picture of the x rays generated by solar wind and will help x-ray astronomers better account for them when analyzing distant x-ray signals.

The issue of soft x-ray contamination was identified three decades ago. Though it had long been known that x rays are emitted by ultrahot gas, it came as a surprise in 1996 when they were found coming from a comet.[2] The observation led to recognition of a process known as solar wind charge exchange: When heavy ions in solar wind interact with neutral matter, such as that found in comets, planetary atmospheres, and interstellar matter, the ions capture electrons and emit x rays at the same wavelengths as the ionized gases in ultrahot astrophysical objects.[3] "All observations are contaminated with this extra emission," says Kip Kuntz of Johns Hopkins University, who studies x-ray emissions.

For bright sources under study, the impact is insignificant. But for faint sources, the contamination can make up a significant fraction of the measured emissions. Estimates for the pressure, mass, and other physical parameters of astrophysical objects are affected by the difference. "That has consequences for [studying] dark matter and even for cosmology," says Dennerl.

X-ray measurements by eROSITA began in 2019, when the Sun's activity was at a minimum, and extended over a two-year period. The data, illustrated in the figure on page 9, provide insights into the spatial, temporal, and compositional variability of solar wind. Solar wind has fast and slow components—slow wind is more ionized and is thus the more dominant source of x rays. As solar activity increased over the observation period, slow wind expanded out from low latitudes. X-ray spectroscopy can reveal the wind's heavy-ion composition and highest charge states, both of which are otherwise difficult to measure remotely and typically require *in situ* sampling.

The new data confirm previous observations that as interstellar matter flows into the solar system, the Sun's gravity sends helium from the matter into a ballistic trajectory that produces a concentrated cone of the gas. The measurements also verified the presence of a hydrogen cavity around the Sun that is caused by the interaction of ionized hydrogen with solar wind.

The eROSITA instrument was built by the Max Planck Institute for Extraterrestrial Physics in Germany and is carried on the *Spektr-RG*, a Russian–German satellite launched in 2019. The collaboration included an agreement that data from the western galactic hemisphere would go to the German eROSITA consortium and the Russian eROSITA consortium would retain data from the eastern hemisphere. The instrument stopped collecting data in 2022 because of a breakdown in cooperation between the consortia following Russia's invasion of Ukraine. **PT**

References

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Analysis of B-meson decay hints at new physics

The measured trajectories of the products of a rare B-meson decay deviate from the predictions of the standard model.

By Sarah Wells

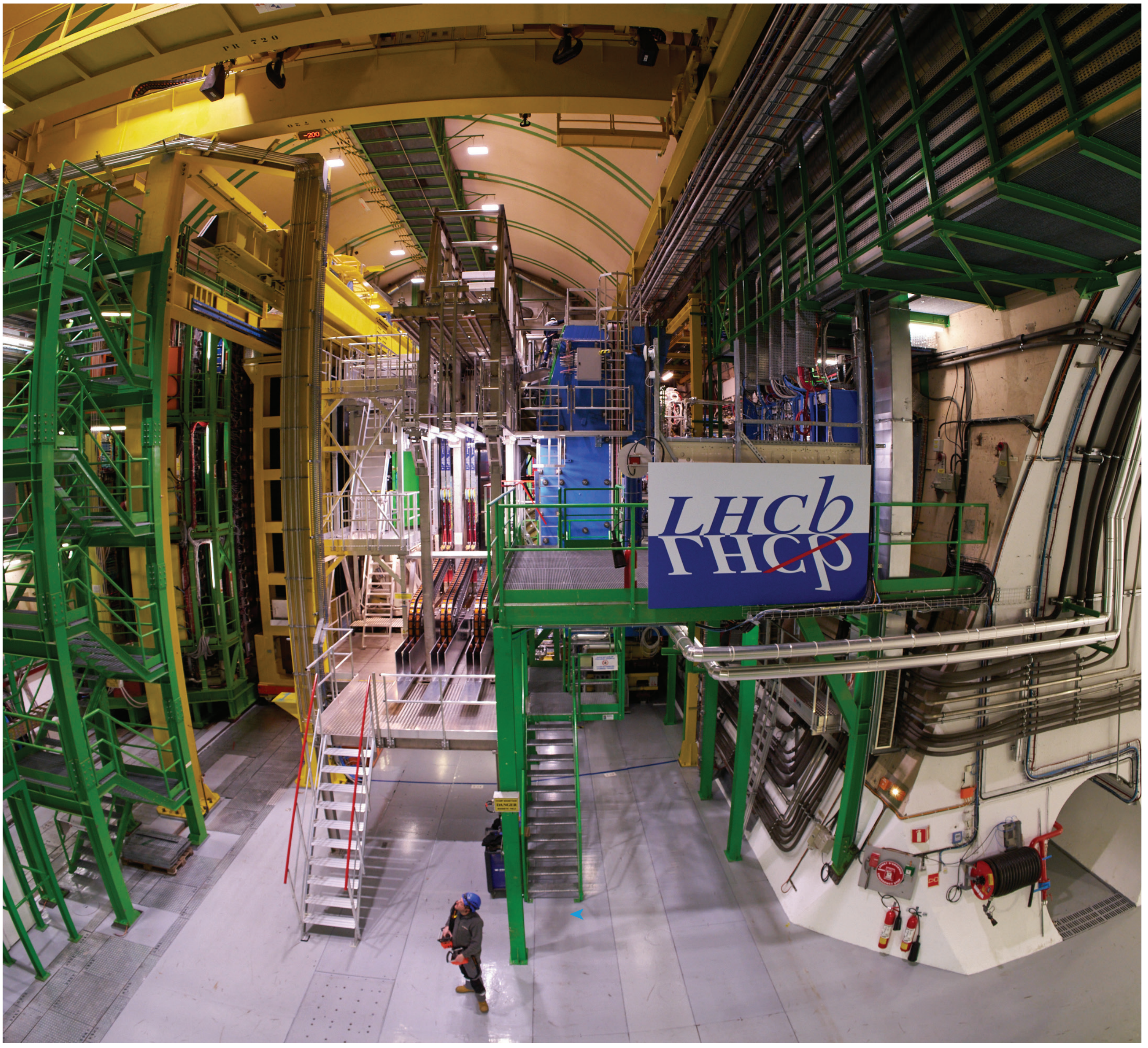
For more than 50 years, the standard model (SM) of particle physics has been the prevailing description of the fundamental forces and elementary particles in the universe. But notable omissions from the theory, such as explanations for gravity and dark matter, have motivated experiments, like those at CERN's Large Hadron Collider (LHC), to search for yet-undiscovered physics. Now an analysis of collision data from the LHCb (Large Hadron Collider beauty) experiment, shown in figure 1, has yielded fresh evidence that the properties of some decays of B mesons, which are composed of a bottom antiquark and a lighter quark, deviate from those predicted by the SM.[1] Though the discrepancy is still under the five-standard-deviation threshold that, by convention, is needed to claim a discovery, it adds to growing support for the idea that new physics may play a role in the behavior of B mesons.

