require parts of the wave to travel with infinite velocity. Also, any negatively refracted wave would be rapidly smeared out in only a few wavelengths by dispersion, which Valanju maintains will always be a major problem in a negative index material.

Smith and Pendry agree that the wave fronts are aligned the way Valanju says but contend that the waves nonetheless travel in the direction of negative refraction. As for dispersion, Smith notes that NIMs are not intrinsically worse than positive index materials in that regard and that within narrow but useful bandwidths the negatively refracted waves can persist. Indeed, the U.C.S.D. team got some validation after a group at Boeing's Phantom Works, including physicist Claudio Parazzoli, repeated the prism experiment out to about 30 wavelengths—much farther than was done in the original experiment.

The question of a perfectly imaging slab remains less clear. Some papers claim that absorption and dispersion will completely spoil the effect. Others argue that although *perfect* imaging is impossible, sub–diffraction limit imaging is still feasible, provided the metamaterial meets a stringent set of conditions. Pendry's latest contribution is to suggest that slicing up the slab and alternating thin pieces of NIM with free space will greatly enhance the focusing effect and that such an arrangement will behave somewhat like a fiber-optic bundle channeling the electromagnetic waves, including the sub–diffraction limit components. Groups such as Smith's are working toward testing the superimaging effect. Judging by past form, however, even experimental results are unlikely to settle the debate quickly.

BIOPHYSICS

Shake, Waddle and Stroll

VIBRATING SHOE INSERTS FOR SURER FOOTING

BY CHARLES CHOI

KEEPING BALANCED is helped by exercise—and someday perhaps by tiny vibrations underfoot.

PATRICK MOLNAR *Getty Images*

People begin to lose their balance in their old age just as their bones get more fragile, a deadly combination that can lead to crippling or fatal falls. The elderly grow wobbly in part because their nervous systems become less sensitive to the changes in foot pressure whenever they lean one way or another. No one keeps perfect posture—everyone sways at least a little—and the brain needs the cues from the soles to stay balanced.

Foot massages could help those who have balance problems. Research led by bioengineer James J. Collins of Boston University shows that gentle stimulation of the feet helps elderly study subjects. The key is that the vibrations must be random—or, put another way, noisy. Usually, noise interferes with the main signal—think of static drowning out a television picture or attempts at conversation in a crowded room. Under the right circumstances, however, noise can actually boost weak signals. The effect is known as stochastic resonance, and it occurs in electronic circuits, global climate models and nerve cells. To see how it works, imagine a frog in a jar: by itself the amphibian might not be able to jump out, but if the jar is in a rumbling truck the frog might get the boost it needs to make it. In the same way, a faint background of random pulses could amplify weak signals sent from the feet to the brain.

The researchers built a platform with hundreds of randomly vibrating nylon rods on which volunteers stood barefoot with eyes closed and arms at their sides. When the rods were tuned so the participants said they could no longer feel their shaking, Collins and his colleagues found that the 16 senior citizens, with an average age of 72, swayed much less. In fact, they performed as well as the young volunteers, average age 23, on solid ground. When the vibrations were perceptible, no benefits were seen.

Collins's team has already developed half-inch-thick vibrating gel insoles, and when subjects stood on prototypes, they swayed even less than they did on the platform. "Within a couple of years one could have commercially viable insoles ready," Collins hopes, thereby marking the first everyday application of stochastic resonance.

Charles Choi is based in New York City.

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