Little Gears, Big Picture

Georgia Tech professor discovers gear-like structures in superlattices

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If there wasn't such a thing as air (seriously, who even needs it?), gears might stand alone as the most ever-present entities on earth.

They are literally everywhere you turn — a universal, inescapable part of the world we live in, sort of like Justin Bieber but with less hair gel and electronic synthesizers.

Unlike the Biebs, however, gears hardly ever wind up in the tabloids, so they tend to exist in invisible space despite being right in front of your eyes.

Still, whether you acknowledge their handiwork or not, the fact remains that gears are what keep the world churning forward. Cars, bicycles, motors, clocks — you see, without gears we would literally become unstuck in time. And those are just the obvious apparatuses that contain them. Look closer, like through a microscope for instance, and you might find a Lilliputian landscape powered by teeny, tiny cogwheels.

That's what computational scientist Uzi Landman did, anyway.

The Fuller E. Callaway Professor of Computational Materials Science at the Georgia Institute of Technology, Landman recently conducted an experimental study of self-assembled, silver-based, crystallite structures known as superlattices.

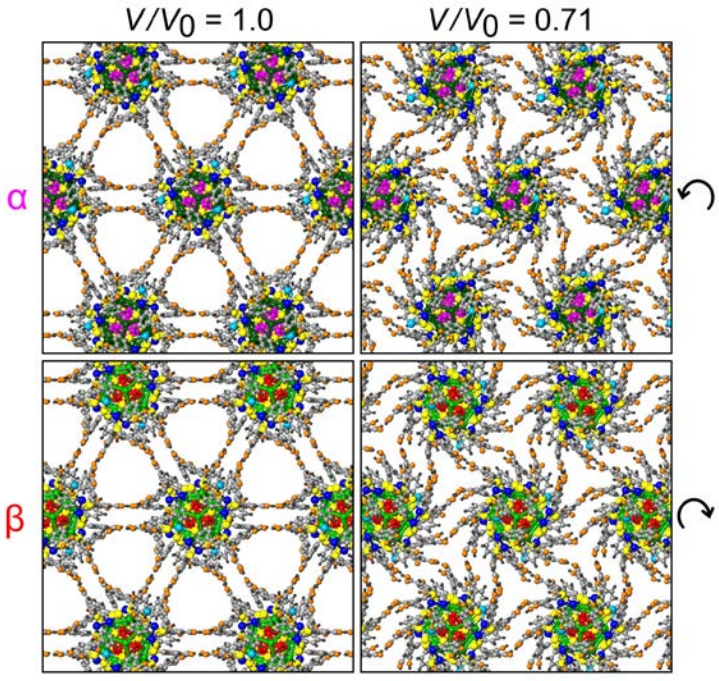
And — surprise, surprise — deep down in even these smallest of forms, there were gears running the show.

Landman, an award-winner in the realm of physics who — despite sharing his name with a death-wreaking Israeli submachine gun — speaks with the kind of soothing, exotic voice that conjures up images of fuzzy woodland critters and religious figures draped in elegant white robes, was ecstatic with the fascinating discovery:

"We started to ask the question of what would happen if you actually take the solids that you can form from these little crystallites when you compress them," Landman said. "To our tremendous surprise, the process that accompanies the compression of these solids is very, very peculiar and unusual.

"In other words, the more you compress them, the easier it becomes to press on. Normally when you compress something there becomes a limit where you cannot compress any further. Think about a spring — you start and it's easy, but the more you compress, the more it resists the compression. These solids have something that is called negative pressure derivative; in other words, the more you press on it, the easier it becomes, which is very anomalous.

"What we found was that the individual crystallites that are neighboring each other, in response to applied pressure, instead of just moving and crowding together, they at some point start to rotate. They rotate in respect to each other very much like gears. The rotation is like the sawtooth of one gear moving the sawtooth of a corresponding gear.



"There is something very cooperative about this motion. It's like a huge array of thousands — of millions — of gears."

These gear-like structures, according to Landman, help to create a molecular machine with some of the smallest moving elements ever observed.

The smallest machine ever? Now that's big — figuratively speaking, of course.

The movement of these silver nanocrystallites could allow the superlattice material studied by Landman to serve as an energy-absorbing structure, converting force to mechanical motion. Think Kevlar on steroids after downing a crate of Mountain Dew.

"I'm not sure if it would be used for bulletproof vests, but it could be a material that will serve like a shield," Landman said. "It could also be used for the landing of a spacecraft, as it can absorb a tremendous amount of impact. If you have this material lined in certain areas of the craft it could be a way to protect from damage."

So yes, gears shoulder some massive responsibilities in our robust, metallic utopia in the sky. They are, in effect, the lifeblood of a sprawling civilization dependent on giant machines to keep pace with our oversized lives.

And yet it seems so fitting that, on a microscopic level, we have these quaint little gears churning and rotating like their bigger cousins — with the added benefit of absorbing damage done by bullets and other deadly impacts.

Big, small, it hardly matters. Gears will just keeping on quietly moving us forward, whether we notice or not.

Justin Bieber, eat your heart out.