Dear Fellow Luthiers,

For the past several years, the VSA and the Oberlin Acoustics Workshop have been running a series of seminars on zoom called "First Fridays" – they are held on the first Friday of each month (except for a summer break). These are open to anyone who cares to attend. Conveniently, they start at 10:00 Pacific and consist of an expert talk for an hour or so, followed by an extended Q&A. Many of the sessions have been posted on YouTube; they are more or less unedited, so they can be rather long.

The topics of the seminars vary widely, from complex engineering analyses of a violin's sound production, to discussions of how we perceive and talk about an instrument's sound, to wood preparation, and violin setup. For the most part, you are not going to listen to one of these talks and then go back to your shop and do things differently, but you will go about your lutherie with a deeper understanding of why violins are the way they are.

In this edition of Sound Post, I will talk about some of the people presenting these seminars who are well worth listening to, and recommend their videos and websites. By way of introduction, I will describe "signature modes" – much discussed in the Oberlin seminars - what they are and how to measure their frequencies with nothing more than a small mic and a laptop.

Chris Waltham - President, VMABC

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Articles

Signature modes: what are they and how to measure them (very quickly)

Previous newsletters (both recent and stretching back to the 50s) have discussed the vibration modes of free violin plates, and how getting these modes and their frequencies right is a step to a serviceable violin. But what happens to the plates when they are glued together in a box? The vibration modes will not remotely be the same, and the vibrations of the individual parts – belly, back and enclosed air – will couple together to form new composite modes of vibration. The lowest frequency three or four of these are called the "signature modes" and they have a lot to do with determining the "voice" of a violin.

The human voice similarly has signature modes, although they are usually called formants. Formants are the lowest vibration modes of the air in our vocal tracts, which starts with our vocal folds ("chords") and ending with our open mouths. We unconsciously manipulate our vocal tracts to move the formants around and make sounds we interpret as different vowels. In addition, our ears and auditory processing (i.e. your brain) are so fantastically sensitive to nuance that we can not only decipher what is being said (in real time), but also who is saying it, and what sort of mood the speaker is in.

For those of us old enough to remember phones without call display, often all it would take to identify a familiar caller would be a preliminary clearing of the throat - and we could do this despite the distortions of a bad phone line.

Back to the violin. Take the two plates, weighing say 60 and 110 g, glue them onto the ribs, and in doing so, enclose a couple of grams of air. Now the plates are held at the edges, and vibrate at the lowest frequency something like a drum skin, with the greatest motion in the middle. At this point, I am ignoring complications of the bass bar and sound post. The belly can't vibrate without setting the back in motion because of the elastic air in between, and the air can pump in and out of the f-holes. All three of these motions are excellent radiators of sound at the frequencies of the composite modes of vibration called the signature modes.

The lowest frequency mode is labelled "A0", "A" for "air", because most of the sound radiation comes from the air in the f-holes. The next mode up is labelled "B1-", "B" for "body", as the motion is mostly in the belly plate, with some in the f-holes and back plate. The third is the "B1+" which is similar to the B1- but the back is moving the most. Both the B1- and B1+ are "breathing" modes, i.e. belly and back swell inwards and outwards together and the volume of the box varies significantly; that's why they radiate so well. At frequencies of the signature modes, the radiation comes from the entire wood-air system, and can't be ascribed to any one piece (at higher frequencies this is not so).

If you want to know more and see videos of these vibrations, see Jim Woodhouse's euphonics.org, which I shall talk about in the reviews. Also Fig.1 below, which shows the radiation spectrum of a famous Strad tapped at the G-side of the bridge, parallel to the belly plate, to simulate the bowing force. The data came from Joseph Curtin (see the reviews).

