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Kluyverprize 2022

Report of the jury, to be presented at the award ceremony, May 15, 2023

The jury selecting the winner of the annual Kluyver Prize has discussed the 12 submissions for 2022 and it is my privilege to present the outcome of the deliberations.

The summaries of the theses provided an exciting overview of the rich scientific programme of the Nikhef alliance.

New frontiers are explored at the Large Hadron Collider and through messages from the cosmos.

Subjects covered in the 2022 theses include the strong interactions at high energy including the non-perturbative domain – even the Pomeron, a Regge trajectory with the quantum numbers of the vacuum, postulated in 1961, is around again and it can still excite emotions!

Studies of the Higgs-boson at the LHC can now access its properties at a level of precision, thanks to new and very clever analysis techniques, that go beyond what was thought to be possible when the LHC started operation. Further important upgrades of the detectors will allow to turn some of the upper limits measured so far, for example for the charm or muon decay channel of the Higgs, into measurements of the branching ratio. The same is true for the measurement of Higgs self-couplings, the ground being prepared by the present analyses. A remarkable study of vector boson-Higgs boson

associated production, not only paves the way for such future studies, but is very interesting in its own right.

The analyses of LHC physics are also in the domain of flavour physics, in particular B mesons in the area of non-standard model decays.

Also the quark-gluon plasma, liquid drops of pure strong matter, that must have been present just after the big bang can presently, and after the upgrades, be studied with new 'tools', covering the whole range from the hot phase to hadronization.

The Nikhef program is not limited to the experimental exploration of these new frontiers but is unique in the sense that also innovative theoretical avenues are being explored both in support of the experimental programme and in more speculative areas, such as sterile neutrinos.

The other frontiers involve cosmic phenomena: cosmic rays and gravitational waves. The successful detection of gravitational waves required and requires the development of sensitive and ultra-stabilized detection equipment that allows the measurement of the distortion of space much smaller than a proton radius. The medium-term future of this research is the Einstein Telescope. One of the thesis summaries included an explanation, not only of the technology frontiers that are being pushed back, but also of the intimate connection between fundamental curiosity-driven research and technological innovation leading to applications that benefit society directly.

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Neutrinos remain, perhaps, the most enigmatic particles of the standard model and their cosmic sources are not fully understood yet either. The detection of atmospheric and cosmic neutrinos by detection of the Cerenkov-light of the charged particles produced in huge instrumented volumes in the deep sea will provide additional handles on both these topics: neutrino properties, in particular oscillations and cosmic neutrino sources. The impressive effort in the framework of the KM3NeT collaboration and notably the ORCA and ARCA detectors has now provided a measurement of neutrino oscillations with only 5% of the ORCA detector complete. The analysis required identification and reconstruction of the muon tracks, determination of their energy and angle leading to a determination of the oscillation variable L/E and, together with the initial atmospheric neutrino flux known from other experiments, leading to a clear observation of the first oscillation minimum and a determination of the oscillation parameters. These are consistent with results from experiments at accelerators and reactors. But this analysis holds an enormous promise for unique measurements with the full detector, when also interactions of electron and tau neutrinos will be detected.

This impressive achievement and the future possibilities offered by this research are described and beautifully summarized in the thesis with the promotional title: ‘Quantum Effects on a Planetary Scale - The First Neutrino Oscillation Measurement

with KM3NeT/ORCA’ written by Lodewijk Nauta. He is the winner of the 2022 Kluyverprijs!