Life, the universe, and everything – the emerging Renaissance of physics and astronomy

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There is currently a remarkable mix of clarity and confusion in fundamental physics and astronomy. The situation in the early 21st century is, in fact, similar to what it was in the late 19th century. Then most physicists were generally satisfied with the successful paradigm of classical mechanics and electrodynamics, but there were some conflicting experimental data and theoretical puzzles. Now most physicists are generally satisfied with the successful paradigm of quantum fields and gauge theories (plus Einstein gravity), but there are again mysteries that suggest the need for a deeper theory. Most recently, the particle discovered by the ATLAS and CMS collaborations at the LHC is now known to be a Higgs boson. A naive conclusion is that the Standard Model of particle physics is now complete. But the more profound interpretation is that the discovery of a scalar boson immediately points to physics beyond the Standard Model. Another major advance has been the discovery and exploration of neutrino masses, which appear to open the door to a more fundamental understanding of forces and matter via grand unification. There are many other mysteries and gaps in fundamental understanding. For example, the discovery and exploration of cosmic acceleration has suggested the need for truly revolutionary new physics. The extremely sophisticated and varied array of current experimental efforts – including the recent birth of gravitational wave astronomy – provides hope that many of the most fundamental mysteries [1-4] will be resolved in the foreseeable future. As one example, we mention the experiments to observe dark matter through direct detection in terrestrial facilities, indirect detection in satellite observatories, particle creation in accelerator laboratories, and new phenomena in astronomy and cosmology [4]. All these capabilities are nearing the regimes of exploration where potential success is expected. In the fairly near future one therefore expects an exciting new era for young researchers – a long-awaited Renaissance in physics and astronomy.

[1] E.g., C. Patrignani et al. (Particle Data Group), Chinese Physics C 40, 100001 (2016)), updated at http://www-pdg.lbl.gov/.

[2] Roland E. Allen and Suzy Lidström, “Life, the universe, and everything – 42 fundamental questions”, Physica Scripta 92, 012501 (2017).

[3] Roland E Allen and Suzy Lidström, “21st Century frontiers—a series of articles on current challenges and future opportunities”, Physica Scripta 92, 010302 (2017) .

[4] Katherine Freese, "Status of Dark Matter in the Universe", Proceedings of 14th Marcel Grossman Meeting, Rome, July 2015; arXiv:1701.01840 [astro-ph.CO].