CONTINENTAL RIFT EXPOSES MANTLE MELTING AT WORK

Mid-ocean ridges form a vast chain of undersea mountains that encircle Earth. At those ridges, melted rock from the planet's mantle rises to fill the gap between spreading tectonic plates (see PHYSICS TODAY, January 2005, page 21). But researchers still have much to learn about the process of melting and when it might drive volcanic eruptions. In a new study, researchers have used GPS measurements to build a model that explains the interplay between the rise and fall of the surface crust and the state of melting rock below. Simon Lamb and colleagues at Victoria University of Wellington studied New Zealand's Taupo Volcanic Zone (TVZ), where the underwater mid-ocean ridge transitions onshore into a zone of continental rifting. Although the 200-km-long rift zone is widening overall, the researchers were surprised to find that a 70-km-long segment is locally narrowing and subsiding, even though it is flanked by regions that are expanding and uplifting.

The model by Lamb and colleagues accounts for the TVZ's structure via the bending of an elastic upper crust. Rocks from the mantle flow upward, but on reaching the more rigid lower crust they are forced to turn and migrate horizontally. The change in flow direction causes a downward suction-like force on the upper crust, effectively loading it from below. The strength of the force is determined by mantle viscosity. Mantle with a high proportion of melted material is less viscous and reduces the downward force, which allows the crust to relax upward. Conversely, mantle with less melted material will be more viscous and

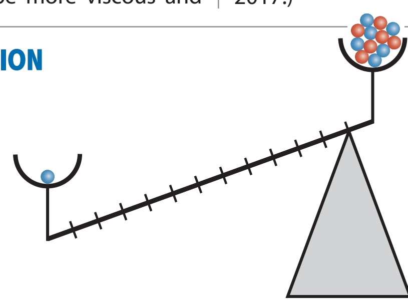
thus create a stronger downward force that drives subsidence.

Using the GPS data, the researchers think they can trace regions of molten rock nearly 20 km beneath the TVZ. The work demonstrates the potential of using remote sensing to explore below Earth's surface and monitor where and for how long the mantle is melting. Future measurements could lead to improved predictions of volcanic activity. (S. Lamb et al., *Nature* **547**, 84, 2017.) —RB

PROTON MASS MEASURED WITH UNPRECEDENTED PRECISION

The particle zoo may house such exotica as K mesons and pentaquarks, but the stuff of our everyday lives is made up of just three beasts: the proton, the electron, and the neutron. The mass of the proton is of interest not just because of the primal nature of the particle but also because the proton mass is used as input in precise determinations of the neutron mass and other quantities. Now a team led by Sven Sturm of the Max Planck Institute for Nuclear Physics has measured the proton mass with a precision of 32 parts per trillion, a threefold improvement on the precision of the currently accepted value. Their result, $m_p = 1.007276466583$ amu (atomic mass unit), is lower than the accepted value by about 300 ppt.

As with other groups who have precisely measured the proton mass, Sturm and colleagues made use of a Penning trap, which uses electric and magnetic fields to confine ions. With their improved design, the researchers could rapidly switch between trapping protons and $^{12}C^{6+}$ and determine their cyclotron frequencies, $qB/2\pi m$, as the ions circled within the trap's magnetic field. The ratio of the frequencies yields the proton mass, given that the mass of the ^{12}C atom is defined to be exactly 12 amu and that the correction



needed to calculate the $^{12}C^{6+}$ ion mass is well known and extraordinarily precise.

The motion of an ion in a Penning trap can be decomposed into faster and slower circular motions perpendicular to the magnetic field and an oscillation along the field axis. Thus the cyclotron frequency must be teased out from observations of the composite trajectory. The greatest source of measurement imprecision is inhomogeneities in the trap's magnetic field.

The lower value of the proton mass suggested by the Sturm group may be key to resolving two measurements of the helium-3 mass that disagree by more than three standard deviations. Both ^3He determinations assumed the currently accepted value of the proton mass. Swapping in the new, lower value determined by Sturm and colleagues cuts the ^3He mass discrepancy in half. (F. Heiße et al., *Phys. Rev. Lett.* **119**, 033001, 2017.) —SKB

WHAT CAUSES THE SUN'S PLASMA JETS?

Dynamic plasma jets called spicules (the thin lines of light pictured in the figure) flare up from the Sun at speeds of more than 200 km per second. At any given time, around 10 million of them are observable on the Sun's surface. Some solar physicists have suggested that the plasma and energy that spicules carry upwards might help explain the high temperature of the Sun's fiery corona (see the article by Jack Zirker and Oddbjørn Engvold, PHYSICS TODAY, August 2017, page 36). Despite spicules' abundance, however, previous models of the Sun have been unable to account for their frequency or for all of their observed properties, including the strong magnetic waves they carry.

Juan Martínez-Sykora and his colleagues at the Lockheed Martin Solar and Astrophysics Laboratory and the University of Oslo have developed a new model of the magnetic properties of the Sun's plasma in an effort to understand spicule formation. They compared their simulation with data from NASA's *IRIS* space telescope and from the ground-based Swedish 1-m Solar Telescope operated by Stockholm University. Their

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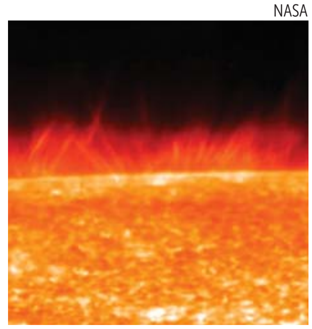

model shows that spicules form when magnetic tension on the Sun's surface pushes plasma upward and that the release of that tension generates strong electrical currents and low-frequency plasma waves. Those currents and waves transmit significant amounts of energy. The findings suggest that spicules and their associated currents and waves could play a role in energizing the outer atmosphere of the Sun. (J. Martínez-Sykora et al., *Science* **356**, 1269, 2017.) —MB PT