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Nanobeams get in rhythm

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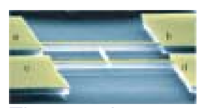
The oscillations of two nanomechanical resonators can become synchronized, according to work by physicists in the US and South Korea. The effect – which is the nanoscale version of the phenomenon first observed by Dutch scientist Christiaan Huygens over 300 years ago – could be used to develop smaller devices for wireless communications and for making neural network computers.

Synchronized oscillations are widely found in nature – fireflies blink in tandem, some crickets sing in unison and the Moon's rotation is synchronized in its orbit around Earth. Scientists have been studying synchronization for over three centuries since Huygens discovered that two pendulum clocks mounted on the same wall synchronize their ticking via weak coupling of acoustic signals.



The experiment

Now, Pritiraj Mohanty and Matthias Imboden of Boston University and Seung-Bo Shim at Seoul National University have found that the same phenomenon holds true even on the nanoscale. The researchers have shown that two mechanically coupled nanobeams resonate over a range of frequencies.

The coupled oscillator used by the team consists of two electrically independent, doubly clamped nanobeams around 10 µm long and 500 nm wide. These are coupled by a beam that is 5 µm long and 500 nm wide attached to the centres of the main beams. Because the beams are electrically isolated, any coupling between them is purely mechanical.

To reduce noise effects and enhance the sensitivity of their measurements, Mohanty and co-workers cooled the structure down to 300 mK. The researchers then drove the structure using an electric current, giving it "pushes" similar to how you would push a swing. This motion results in a detectable voltage, which is directly related to the amplitude of the nanobeams' oscillations. After "sweeping" for several hours, the team characterized the resonant modes using a network analyser and the synchronization regimes with a spectrum analyser. They found that the nanobeams oscillated in unison at two radio frequencies (see figure).

"Similar high-frequency nano-oscillators have been studied for

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over ten years, revealing rich behaviour and a multitude of applications, ranging from mass sensors with unprecedented sensitivity to mechanical memory elements that may outperform current data-storage techniques," explains Mohanty. "Now that we have shown that nano-oscillators can be mechanically coupled, we hope this will lead to further experiments with more complex structures."

An ultimate goal would be to use such oscillating devices in a large array to perform neuro-computations, says Mohanty, because such networks could store and retrieve complex oscillatory patterns as synchronized states. "What we have demonstrated is that silicon-based neurocomputers (systems capable of learning) could indeed be feasible in the near future."

The Boston-Seoul team now plans to scale up its device so that it can be coupled to a larger array of oscillators. "Demonstrating memory effects and investigating the non-linear two state parameter space would also be very interesting because such steps are necessary to demonstrate the feasibility of a neural network computer," Mohanty told *nanotechweb.org*. The nanomechanical signals could also be processed and used for communication at radio and microwave frequencies.

The researchers reported their work in *Science*.

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