The new work focuses on the decay of a B meson into a kaon, pion, and two muons. Known as a penguin decay, it is playfully named for the rough resemblance its Feynman diagram has to the flightless bird, as shown in figure 2. The penguin decay of B mesons is particularly useful for the study of new physics because it occurs only via quantum loops mediated by virtual particles, as opposed to via direct decays. As a result, the process is extremely rare: Only 1 in 1 million B mesons undergo this type of decay. The rarity means that when searching for new physics, researchers have less noise from the signals of SM processes to contend with than when they study more-frequent decays. Additionally, because of its quantum nature, the loop process is susceptible to being infiltrated by potential heavy non-SM particles that would influence the products of the decay in ways that SM particles cannot. Such heavy particles cannot be produced directly by the LHC, but the decay process offers an opportunity to indirectly observe their impact.

Evidence that something unusual is happening in the penguin decay of B mesons has been mounting for over a decade. In 2013, the LHCb collaboration reported a 3.7σ discrepancy from SM predictions in the directions that the final particles fly off, known as the angular distribution, following the decay. CERN's Compact Muon Solenoid collaboration reported similarly anomalous behavior last year but at a lower level of statistical significance.

In the new work, the collaboration analyzed 2011–18 proton–proton collision data, which encompassed about 650 billion B mesons, and reconstructed some 12 000 instances of B-meson penguin decay. The team then analyzed the angular distribution of the final particles and determined that there was a deviation of about 4σ from

Figure 1. The Large Hadron Collider beauty (LHCb) is one of several detectors installed at the LHC. Researchers at the LHCb study bottom quarks, as well as related particles like B mesons, that are produced in proton collisions. (Photo © CERN.)



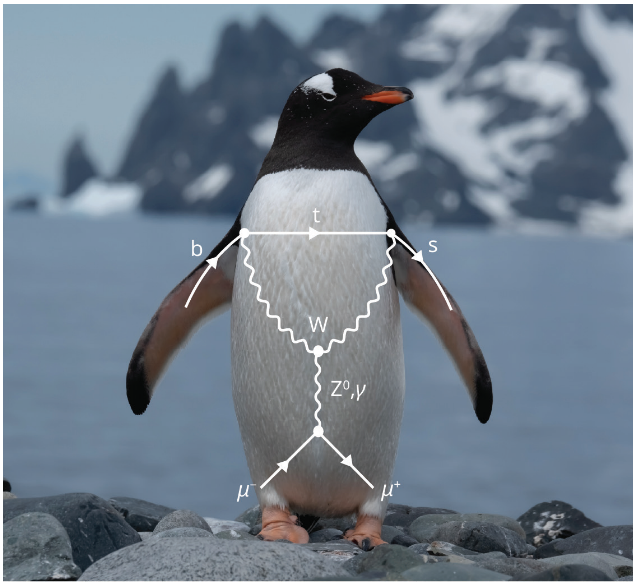


Figure 2. This decay of a B meson is called a penguin decay, with its name the result of a bet that CERN theorist John Ellis lost in 1977. The decay of the B meson's component bottom quark (b) yields a strange quark (s) and a muon and antimuon (μ^- and μ^+). The process is mediated by a quantum loop that includes a virtual W boson, top quark (t), photon (γ), and Z boson (Z^0). (Image by Freddie Pagani with photo by iStock.com/Leamus.)

the predictions of the SM. "This result has a probability of about 1 in 16 000 that it is just a statistical fluctuation from the standard-model predictions," says MIT's Leon Carus, who contributed to the work.

If new physics is responsible for the anomalous angular distributions, there are particle candidates that researchers believe might fit what they see. Those include the Z′ boson, a proposed heavy cousin of the Z boson, and the leptoquark, a heavy particle that would have properties of both leptons and quarks. SM physics is not entirely ruled out, however. One explanation to remedy the B meson's tension with the SM is the existence of an alternative decay path that includes a separate quantum loop that involves charm quarks. Although researchers estimate that the impact of such decays, known as charming penguins, should be too small to fully explain the anomaly, it is difficult to predict.

Ultimately, collecting more data is necessary to better understand the behavior of B mesons. The LHCb collaboration will soon be analyzing data collected during the experiment's third run, which concludes at the end of June and will provide five times as much data as collected in the two previous rounds combined. **PT**

Reference

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