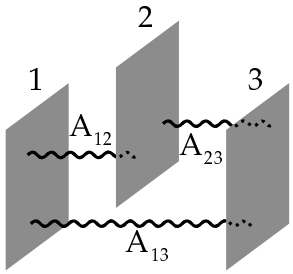
A Theory Without a Name

We are currently experiencing a new 'revolution' in the quest for the Fundamental theory of the Universe. During the past few years a new class of symmetries known as Duality have been discovered in string theory. These symmetries identify, for instance, the physics at large distances with the physics at very small scales! Using duality symmetries it has been proposed that the full dynamics of the 5 different string theories can be understood in the framework of a single M-theory probably living in 11 dimensions. On the picture you can read the names of the various theories, type IIa, type IIb, heterotic $SO(32)$, $E_8 \times E_8$ and type I $SO(32)$ for the string theory or eleven-dimensional supergravity (not a string theory and a previous candidate for unifying all the interactions), they are all believed to be just different manifestations of M-theory. The M can stand for Magic, Mystery, Mother, Membrane or Master. The high symmetry of the picture gives an idea of the duality correspondences: each name can be exchanged with any other by rotating or flipping the picture. Dualities achieve this by interchanging the well-known states, which come from the vibration of strings, with new states called D-branes.

The Dirichlet-branes

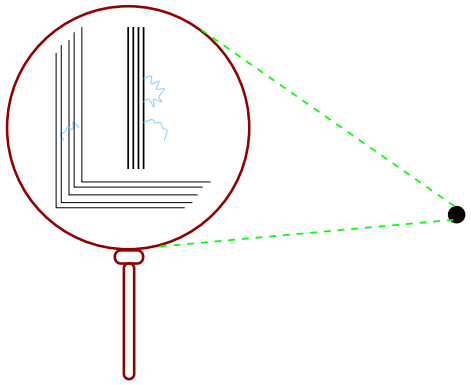
Dirichlet-branes are dynamical extended objects sensitive to the effects of gravitation and carry charges. They are hyper-surfaces where the end points of open strings (see other poster) are stuck.



According to this picture, the charge, color or other degrees of freedom which characterise the elementary particles of our universe are present on the surface of the D-branes. But as the small open strings can split and emit closed strings which carry gravitational interaction, the D-branes sensitive to the gravition. These dynamical features have some deep consequences for theoretical physics.

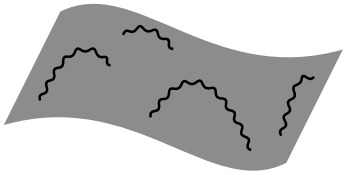
Looking inside the Black Hole

An extremely difficult problem for theorists is to reconcile Quantum Mechanics with the physics of strong gravitational forces, like those near a black hole. In the 1970's Stephen Hawking and others discovered that quantum black holes evaporate, emitting radiation with a well-defined entropy and temperature. But their thermodynamical analysis did not tell anything about the microscopic origins of this radiation.



Surprisingly, using M-theory and D-branes it has been possible to show for the first time that the microscopic states of (certain) black holes are described by configurations of intersecting D-branes (see picture) reproducing precisely the macroscopic results. A quantitative triumph of M-theory!

Our World as a D-brane



D-branes have really changed the way physicists are seeing the Universe. Now it is possible to imagine our world as a D-brane of extension 4 (3 space and a time dimensions) embedded in a 10 dimensional space, on which the interactions between charged particles, like the electron, the proton and other particles of Nature, are occurring.

As noticed previously, gravity is not restricted to our Universe described by the D-brane but can propagate in the ten dimensional space. Those 6 extra dimensions could then be detected indirectly through induced gravitational effects.

It is then conceivable that quantum gravitational effects of M-theory could be seen at energies much lower than previously believed. Probably low enough as to be tested experimentally in the near future!


Sugra 11d
Het E8xE8
IIa
M theory
Het SO(32)
IIb
I SO(32)