MITP SCIENTIFIC PROGRAM

"Probing the TeV scale and beyond"

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The four week scientific program gathered forty six prominent theorists working on physics beyond the Standard Model, an excellent representation of more senior and young researchers. The main emphasis of the program was on providing opportunities for individual interactions to continue the existing and begin new collaborations among the participants. However, the atmosphere of the program has also strongly profited from the spontaneously organized talks and discussion sessions, not to mention the morning and afternoon coffee time. That formula of the program turned out to be very successful, the feeling shared by most of the participants.

The program happened to be organized after the end of the first phase of the LHC experiments.The discovery of the 125 GeV Higgs boson and the absence of any obvious signals of physics beyond the Standard Model have largely shaped the scientific discussions and the research conducted during the program. The lack of definitive evidence for new physics and the variety of theoretical possibilities require a careful reexamination of questions such as the likely scales of new physics and how to look for them at the LHC and at other present and future facilities. The well known naturalness problem of the Standard Model, considered for many years as the main guiding principle for searches of physics beyond the Standard Model, is being more and more challenged by the experimental data.

Among the most important topics discussed and under investigations of several groups of the participants were the theories for dark matter and the status of its experimental searches in colliders and in direct and indirect detection experiments. Several talks and a special discussion session were devoted to the dark matter issue. Some of the existing, though not yet confirmed signals of dark matter such as the gamma-ray excess from the galactic centre and the anomalous x-ray line from galaxy clusters hint to specific models of dark matter that may then be probed in colliders. It was also stressed that the new results from the direct detection experiment (LUX) provide very strong constraints on a WIMP as the dark matter candidate, in particular in supersymmetric models. The role of the synergy between different experiments in the search for the dark matter particle was very evident. The new LHC run will provide further significant probe of the supersymmetric dark matter.

Another topic under intense discussion was of course the fate of the naturalness of the Higgs potential, that is the fate of the theories proposed as solutions to the naturalness problem. A special discussion session was devoted to the searches for the supersymmetric particles in the second phase of the LHC experiments starting in 2015. So-called simplified models are very useful for estimating the discovery potential of the new LHC run, with an unfortunate conclusion: the range of the stop mass accessible in the new run will not increase significantly enough for drawing any new strong conclusions on the naturalness of the

MSSM. It has been stressed that the colorless supersymmetric particles are equally important and promising target for the new LHC run. Composite Higgs models and their experimental signatures were also presented by several participants who pointed out that the present error bars on the Higgs boson couplings measured by ATLAS and CMS still leave some room for its compositeness.

Among the interesting events, spontaneously arranged by volunteers eager to contribute with short presentations, was a mini symposium on potential anomalies seen at the LHC. The list included single plus dilepton plus jets rate, di-Higgs resonance, W boson pair production rate, trilepton signature and the decay rate for B meson into a K meson and a lepton pair. The presentations, followed by critical discussions, clearly showed that those exotic events are far from being convincing hints for new physics.

Neutrino physics, flavor physics, electric dipole moments of quarks and leptons as probes of new physics, as well as prospects for the discoveries at the 100 TeV collider were briefly touched upon in a couple of talks and discussion sessions.

The program gave an excellent overview of the status of the theoretical beyond the Standard Model scenarios and the prospects for their further experimental verification with the new LHC run at 13 TeV collision energy. It was clear that, not giving up on the naturalness issue as the motivation for new mass scale close to the electroweak scale, the theoretical and experimental efforts to discover the identity of the dark matter particle and to understand the origin of its mass are the most pressing empirical problems in particle physics and become the frontrunners among the open fundamental questions.

The MITP scientific program “Probing the TeV scale and beyond” was very successful in stimulating scientific collaborations among participants. A good balance between common events and ample time for discussions and interactions among collaborators was crucial for the success of the program. The social atmosphere was excellent and very helpful in establishing new scientific links and new collaborations. The participants appreciated very much the hospitality of the MITP staff.