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LETTERS AND COMMENTS

Comment on 'The dead zone for string players'

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Abstract. A mechanism is proposed for the generation of sound waves by the bowing of a violin. It is suggested that 'kicked oscillator' studies may be applicable to future research in this field.

In a recent letter Broomfield and Leask [1] found experimentally that 'It is not possible to produce sound from a string when it is bowed at its midpoint.' This finding is trivial if one knows the following mechanism of bowing.

It is well known [2] that if one puts a horse-tail bow hair under a microscope, there are many 'small nails' on its surface. It is these 'nails' which continuously pluck the string as the bow moves that produce sound. This is different from what happens when one plucks a string with one's finger. In the latter case the string can vibrate freely once the finger has left the string, while in the former case the finger constantly intervenes with the vibration. The nail spacing is so close that it is perhaps better to describe these 'nails' as 'brushes' or 'combs'. This kind of vibration is therefore better described as a 'forced' or 'kicked' vibration (see figure 1). Once one nail has passed over the string, the string can only vibrate freely for a short period before the next nail arrives. It is therefore better for the amplitude of vibration at the bowing point to be about the same as the spacing of the nails so that the intervention of the nails is minimized. If the amplitude is larger than the spacing of the nails, the string does not manage to vibrate much before the next nail arrives.

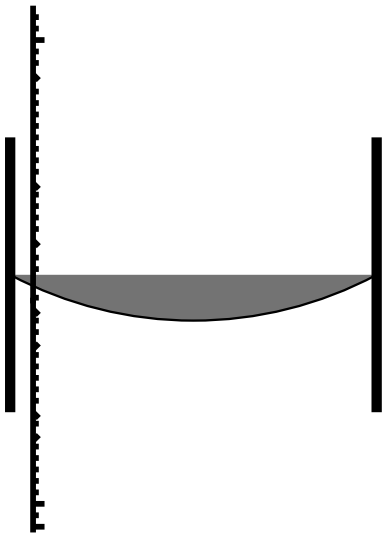

Figure 1. Schematic plot of bow-hair–string interaction. Bowing a string is just like sawing it. The sound generating mechanism is something in between plucking a string with one's finger and macroscopical frictional effects. One should consider the process as a kicked vibration. The presence of the next nail will stop the vibration if one bows at the middle of the string.

There are already mass-and-spring models for bowing of string instruments in the literature [3]. Generally, they consider bowing as a *macroscopic* frictional effect. These friction-like models will have difficulty in explaining the silence of bowing in the middle of the string. However, with the *microscopic* mechanism proposed here the phenomenon is clear.

This mechanism applies to every part of the string, but the influence of the next nail becomes most significant as one bows at the midpoint. Furthermore, the mechanism has nothing to do with the resin used. Resin increases the friction, or the length and the

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number of the nails. A clean bow without any resin can still produce sound.

More refined models can be developed based on the reasoning given above. It will be interesting to find out experimentally what kinds of modes are excited under different bowing conditions. Remember that the string is not a rigid body and the nails do not always pluck the string in a direction normal to it. Therefore, the generation of the vibration and the interference of the next nail is always imperfect. In the field of nonlinear dynamics, the phenomena of 'kicked oscillators', which display interesting chaotic behaviour, have been studied. It will also be interesting to see how they apply to the bowing of violins.

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