How Do Crickets Sing So Loudly?
The Mechanics behind Nature's Micro-Transducer Orchestra

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Abstract

The familiar cricket chirp is male crickets singing to attract mates. This loud song is not made by the cricket's vocal chords; it is made by coordinated motions and vibrations of an ensemble of clever natural transducers. These purely mechanical transducers, with critical micro-scale features, work with clockwork precision. They produce songs with a few KHz central frequency, in a specific frequency band allocated to the particular species (yes, crickets have spectrum allocation too!). The song production unit uses a beautiful mechanism as a frequency multiplier to convert the slow wing beat frequency into a high frequency impulse train. The impulse train, in turn, forces the *harp*—a thin triangular part of the wing—into resonance, modulating the subsequent motion into a beat pattern to produce the characteristic song. We have been studying the mechanism of these natural micro-scale transducers using a finite element model of the harp, measurement of its material properties, using experimental techniques such as nano-indentation and atomic force microscopy, making multiple simulation runs to get the vibration response of the harp, and finally, comparing the sound produced by the model with the sound recorded from the field crickets. The uncanny resemblance of the sound and the matching of the frequency content give evidence in support of the model. We also used our model to find a scaling law that crickets seem to use for "spectrum allocation". The scaling law predicts geometric scaling for the harp structure. Evolution seems to have used this scaling so that crickets of different sizes can sing species-unique songs. The design principles used by crickets for low frequency driving, for their multiplier, and for their vibration amplifier may have application in micro scale devices. We have successfully designed a MEMS device that mimics the cricket song. We are now trying to use the ideas to develop paper-thin MEMS speakers that could be used in the home.