Probing Baryogenesis via LHC and Gravitational Wave Signatures

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18-29 June 2018

The origin of the baryon asymmetry of the universe is one of the main open questions in fundamental science. The solution to this puzzle requires physics beyond the SM (BSM) to which the LHC is supposed to be sensitive. TeV scale baryogenesis mechanisms typically require a strong first order phase transition, which might be responsible for setting the dark matter abundance in asymmetric DM scenarios.

The scientific program brought together experts from the fields of collider physics, model building, baryogenesis and phase transitions, dark matter and gravitational wave physics to tackle the puzzle of the baryon asymmetry of the universe. Several SM extensions that aim at generating a baryon asymmetry with signatures that should be testable in the forthcoming decades, were analyzed. Such signatures include EDMs, LHC searches and GW measurements. All of them were reviewed and critically reinterpreted in view of the models that have been discussed.

Particular emphasis was dedicated to the GW observables, since this field is quite new for the particle physics community. The participants showed great interest in this topic. Their better comprehension of the GW phenomena is expected to impact their future publications, allowing them to provide estimates according to the state of the art in the field. In particular one expects general improvements about the reliability of the predictions, where the uncertainties on the GW signals are not overlooked.

The scientific program also highlighted that even for the experts on the GW production from phase transitions there remain several open questions. These are possibly due to the fact that our comprehension of this GW phenomenon is strongly based on the outcome of the numerical simulations, because the analytic understanding is still not sophisticated enough. In view of this, the few researchers working on analytic results will hopefully not be discouraged by the complexity of the subject and keep scrutinizing the outcome of the simulations by means of analytic methods.

As regards the general discussions on the possible baryogenesis realizations it has been observed that it is somewhat difficult to achieve simple UV completions of the SM that produce the observed BAU and at the same time naturally overcome the present EDM and LHC constraints. The explanation of the BAU thus seems to require some tuning in the minimal extensions, or a radical departure from minimality. In some cases, the (nonminimal) SM extensions manage to modify the scale of the EW symmetry breaking by order of magnitudes. Due to this feature, it seems reasonable that, for instance, the typical frequency of the SGWB spectrum possibly generated by the EW phase transition is not necessarily within the LISA band. Of course, insights on the complete model of particle physics can be deduced by breakthroughs in complementary fields. As stressed in several discussions, the problem of the BAU can be connected to the puzzle of DM (via e.g. phase transitions in the hidden sector or asymmetric dark matter), the origin of the primordial magnetic fields, or the breaking of high-scale symmetries (e.g. leading to cosmic strings). In the scientific program there was only time to briefly mention these aspects. In order to analyze these topics in some detail, workshops dedicated to each of these subjects would be necessary.

The main goal of the scientific program was to support collaborations. The multiple discussions carried out in large groups were aimed at summarizing the state of the art of the BAU problem and, moreover, draw the participants' attention to the most relevant open issues. It looks that the participants spontaneously formed small groups to start new projects. The publications of these groups will be an objective measure of the success of the program.