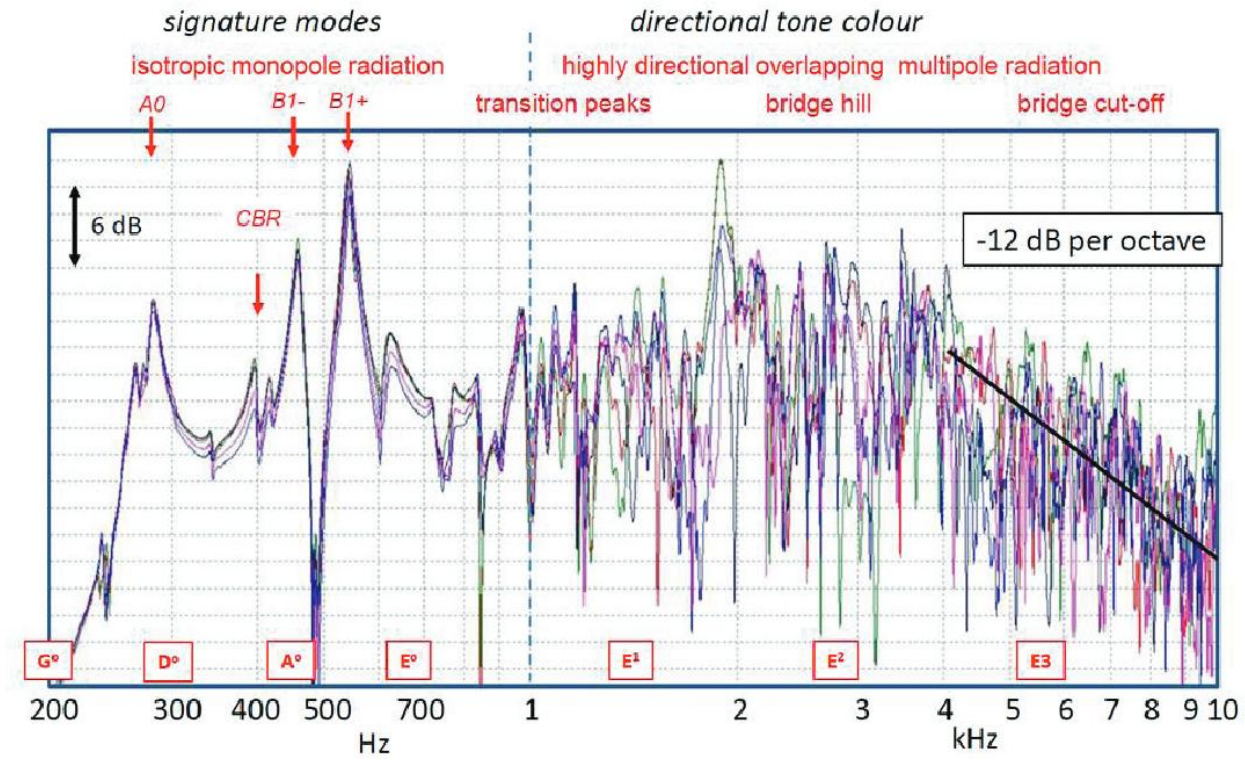


Figure 1: Radiated sound spectrum of the 1734 Willemotte Stradivari violin, from Colin Gough's article "Violin Acoustics" in Acoustic Today, summer 2016 (without permission).

A quick way to measure the signature mode frequencies

The method is similar to the one I talked about in the August Newsletter for finding the mode frequencies of the free plates, using a microphone and a laptop running a frequency analysis app. However, here it is easier if you have a tiny positionable microphone to be able to focus in on particular parts of the violin body that move most vigorously in the different modes. (In fact, a small microphone would also make plate modes easier to analyze). I bought a lavaliere microphone with a TRRS 3.5mm jack that was compatible with my seven-year-old laptop – for about $12.

The euphonics site, and many others, are excellent for body motion, but the animations were made with accelerometers and they do not include the all-important air in the f-holes. About eight years ago, I made detailed mode maps of a couple of my violins using accelerometers and tiny microphones to capture the motion of both the body and the air (fig.2).

