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President of the Swiss Physical Society – DOI: https://doi.org/10.1051/epn/2021307

Is there new physics around the corner?

New results from the LHCb collaboration at CERN and the muon g-2 collaboration at Fermilab have made headlines in recent weeks, not only in scientific journals but also in daily newspapers around the world, dubbing the standard model of particle physics getting cold feet or being at the end of the line. All lurid headlines aside, these new results make it clear that something new may be on the horizon.

Discrepancies

The LHCb result is putting stress on lepton universality between electrons and muons in specific decays of B mesons, of which the decay rates of $B^+ \rightarrow K^+e^+e^-$ and of $B^+ \rightarrow K^+\mu^+\mu^-$ are found to disagree at the 3.1 sigma level with each other. The muon g-2 result is measuring a discrepancy at the 4.2 sigma level, where the measured value of the muon magnetic moment is off from its theoretically predicted value. Measuring the magnetic moment of electrons and comparing it with its theoretical prediction yields to the best tested result in physics, with more than 10 significant figures accuracy. Both discrepancies hint that muons and electrons behave differently, unexpectedly. Both these discrepancies are extremely tiny and it takes enormous effort to measure them.

Evidence for new physics?

Statistical fluctuations or a forgotten systematic effect may still be at the cause of these reported preliminary results. More data taking and more scrutiny is needed and will not lead to a final conclusion for another couple of years to come. Still, if both results could be confirmed, new particles would need to be added to the well-known quarks, leptons and bosons, where leptoquarks or supersymmetric particles are among the most promising candidates.

Historical analog

Changing from particle physics to gravity and changing time from now to the mid-19th century, another extremely tiny effect made history. Back then, measuring the perihelion of Mercury and how it shifts year after year has been done with great care over many decades. A shift that resulted to be off from its theoretical prediction by the extremely minute amount of only 43 arc seconds per century. The calculation, based on Newtonian gravity, included the gravitational pull of the sun and of the known planets. Adding a new planet to our solar system was proposed to provide remedy to this minute discrepancy. This hypothesized planet was dubbed Vulcan with an orbit inside the orbit of Mercury and so close to the sun that no optical instrument would be capable of seeing it directly. This was the state around mid 1850 and it took almost 70 years to resolve. The name Vulcan will ring a bell to all fans of the Star Trek series and of Mr Spock, the most prominent Vulcanian. Gene Roddenberry, the author of the original series, must have known about Vulcan and decided using it in his plot back in 1964. Einstein presented his theory of general relativity in 1915/16 and revolutionized the understanding of gravity. Conceptual flaws of the otherwise extremely successful Newtonian description of gravity were removed and the perihelion shift of Mercury be understood precisely without the need of Vulcan. Gravity is no longer a mysterious action at a distance, but is emerging from space-time itself, no longer acting instantaneously but propagating at the speed of light. Still, Newtonian gravity is being used for almost all calculations in everyday life. We do so in full confidence, because with the realm of general relativity, we know why Newtonian gravity works so well, and also up to which extreme conditions it will provide useful results. Newtonian gravity is, this way, fully complete.

Future expectations

We do not yet know what the new results from the LHCb and the muon g-2 collaborations tell us and where these will lead us. Maybe the hypothesised leptoquarks will have the same fate as the hypothesised planet Vulcan that, based on new insights obtained, was no longer needed. It took 70 years then, only the future will tell, how long it will take now. What is however clear already today, is that the Standard Model of particle physics works extremely well and will continue to be working extremely well. However, we do not yet know up to which extreme conditions it can provide useful results. The results from LHCb and muon g-2 may be those capable of paving the way further. ■

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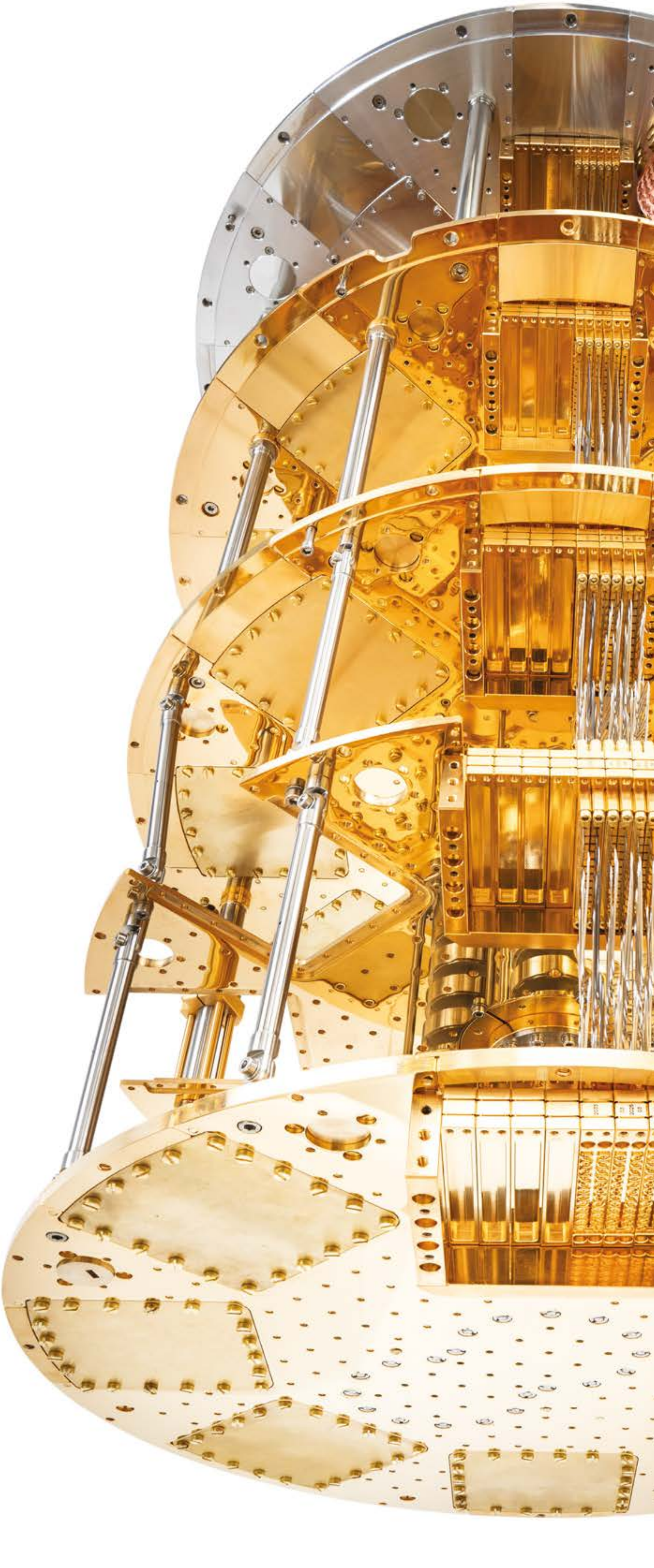

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