Physical Sciences 2013

"It is a completely remarkable fact about the world we live in that everything appears to function according to mathematical laws. Moreover these laws seem to be accessible to our limited human thought. It seems like a natural — and perhaps the most important — endeavor for human beings to try to understand these laws. To try to figure out what the rules of existence are."

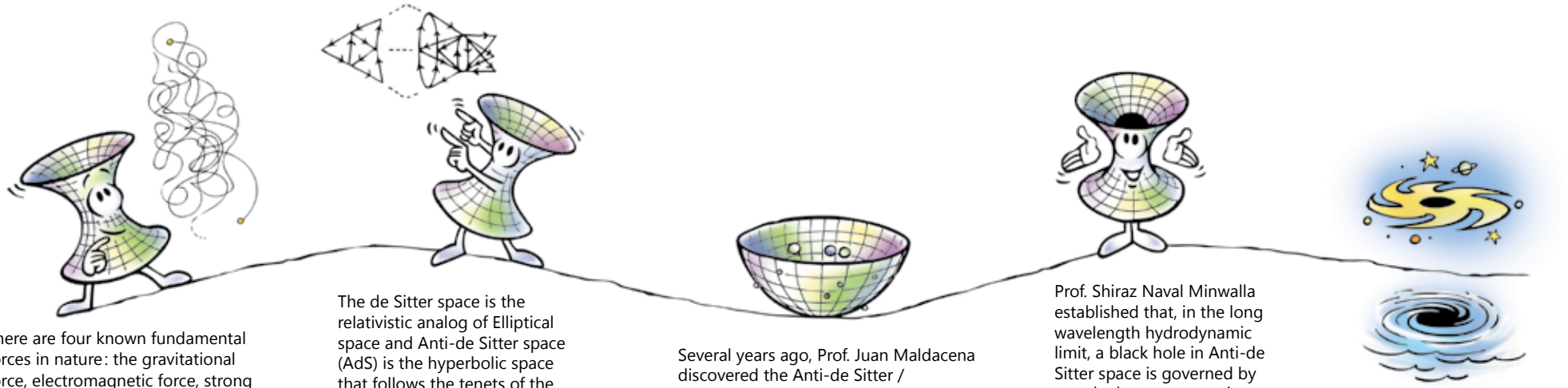
Shiraz Naval Minwalla

Professor, Department of Theoretical Physics, Tata Institute of Fundamental Research, Mumbai and IBM Einstein Fellow and Visiting Professor, Institute for Advanced Study, Princeton

- M.Sc. in Physics from the Indian Institute of Technology, Kanpur
- Ph.D. in Physics from Princeton University

Prof. Shiraz Naval Minwalla is a leader in quantum gravity research. He has made deep contributions in the field of string theory, in particular to the study of the AdS / CFT correspondence. Prof. Minwalla uncovered an unexpected connection between the equations of fluid and superfluid dynamics and Einstein's equations of general relativity.

Understanding gravity within the framework of quantum mechanics



There are four known fundamental forces in nature: the gravitational force, electromagnetic force, strong force and weak force. Physicists have a satisfactory mathematical description of the last three of these within the framework of quantum field theory. The only theory currently available for gravitational force, however, is Einstein's classical theory of general relativity.
A satisfactory quantum theory of gravitation is not currently available.

The de Sitter space is the relativistic analog of Elliptical space and Anti-de Sitter space (AdS) is the hyperbolic space that follows the tenets of the theory of relativity. A conformal field theory is a special kind of quantum field theory, one which has no dimensionful constants. The conformal field theories of most relevance to string theory often also enjoy invariance under supersymmetry, a symmetry that ensures that every particle has a corresponding super particle partner with opposite statistics.

Several years ago, Prof. Juan Maldacena discovered the Anti-de Sitter / Conformal Field Theory (AdS / CFT) correspondence which is a conjectured holographic relation between gravitational theory in the bulk of Anti-de Sitter space and a conformal quantum field theory that resides on its boundary. Since then scientists have tried to understand the significance of this correspondence, which provides an in-principle complete description of at least some quantum theories of gravity.

Prof. Shiraz Naval Minwalla established that, in the long wavelength hydrodynamic limit, a black hole in Anti-de Sitter space is governed by exactly the same equations as the nonlinear Navier-Stokes equations of a fluid. This AdS / CFT-like holographic view of fluid dynamics is called the fluid / gravity map.

Prof. Minwalla's work unifies two of the best-studied nonlinear partial differential equations in physics. Using the fluid / gravity map, Prof. Minwalla established a connection between the classical area theorems of black hole physics and the positivity of the divergence of the entropy current in fluid dynamics.