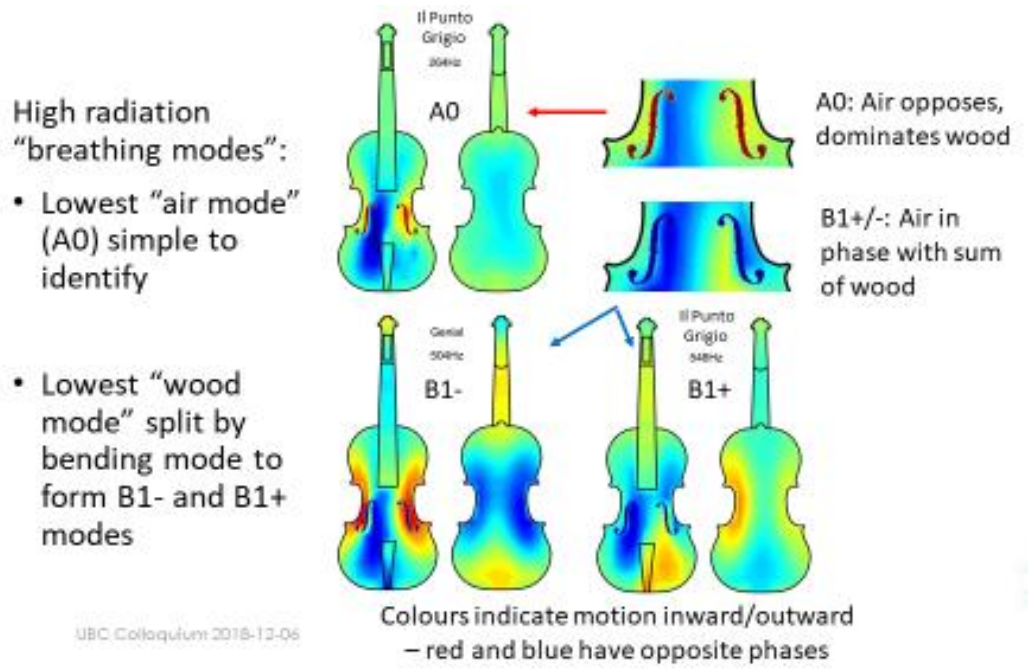
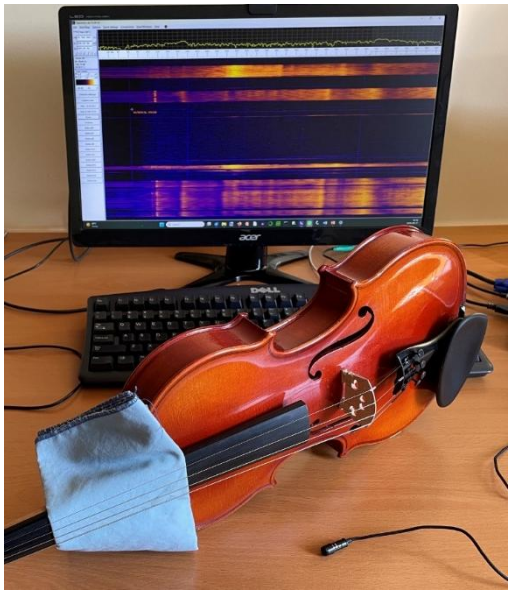


Figure 2: Shapes of signature vibration modes of a violin



The deeper the colour, the greater the motion. As can be seen, there is always a lot going on at the G-foot of the bridge; this is a result of the bass bar that keeps most of the left side moving as if a rigid piece. Similarly, not much happens near the sound post, as belly and back are tied together here. It is good to dampen the strings somehow (I slipped a piece of cloth under them, as in fig.3) as they resonate really well and complicate things. Take data with a frequency analysis app:

A0: Microphone just above an f-hole. Tap the G-foot (repeatedly). A bright line appears at about 275 Hz.

B1- and B1+: Microphone at the bass of the back; tap there. Lines appear at about 465 and 550 Hz.

The results are shown in fig.3. You may find that tapping in other places gets you a cleaner signal.

Figure 3: Measuring the signature mode frequencies of a 1992 Karl Höfner.

