

physics update

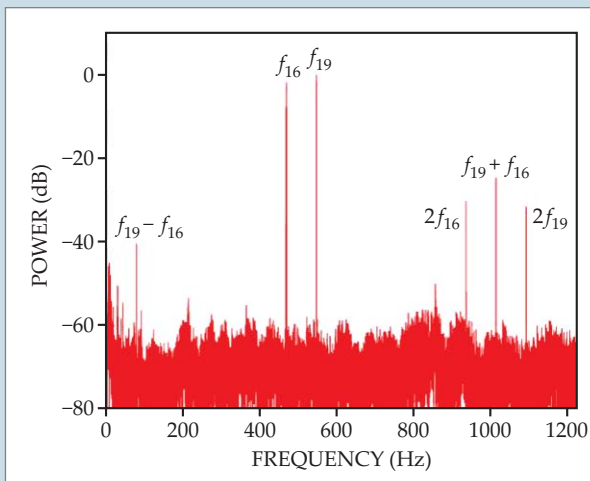
These items, with supplementary material, first appeared at <http://www.physicstoday.org>.

New lows for magnetic shielding. We are awash in magnetic fields. Power lines, earbuds, and motors each generate their own fields, and some cars have upwards of 150 magnets; Earth's field varies between about 25 μT and 65 μT at the surface, roughly 1/200 that of a refrigerator magnet. For precision measurements, whether of fundamental physical quantities or of brain activity, magnetic fields can be unwanted sources of noise, and experiments require environments shielded from fields both constant and varying in space and time. As part of a quest to put new limits on the electric dipole moment of the neutron (see the article by Norval Fortson, Patrick Sandars, and Steve Barr, *PHYSICS TODAY*, June 2003, page 33), an international team led by Peter Fierlinger of the Technical University of Munich has demonstrated the ability to reduce field fluctuations at millihertz frequencies by a million-fold over a 4-m³ volume. That shielding represents an order-



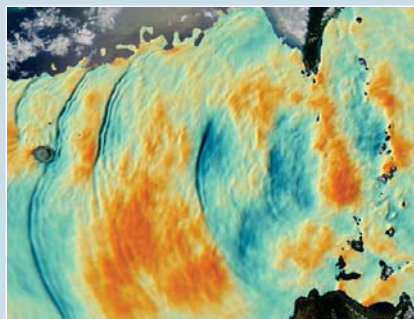
of-magnitude improvement in a challenging frequency range. To achieve that level of attenuation, the researchers fashioned five nested boxes of a highly magnetizable alloy; the three inner shells formed an insert that, as seen here, can be rolled out from within the surrounding shells. Among the design elements the team implemented are thin shells spaced close together and a refined procedure for using interlayer coils to equilibrate the layers. The approach reduced the fields from typical external sources to below 1 pT and limited gradient drifts to 1 pT/m over several hours. (I. Altarev et al., *J. Appl. Phys.* **117**, 183903, 2015; photo by Astrid Eckert/TUM.) —RJF

Longitudinal waves in piano strings. When you strike a piano key, a felt hammer excites a complex set of waves that travel along a musical wire to the piano's bridge and soundboard. Surprisingly, not all of those waves are the expected transverse variety; two kinds of longitudinal waves also propagate and have been studied, though with little empirical input, for at least 20 years. Free-response longitudinal waves arise from the local increase in tension caused by the wire's elongation, and they have frequencies determined by the length of the wire and its speed of sound. More interesting are the forced-response longitudinal waves, induced by nonlinear mixing of transverse waves; they occur with significant audible power at frequencies that don't correspond to transverse overtones. Recognizing that theory needs experiment, Thomas Moore of Rollins College in Florida and two of his undergraduate students, Nikki Etchenique (now graduated) and Samantha Collin, simplified the complexities of a real piano. They attached two steady-state mechanical shakers to a piano's lowest B-flat string—one at each end, oscillating at the 16th and 19th overtones of the string's fundamental frequency of 27.4 Hz. With only two transverse modes, the



audio signals generated a simple power spectrum. As predicted by the theory and as shown here, the sum and difference frequencies of the two overtones have significant audible power. Also in accordance with theory, the amplitude of the induced longitudinal motion is linearly related to each of the driving amplitudes, within the range of normal piano playing. If your four-year-old starts banging away, however, all bets are off. (N. Etchenique, S. R. Collin, T. R. Moore, *J. Acoust. Soc. Am.* **137**, 1766, 2015.) —SGB

Internal waves in the South China Sea. The 250-km-wide Luzon Strait divides the Philippine island of Luzon from Taiwan to the north. To the east of the strait lies the Pacific Ocean; to the west, the South China Sea. When tides drive water back and forth through the strait, the sloshing of the vertically stratified water generates internal gravity waves. Of all the internal waves in Earth's oceans, the ones that propagate westward through the shallow South China Sea are the largest. Now, thanks to a marine field campaign that involved measurements from ships, autonomous underwater vehicles, buoys, and spacecraft, those waves have been comprehensively characterized. Known as the Internal Waves in Straits Experiment (IWSE), the 25-institution campaign began as a pilot in 2010 and ran in earnest in 2011. Analysis of the data gathered,



combined with numerical modeling, has revealed that internal tides in the Luzon Strait generate 24 GW of wave power, of which 60% propagates away and 40% dissipates locally. Internal waves in the South China Sea can top 200 meters in height. When they break on China's continental shelf, they engender levels of turbulence that exceed those found in the open ocean by a factor of 10 000. Derived from a simulation, the accompanying figure shows the waves' amplitude at a depth of 200 meters. The findings from IWSE will improve climate models and elucidate the waves' role in the transport of nutrients, sediment, and pollutants. (M. H. Alford et al., *Nature* **521**, 65, 2015.) —CD