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ERC Advanced Grant for Matthias Neubert

Funding worth EUR 2.5 million - Novel theoretical predictions to advance the search for new physics at the LHC

Professor Matthias Neubert of Johannes Gutenberg University Mainz (JGU) has been awarded a grant of nearly EUR 2.5 million by the European Research Council (ERC) for research in the field of theoretical elementary particle physics. In his proposed project "EFT4jets", he wants to focus on the theoretical description of so-called jet processes based on effective field theories. This should make it possible for the first time to describe subtle quantum effects that have so far eluded quantitative theoretical description. A deeper understanding of these processes will be essential for discovering clues of new physics beyond the Standard Model of particle physics in the accelerator experiments at CERN's Large Hadron Collider (LHC). The ERC Advanced Grant is the EU's most highly endowed funding measure for individuals, awarded by the ERC to outstanding researchers from all disciplines. It is already the second award of this kind for Matthias Neubert.

Fundamental understanding of physics on smallest distance scales

In recent years, various low-energy measurements in particle physics raised broad attention, because they provide promising hints of new physics beyond the Standard Model – first and foremost the anomalous magnetic moment of the muon, whose theoretical prediction deviates significantly from the experimental value. On the other hand, the new heavy elementary particles responsible for this discrepancy have not yet been discovered at the LHC.

In view of this dilemma, the initial question of the research program called "An Effective Field Theory for Non-Global Observables at Hadron Colliders" (EFT4jets) and proposed by Professor Matthias Neubert is: What strategy should be pursued on the theory side to fully exploit the discovery potential of the LHC as the world's most powerful high-energy particle accelerator? "Subtle signals for new physical phenomena may already be hiding in the LHC data. However, we lack the precise theoretical methods that would be necessary to discover them," explained Matthias Neubert. In this context, so-called jet processes are among the most interesting observations. Thus, it is the goal of the planned research program to better understand them theoretically.

These jets are produced when particles collide at the highest energies. They consist of the fragments of colliding elementary particles – quarks and gluons – and are therefore probing at the deepest level the fundamental forces acting at smallest distances. New and powerful theoretical methods are needed to fully control quantum effects that affect these processes, both in the Standard Model and in its extensions with new particles. "It has been suspected since as early as 2006 that the strong interactions between colliding particles lead to subtle quantum mechanical effects known as entanglement of quantum particles. Similar effects enable quantum computing and quantum teleportation," said Matthias Neubert. "But there have been no theoretical methods to calculate their influence on the measured data for processes at particle accelerators. I would like to close this gap with my research project." Matthias Neubert published the first groundbreaking theoretical foundations for the project in the renowned Physical Review Letters in 2021, together with Professor Thomas Becher from the University of Bern and Professor Ding Yu Shao from Fudan University in

Shanghai.

"Understanding the physics behind these processes even better will enable us to search for new phenomena in a more targeted way. We will then know, so to speak, what to look for and what events in the LHC experiments we should pay special attention to," explained Matthias Neubert. Some benchmark processes are of particular importance with regard to the search for new physics. These include the production of Higgs bosons and the search for dark matter particles, each in association with one or more jets. "Our approach will give us very detailed predictions for these important processes. Our new methods will enable more accurate calculations than ever before, significantly increasing the discovery potential of the LHC for new physics."

Second ERC Advanced Grant for Matthias Neubert

Matthias Neubert studied physics in Siegen and Heidelberg, where he received his PhD in 1990. After a research stay at Stanford University in the USA, he moved to the European Research Center CERN near Geneva as a Staff Scientist in 1993. In 1999, he became a professor at the renowned Cornell University (USA), where he is still active today as an adjunct professor. Since 2006, he holds the professorship for Theoretical High Energy Physics at JGU. Since 2012, he is also spokesperson of the Cluster of Excellence PRISMA and its successor PRISMA⁺ as well as Director of the Mainz Institute for Theoretical Physics (MITP). Matthias Neubert received his first ERC Advanced Grant in 2011 and is one of the most highly cited theoretical physicists in Germany. His research results have appeared in over 250 publications and review articles. Matthias Neubert is a member of the Mainz Academy of Sciences and Literature and the Heidelberg Academy of Sciences.

ERC Advanced Grants are awarded to outstanding researchers to enable them to work on projects considered to be highly speculative due to their innovative approach, but which, because of this, can open up access to new approaches in the corresponding research field. Only researchers who have already made significant breakthroughs and have been successfully working for at least ten years at the highest levels of international research are eligible for the grant. The only criteria considered in awarding ERC funding are the academic excellence of the researcher in question and the nature of their research project. An ERC grant thus also represents an important acknowledgement of the recipient's individual achievements.

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