Dundee team's sonic screwdriver, pictured in figure 1, features an array of more than 1000 individually addressable ultrasound transducers and can generate beams with up to 12 intertwined helices.

In the team's experimental setup, depicted in figure 2, the transducer array directs a vortex beam upward toward a sound-absorbing disk submersed in a water chamber. The rising vortex lifts the disk by a distance related to E and spins it at a rate related to L. In the end, OAM theory emerged from the experiment unscathed: The measured ratio L/E plotted against l agreed with predictions to well within experimental error. With one case now closed, the researchers look to use the sonic screwdriver to design nondiffracting Bessel beams and other complex beam shapes that could prove useful for ultrasound surgery.

Ashley G. Smart

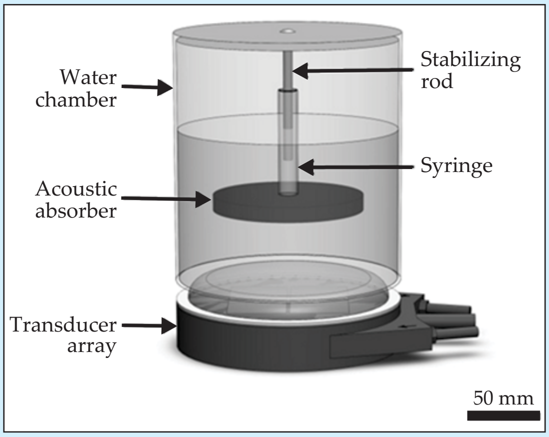

Figure 2. The experimental setup. The energy and orbital angular momentum of the acoustic beam emitted by a transducer array reveal themselves in the mechanical response of a sound-absorbing disk: The disk levitates by a distance related to the beam energy and rotates at a speed related to the orbital angular momentum. An air-filled syringe, free to slide vertically along the stabilizing rod, helps to buoy the disk and prevent it from tilting. (Adapted from ref. 1.)

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Time to reset isotopic clocks?

Two new studies revise key parameters in radiometric dating.

Just as radiocarbon dating gives the ages of once-living materials up to tens of thousands of years old, longer-lived radioisotopes are used to date rocks that are millions or billions of years old. Now, two wrenches have been thrown into the works. Joe Hiess and colleagues of the British Geological Survey have found that the ratio of uranium-238 to uranium-235 varies more than anyone previously thought it did, or could.[1] The result has a small but significant effect on the widely used uranium–lead dating scheme. And a team of researchers led by Michael Paul (Hebrew University in Jerusalem) and Takashi Nakanishi (Kanazawa University, Japan) measured the half-life of samarium-146 to be 35% less than the currently accepted value.[2] Samarium-146 dating is of more limited applicability, but if the new measurement is upheld, it means a major revision in all the dates derived from it.

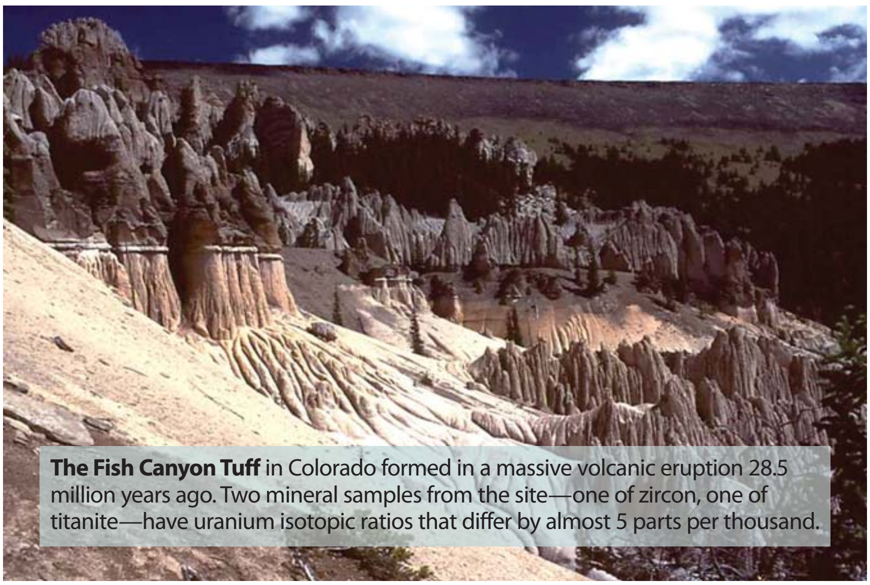
Uranium

Uranium's two long-lived isotopes, ^{235}U and ^{238}U, decay through a series of alpha and beta emissions into ^{207}Pb and ^{206}Pb, respectively. Uranium–lead dating is usually done on minerals, such as zircon, that can incorporate U impurities into their crystal lattices but that strongly reject Pb. If no Pb was present in the mineral when it first formed, any Pb found in it later must be radiogenic. Knowing U's half-life and measuring the relative amounts of U and Pb thus gives the age of the mineral.

That two U isotopes decay into Pb with different half-lives (704 million years for ^{235}U and 4.47 billion years for ^{238}U) offers a valuable double check: The ^{235}U–^{207}Pb age should agree with the ^{238}U–^{206}Pb age. The redundancy also provides a convenient shortcut. If the ^{238}U/^{235}U ratio is already known, then ages can be calculated through measurements of Pb isotopes alone. That Pb–Pb dating is typically used with samples older than about a billion years.