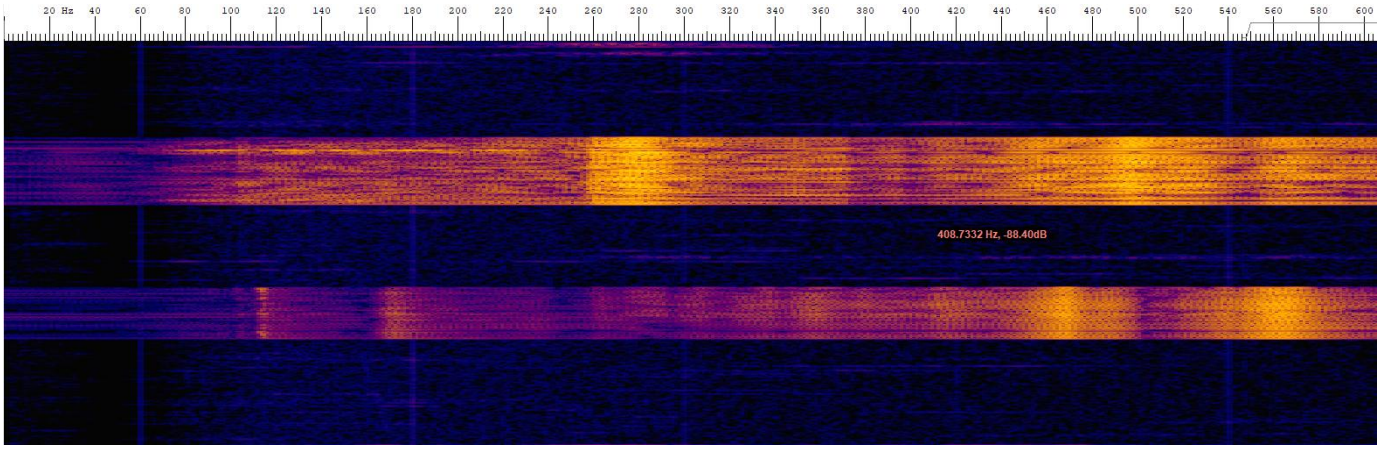


Figure 4: Scale: frequency in Hz. Top band: tapping G-foot with mic near f-hole. Bottom band: tapping and mic at base of back.

I conclude from fig.4 that the following mode frequencies for my 1992 Karl Höfner:

A0: 278 Hz, B1-: 470 Hz, B1+: 567 Hz.

The extra bright patch at about 500 Hz in the top band is probably due to higher air modes in the cavity. In the bottom band, the line at 115 Hz the tailpiece vibrating; that at 155 Hz is the fingerboard – this was easily determined by deliberately tapping these parts.

There are two additional modes that are non-radiating but possibly of importance: the lowest bending mode B0, and the next air mode A1. I will talk about these in the future issue.

As with the free plate vibrations, there is no fundamental law that says the signature mode frequencies should be anything particular. All we know is what we find when we measure old, and especially Italian, violins that are deemed to be fine instruments. As can be seen from the euphonics website, there is considerable variability even between top-quality instruments. Moreover, as yet no amount of physical measurements can tell us the difference between an OK violin and a great one.

You will notice that the resonances are quite broad on the frequency spectrum. There is trade off here: the signature modes give the violin its characteristic voice (just as formants do for the human voice), but if they were too high and narrow, there would be dead frequency regions where the violin would not radiate. Similarly, if they were very low and broad, the violin sound box would function more like an electronic speaker, and have no character of its own. It's a goldilocks thing.

So why do this? It is possible to use the measured frequencies to diagnose issues, and in some cases, do something to fix them. As an example, I noticed that all my violins have A0 frequencies on the low side. On investigating, I discovered that the way I transfer the f-hole shape from the pattern to the wood has led to my f-holes being systematically too narrow. (The A0 frequency is proportional to the quarter root of the hole area, so an 8% increase in width should increase the A0 by 2%, i.e. a significant 5 Hz). I am now busy widening them all.

Patrick Kreitz has a set of desiderata for all these modes listed on his website. As a note of caution, I found that one of my violins matches all these criteria far better than my Höfner, but I have to admit that the Höfner is a much nicer instrument to play.

