Focus Week on Primordial Black Holes

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The focus week on primordial black holes, held on November 13-17, 2017, coincided with the 50th anniversary of the first paper, by Zeldovich and Novikov, which suggested that black holes could form in the early universe. This fascinating possibility was brought in sharper focus by recent progress in theoretical understanding as well as observations, in traditional and gravitational wave astronomy.

There is growing evidence that black holes exist, but their origin is not well understood. Black holes with masses, roughly, ten times the solar mass have recently been discovered in gravitational waves. Observations confirm the existence of supermassive black holes in active galaxies, as well as a large black hole at the center of Milky Way. While explosions of massive stars can lead to formation of black holes, our understanding of the mass function of astrophysical black holes is limited. There is no compelling explanation of how astrophysically produced black holes could grow to be supermassive in a short amount of time since the big bang. Black holes of primordial origin could be an important component of today's universe, and they could be the key to solving astrophysical puzzles.

The workshop started with a historical overview by Bernard Carr, who pioneered the field. The participants discussed a broad range of topics, from formation mechanisms, to observational constraints, to interactions of primordial black holes with neutron stars. There is a fascinating possibility that recently discovered gravitational waves from merging black holes can be, at least in part, due to primordial black holes. In a different mass range, there is a three-orders-of-magnitude window for primordial black holes to account for all dark matter in the universe. Finally, disruptions of neutron stars by primordial black holes can contribute to formation of gold, platinum, and other heavy elements.

One of the recent developments at the focus of discussion was a class of new, fairly generic, mechanisms by which primordial black holes could be produced. Depending on their origin, such black holes can have different masses and spins.

The subject of primordial black holes has a strong overlap with scientific programs at the Kavli IPMU, and it illustrates how particle physicists, astrophysicists, and cosmologists work together, building on synergy of the multidisciplinary institute. Particle theorists Masahiro Kawasaki, Alexander Kusenko, and Tsutomu Yanagida, along with several collaborators have contributed some key theoretical ideas: they identified several new ways in which black holes could form in the early universe, showed how primordial black holes could seed supermassive black holes found at the centers of galaxies, and pointed out that neutron star disruptions by primordial black holes can be responsible for synthesis of heavy elements. Astrophysicists Hiroko Niikura, Masahiro Takada, Surhud More, and their collaborators have carried out an observational campaign searching for black holes in the mass range previously inaccessible to observations. The new opportunity to search for black holes opened up thanks to the unique capabilities of Hyper Supreme-Cam on the 8.2m Subaru telescope.

The workshop participants were united in anticipation of exciting future developments and, hopefully, great discoveries.