

tween the nonrelativistic and relativistic regimes is expected to be found on a size scale of tens to hundreds of nanometers—a scale that, until the ETH Zürich researchers' work, had been stubbornly difficult to explore.

The researchers plan to study those dispersion forces by dropping a nanoparticle in close proximity to a vertical glass plate. By measuring the horizontal and

vertical oscillations separately, they hope to determine whether the particle falls straight down or is attracted to or repelled from the plate. That experiment, however, poses yet another technical hurdle: "We'll need to deal with the optical reflection off the glass," says Frimmer. "But we're learning how to do that."

Johanna Miller

References

1. E. Hebestreit et al., *Phys. Rev. Lett.* **121**, 063602 (2018).
2. A. Peters, K. Y. Chung, S. Chu, *Nature* **400**, 849 (1999).
3. A. Geraci, H. Goldman, *Phys. Rev. D* **92**, 062002 (2015).
4. M. Frimmer et al., *Phys. Rev. A* **95**, 061801 (2017).
5. See, for example, J. Moser et al., *Nat. Nanotechnol.* **8**, 493 (2013).

PHYSICS UPDATE

These items, with supplementary material, first appeared at www.physicstoday.org.

A PUZZLING GAMMA-RAY SURVEY OF THE SUN

Gamma rays produced via thermonuclear fusion in the Sun's core are absorbed long before they reach the visible surface, or photosphere. Nonetheless, our neighborhood star glows brightly in the gamma-ray spectrum due to interactions with cosmic rays: Speedy protons passing through the solar system smash into the photosphere and unleash cascades of particles and high-energy radiation.

Theorists have struggled to model how the incoming cosmic rays and the solar magnetic fields that steer them produce the Sun's observed gamma-ray spectrum. New measurements from the *Fermi* Gamma-Ray Space Telescope's Large Area Telescope offer the best-ever look at the Sun's gamma emissions—and reveal that theorists still have a lot of work to do.

Analyzing data collected between August 2008 and November 2017, Tim Linden of the Ohio State University and his colleagues charted gamma-ray events by their energy and their position on the solar disk. Throughout the observing period, *Fermi* detected a relatively steady flux of photons, in the tens of GeV, that was concentrated at the Sun's poles. The flux significantly exceeded that

predicted by the one and only model that takes on cosmic-ray interactions with solar gas.

The picture became more complex when the researchers focused on events before 2010, when the Sun was in the minimum phase of its roughly 11-year cycle of magnetic activity. From late 2008 to late 2009, *Fermi* detected six gamma rays with energies exceeding 100 GeV, the only ones of such high energy it would see during the nine years. Those events and other pre-2010 events exceeding 50 GeV emanated mostly from the Sun's equatorial region. Linden and colleagues conclude that separate cosmic-ray-triggered mechanisms are responsible for the relatively steady, lower-energy gamma rays at the poles and the equatorial, higher-energy photons that peak at solar minimum.

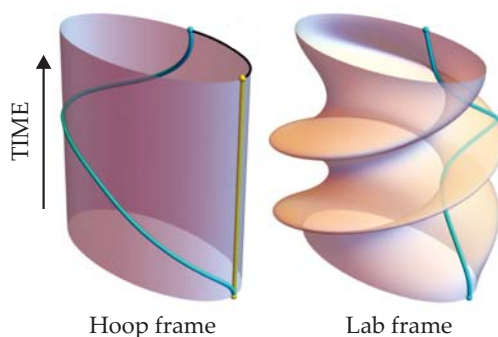
The new study offers theorists a rich and puzzling data set, one that also includes an unexpected dip at 30–50 GeV in what otherwise resembles a power-law spectrum. The underlying physics may become clearer once *Fermi* completes a full solar cycle's worth of observations through the upcoming minimum; in fact, earlier this year, as the Sun continued its slide into quiescence, the telescope spotted its seventh event exceeding 100 GeV. The High-Altitude Water Cherenkov Observatory in Mexico and the IceCube Neutrino Observatory in Antarctica may also provide clues by capturing particles produced in air showers triggered by high-energy gamma rays. (T. Linden et al., *Phys. Rev. Lett.*, in press.) —AG

OBSERVING NEW GEOMETRIC PHASES IN THE LAB

Falling cats and Olympic divers share the ability to twist, spin, and reorient themselves to land on their feet or make minimal splash. To accomplish that feat, they bend and contort to make a complete loop in their body's "shape space," so their bodies end up in the same shape they started in. But in physical space, they don't end up where they started: They rotate through a finite angle. Michael Berry described that acquired rotation, a so-called geometric phase, 35 years ago for quantum systems, and the phase now bears his name. Shortly thereafter, John Hannay extended the concept to classical analogues, for which the iconic example is a bead sliding frictionlessly on a horizontal, rotating, noncircular hoop. After one rotation, the hoop returns to its starting orientation, but the bead will have moved by an angle that depends only on the

hoop geometry, not on its rotation speed.

Hannay's original analysis considered only slow, adiabatic rotations. John Lindner and colleagues at The College of Wooster



now generalize it to arbitrary motions, including regimes that can be readily realized in laboratory experiments. In the hoop's rotating frame of reference, the bead experi-

ences multiple fictitious forces, of which the Coriolis and centrifugal forces are the more familiar. But it is the Euler pseudo force, arising from the hoop's initial angular acceleration, that sets the bead in motion in the hoop frame. Numerical simulations (see the figure) showed that the resulting trajectory in the lab frame (blue curve, right) can be quite complex and include multiple kinks. The researchers validated their simulations experimentally, with a cylinder of wet ice, weighted down by a steel ball, that slid around an elliptical track fashioned from 3D-printed plastic rails affixed to an aluminum sheet on a turntable. Converting a classic, idealized example into a realized experiment offers a firsthand opportunity to explore geometric phases in all their classical and quantum forms. (H. Bae, N. Ali, J. F. Lindner, *Chaos* **28**, 083107, 2018.) —RJF [IT](#)