Aside: Darkening wood with an LED UVB light

I have long intended to build a UV box for darkening wood and curing varnish. Using an LED UVB light could potentially achieve these goals without the complication of heating. Luthier chat sites did not seem conclusive about their effectiveness, so I bought an ECKPO Dimmable LED Reptile UVB Lamp from you know where, and did an experiment. I placed a piece of maple on the bench and illuminated it with the LED light for nine days. I covered a strip of it to preserve the original surface hue. For comparison, I put a piece of maple, from the same board, in an ammonia atmosphere overnight (suspended above concentrated ammonium hydroxide solution in a sealed box).



Figure 5: Maple exposed to LED UVB for 9 days (L) and overnight in an ammonia atmosphere (R).

Fig. 5 is revealing. The LED UVB light has no diffuser; it is just an array of a few tiny LEDs, and so it produces blotchy darkening (the lighter strip at the bottom is due to deliberate covering for comparison). On the other hand, holding the wood over concentrated ammonia quickly produced a even darkening. I returned the LED lamp from whence it came.

Reviews

The September 4, 2026 VSA-Oberlin "First Friday" lecture.

Beyond the Violin's Signature Modes, by **Jesús Alejandro Torres** of the Instituto Nacional de Bellas Artes y Literatura, Mexico, and the Queretaro Violin School.

Torres is a well-known musical acoustician who has worked with the Queretero Violin School, and also with some famous old violins in Mexico, notably the Lord Coke Guarneri.

In this lecture he described his attempts to gain some insight into violin quality by the studying the many body resonances above the signature modes, in the so-called "transition" and "statistical" regions (see fig.1). The statistical region is so called because there are so many closely-packed resonances that it is impossible to single out any one, of even identify the same resonance in two different instruments. However, taken as a whole, there is a general increased density of resonances around 2.5-3 kHz due to the rocking motion of the bridge, and this contributes to the violin's human-like sound. This "bridge-island hill", as it is called, mimics the "singer's formant" that can be found in the voices of trained opera singers, allowing them to rise above an fff orchestral tutti.

Torres described his experimental approach; it is a work in progress. The talk is not yet posted.

Lecturers frequently appearing in Oberlin's YouTube archive that are worth your attention

Jim Woodhouse

Now retired from the Engineering Department of Cambridge University, Jim Woodhouse has been publishing papers on many aspects of violin physics (and more general vibration engineering) since 1974. An amateur luthier himself, his hobby provided the topic of his Ph.D thesis. Although many of these papers are highly technical/mathematical, he can also talk to lay audiences with exceptional clarity. (Decades of instructing undergraduates teaches you not to assume anything about your audience.)

Woodhouse has been building over the last few years a compendium of all he knows about the science of music and putting it out as he creates it, on the website euphonics.org. This is a site to be dipped into. The initial chapters cover very basic physics. If you hang onto your hat, later chapters will take you to up-to-the-minute research and as much nuance and complexity as you wish.

On the hand, if you want a gentle introduction in video form, you will do no better than to watch his Introduction to the basic physics of stringed musical instruments, a set of eight bite-sized Oberlin lectures, about a quarter of an hour apiece.

George Stoppani

A British luthier of Venetian heritage, for many years George Stoppani hosted a very useful website platetuning.org. This site was a compendium of all things to do with plate tuning, and how to characterize a completed violin, based on its signature modes (which is where I got the idea!). Unfortunately, he died last year and the site is no longer accessible.

However, his 2022 Oberlin lecture Modal Analysis Basics and More remains available.

Joseph Curtin

Joseph Curtin is an American contemporary violinmaker, recognised as one of the world's greatest luthiers. He uses advanced technology to measure the acoustics of violins, to aid in his designs. He uses the information gathered to create replicas of famous antique violins, as well as instruments made from novel materials (meeting him 20 years ago set me on the path to experiment with making balsa and paulownia instruments).

He was the author, with Claudia Fritz and others, of the famous (infamous?) 2010 double-blind study that showed Strads were not particularly favoured over modern instruments.

Curtin has talked many times about how he measures instruments, and he has produced a low-cost kit for others to do the same.

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