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COVER STORY

Beyond the Standard Model

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Now, the chase to detect supersymmetric partners of particles.

The first week of July had physicists around the globe excited by rumours, and then an announcement by CERN, that the Higgs boson had finally been detected at the Large Hadron Collider (LHC) by two independent experimental teams. While currently the case for Higgs is not totally airtight, the 5-sigma detection does indicate the existence of a new boson particle with a mass of 125 GeV. Higgs has been so intently sought after to complete the experimental verification of the remarkably successful Standard Model of elementary particles that the "premature" excitement frowned upon by some serious scientists is perhaps more than justified. It is often not appreciated that experiments such as the LHC are mammoth human enterprises involving years of dedicated labour by a very large team of scientists and technologists, and it is important for sustenance that they get to cheer every step of success.

From the least exciting point of view, the detection of Higgs completes the experimental chapter of verifying the Standard Model of particle physics. All the players in the model are now tagged. Truly exciting! But that is like watching the closing act of a play with a well-known script. However, we scientists are greedy and ask for more, a trait of humanity we share with all others.

In particular, cosmologists seek to understand the origin and evolution of the entire universe in terms of the known laws of physics. As the Higgs discovery seals a chapter of particle physics, its cosmological implications induce new excitement on many more new frontiers. For decades now, modern cosmology has invoked a phase of rapid expansion called inflation to build a consistent standard model of cosmology. Recent cosmological observations, in particular the exquisite measurements of anisotropy and polarisation of the cosmic microwave background radiation, have vindicated most of the generic cosmological predictions of an inflationary epoch in the early universe. To most cosmologists, inflation is a working paradigm within which we could explain the universe we observe.

Models of inflation are constructed invoking the physics of a scalar 'inflation' field at ultra-high energies well beyond the reach of LHC. (The particle manifestation of a scalar field, namely its quantum excitation, has zero value for the quantum attribute called 'spin'.) The discovery of the postulated Higgs boson does help to hold off critics of inflation who have been pointing to the absence of a scalar fundamental field to date.

Although the experimental results announced at this time are not able to claim that yet, this indeed could be the first detection of a fundamental scalar field. Higgs boson is widely expected to be scalar field excitation. Suddenly, building the foundations of our primordial universe on

scalar field physics is not as unreasonable! But the Higgs field at 125 GeV is very unlikely to be the inflation, which must be explained in the physics beyond the Standard Model.

Interestingly enough, the Higgs discovery necessitates the existence of physics beyond the Standard Model. A 'light' (low mass) Higgs is difficult to explain without invoking supersymmetry, a higher level of symmetry than is present in the Standard Model, which requires each particle of the Standard Model to have a supersymmetric partner. In fact, the opening discovery of the LHC now sends particle experimentalists on another chase for detecting supersymmetric (SUSY) partners of the Standard Model particles, expected to be seen in the LHC as it accumulates more statistics with years of operation. SUSY also provides a reasonable route to the unification of fundamental forces of particles in a Grand Unified Theory (GUT), and that too at an energy scale where cosmic inflation scenarios can operate. Cosmologists are pleased that there is now experimental support to expect an inflation field that seems to be consistent with current observations.

On a second front, in the past decades cosmologists have been convinced from numerous consistent observations that there is about six times more gravitating dark matter than ordinary matter. These observations are compelling and can no longer be wished away. The SUSY world of particles also brings to cosmologists a viable candidate particle (lightest SUSY particle) for the observed dark matter.

While the above two are possibly the most exciting implication of Higgs for cosmology, there are many more aspects to this link. We live in truly exciting times where a frontier experimental result of particle physics has ramifications for the origins of the entire universe. The Higgs discovery at the LHC is just a warming-up phase in the list of expected discoveries eagerly awaited by particle theorists and also "star gazer" cosmologists.

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