It's long been assumed that the present ^{238}U/^{235}U ratio should be the same everywhere on Earth: The mass difference between the two isotopes was presumed to be too small to affect their behavior in natural geological processes. Standard Pb–Pb dating protocol uses a ^{238}U/^{235}U ratio of 137.88 with zero uncertainty. But several recent studies have cast doubt on that number.[3] Some have suggested, based on analysis of U ores, that it should be closer to 137.80, and others have found that it might not even be constant.

To examine the issue systematically, Hiess and colleagues looked at 58



The Fish Canyon Tuff in Colorado formed in a massive volcanic eruption 28.5 million years ago. Two mineral samples from the site—one of zircon, one of titanite—have uranium isotopic ratios that differ by almost 5 parts per thousand.

samples from around the world. Those samples all include U as impurities, not major components, so to get enough U to measure the isotopic ratio with sufficient precision, the researchers needed tens to hundreds of milligrams of material from each location—orders of magnitude more than is necessary for a routine dating measurement.

For most of their samples, they found a $^{238}U/^{235}U$ range of 137.818 ± 0.045, about 0.5 parts per thousand less than the commonly used value. But they also found a few outliers far outside that range, including a sample from the Fish Canyon Tuff in southwest Colorado (shown in the figure), for which they measured an anomaly of almost 5 ppt, the largest found to date. But a second Fish Canyon sample, of a different mineral, showed a $^{238}U/^{235}U$ ratio in the normal range. Previous U anomalies were all found in materials formed at low temperature, such as sedimentary rocks and fossil corals. Their U ratios could be affected by U fractionation in chemical processes in water. But the Fish Canyon Tuff formed volcanically, from cooling magma, in which no such chemistry was at work. The mechanism of high-temperature U fractionation has yet to be understood.

A 0.5-ppt change in the $^{238}U/^{235}U$ ratio means that ages calculated through Pb–Pb dating need to be revised by almost a million years. A 5-ppt anomaly would mean a change of several million years. (The Fish Canyon Tuff itself is only 28.5 million years old, so its age was not calculated by Pb–Pb dating and therefore doesn't need to be revised.) That's a small relative error in an age of a billion years or more, but it can potentially make a qualitative difference, especially in questions of which of two events happened first.

Samarium

There's virtually no ^{146}Sm left in the solar system. No natural process creates it in any measurable amount, and all of the primordial ^{146}Sm has long ago decayed into stable neodymium-142. So the usefulness of ^{146}Sm dating (measuring the amount of radiogenic ^{142}Nd relative to other Nd isotopes) is limited to materials and events from the first few hundred million years after the solar system began to condense into solid objects.

The accepted ^{146}Sm half-life of 103 million years is based on two measurements: one from 1966 by a group at Argonne National Laboratory and one from 1987 by a group at the University of Göttingen.[4] But other, earlier measurements had found the half-life to be much shorter (albeit with large uncertainty), which inspired Paul, Nakanishi, and colleagues to revisit the question. They used three nuclear reactions to create some ^{146}Sm in a sample of ^{147}Sm. Alpha decays from ^{146}Sm and from ^{147}Sm are distinguishable by their alpha-particle energies, so the researchers could count the number of decays from each isotope over a period of several months. Then they measured the Sm isotopic ratio in the sample. From that information and the known half-life of ^{147}Sm, they found the ^{146}Sm half-life to be just 68 ± 7 million years.

The 1966 Argonne measurement used a similar technique; that group's measurement of the sample composition could have been marred by isobaric contributions—specifically, ^{146}Nd masquerading as ^{146}Sm. Paul, Nakanishi, and colleagues avoided that problem by analyzing their samples with accelerator mass spectrometry, which distinguishes atoms not only by their mass but also by their atomic number. But the 1987 Göttingen measurement used a different technique entirely, one that wasn't prone to isobaric interference. Paul has no explanation for the discrepancy between their measurement and the Göttingen one, and he suspects it will take an independent new measurement to settle the issue.

If the new, shorter half-life turns out to be correct, it means that every event dated with ^{146}Sm happened much earlier during the solar system's formation than previously thought. That would have important implications for the timeline of the differentiation of Earth's mantle, the solidification of the Moon's magma ocean, and the accretion of Mars.

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DNA-based sensors know what the nose knows

The sensors can "smell" the difference between similar molecules.

Can a machine mimic the human—or better yet, the canine—sense of smell? To do so, it would have to not only determine whether a chemical vapor is present in small amounts but also figure out, at least partially, what chemical it is.

Carbon nanotubes and other nanomaterials do a good job on the first front. Their small size means that the presence of just a few gas molecules is enough to measurably change their electrical properties. But to discriminate among many different molecules, an "electronic nose" must contain an array of sensors, each with different response characteristics.

In 2005 A. T. Charlie Johnson (University of Pennsylvania), Alan Gelperin (Monell Chemical Senses Center in Philadelphia), and their colleagues began to investigate whether a nanotube

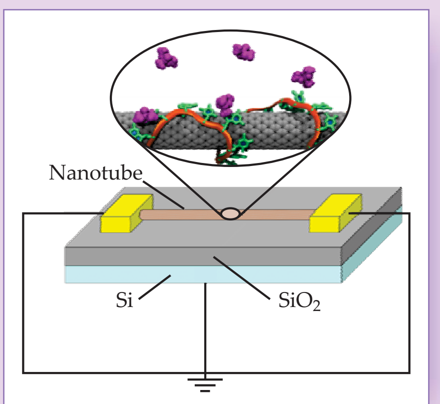

Figure 1. A chemical sensor based on a carbon nanotube (tan) decorated with a piece of single-stranded DNA (red and green). The presence of odorant molecules (purple) is detected by a change in the nanotube's conductivity. (Adapted from ref. 2.)