge rocking frequency, typically near 3 kHz, affect only mode excitation, strongly emphasizing frequencies near 3 kHz, with minor effects on the B1 signature modes. Surprisingly the soundpost semi-"freezes" the bridge foot on the soundpost side for only three of the signature modes and not for the higher modes. The recursive rocking frequency-soundpost placement interaction exploited during setup is necessary to optimize the desired sound/response for individual players.

Both of these fundamental areas relate both to how the violin creates sound and also to how the violinmaker can modify the sound.