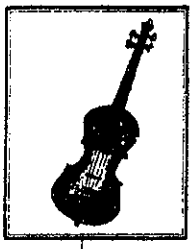
Air and Body Modes in the Violin



by John McLennan

Raymond Howes puzzlement (JAAMIM March 1997, Letter to the Editor) at the sound quality of old violins not being affected apparently by the neck and other changes of the early 19th century, may not be real. He mentions specifically the "cavity mode" and the "main bending mode". Other names for these, if I interpret him correctly, are the "first higher air mode" and what has been called the "main top plate or body mode".

The "first higher air mode" is clear enough. It is determined by the internal length of the body cavity as it consists of a standing wave with pressure maxima at each end and has a fixed frequency at about 480Hz for a full size violin. The lowest or "main air resonance" (misnamed Helmholtz although linked with it) occurs at about 280Hz and is determined by the air volume and area of the f-holes. Without the soundpost it occurs at about 250Hz.

The understanding of the "main body resonances" has increased in recent times. There appear to be two related body modes, sometimes referred to as "baseball" modes because of their nodal patterns; across the top and along the back for the upper one and vice versa for the lower one. The upper one which occurs at about 550Hz has the lower nodal line on the top pulled up to take in the soundpost. This does not happen if there is no soundpost present. The lower mode occurs at about 480Hz. For both these modes the neck undergoes bending in a vertical plane. The two modes are labelled B1- and B1+ and correspond to T1 and C3 respectively of Saldner H.O., et al.[1]. B1+ shows a variant in that the same nodal shape is present but at a slightly lower frequency.

The neck in this case undergoes torsion instead of bending. These modes are set out by Marshall[2].

It is now thought that the relationship suggested by Hutchins[3] between A1 and B1 involves B1+. This raises the question as to whether B1- and not A1 is the other relevant parameter. B1- and B1+ can be separated by as much as 100Hz. A1 itself is not a cause of sound radiation as no peak appears for it on external excitation of the violin. Peaks appear for both B1- and B1+ on external impulse excitation with a microphone pickup.

Concerning the question raised by Howes about the implication for changing the setup of the master violins, it would seem that they would not affect the peaks above, very much. The extra stiffening of the body due to the heavier bassbar and soundpost would raise Ao and B-pair a little but A1 would not be expected to change.

A change in standard pitch to A440 would move the harmonics up slightly so both changes would brighten the violin sound a little.

It is thought these changes allowed a larger sound output to the obtained. I doubt this was substantial. What we need are some measurements. It certainly made the instrument easier to play in the higher positions as it coincided with the use of the chinrest. The chinrest enabled the player to support the violin independently of the left hand giving him greater freedom. The Baroque setup did not stop virtuoso violinists, like Locatelli, who stopped notes on the E string above the fingerboard which only extended one and a half octaves. They also tuned their top string to the higher pitch possible and at times moved their bridge nearer to the tailpiece.

References:

(1) Saldner H.O., Molin N.E. and Jansson E.V., "Vibration modes of the violin forced via the bridge and action of the soundpost." J.Acoust.Soc.Amer. 100(2), 1168-1177, 1996.

(2) Marshall K.D., "Modal analysis of a violin". J.Acoust.Soc.Amer.77(2), 695-709, 1985.

(3) Hutchins C.M., "A Measurable Controling factor in the tone and playing qualities of violins." JCAS, Vol 1(4), (Series II), pg 10-15, 1989.