Research in theoretical physics in recent years has led to an entirely new way of looking at the universe. 120 of the leading researchers in string theory, the answer of physics to a unified theory, are meeting under the headline "The quantum structure of space-time and the geometric nature of fundamental interactions" .

Workshop about string theory in CRETE

From Sept. 6-10 there is a workshop centered around the latest developments in research of string theory, gravity and quantum field theories. This is the fourth workshop organized by a EU network which gathers many of the researchers inside the field. For many years similar meetings have been held in Europe, and now it is Crete's turn.

The workshop is supported by the European RTN network "*The quantum structure of space-time and the geometric nature of fundamental interactions*" and the European Excellence Grant "Fundamental Interactions and the structure of spacetime" of Ecole Polytechnique. The workshop is organized by the string theory groups of the University of Crete and the Laboratoire de Physique Theorique de l' Ecole Polytechnique in Paris. The aim of the workshop is to convene 120 scientists, many of which young researches.

Why string theory?

During the last 25 years, research in string theory has developed towards being one of the leading areas in theoretical physics and has been called "the physics theory of the 21st century", because string theory is a very promising road towards a "theory of everything". String theory tries to unify the four fundamental forces in nature, i.e. gravity, electromagnetism and the strong and weak forces. If this project succeeds, one will be able to explain the origin of the universe, (big

bang), as well as the physics inside black holes, two phenomena where gravitational forces are very strong at short distances.

The best theory for gravity - Einstein's general relativity - breaks down at very short distances. Such short distances are encountered in the Big Bang and inside black holes. It seems that the theory of gravity is inconsistent with quantum mechanics. For decades, there was a quest for a theory of gravity that is functional at short distances. String theory has this property built in naturally, but is much more complicated to solve compared to Einstein's theory. If we could build a bridge between Einstein's theory and quantum mechanics, we could hope to describe the first exciting periods of the development of the universe and address what is inside a black hole.

String theory assumes that the fundamental objects in nature are extended strings instead of point particles. Strings can be both open or closed and necessarily live in ten dimensions. Beyond the three spatial dimensions and time, which is the fourth dimension, there have to be therefore six extra dimensions. These extra dimensions are rolled up, like threads in a carpet. Moreover, the theory predicts a new symmetry in nature, called "supersymmetry". It is a symmetry that relates matter particles (like the electron) and particles that are responsible for interactions (like the photon).

At the European particle physics center, CERN, construction is under way to build a particle accelerator, which will collide protons at very high energy. Among other things, physicists will search for signals of supersymmetry. If supersymmetry is found in nature, an entire zoo of new particles will show up in the accelerator. String theory has also stimulated experiments which will determine if there exist extra dimensions. At this point, we have not yet seen signals of supersymmetry or extra dimensions. But experiments, which will take

place at CERN in the coming years, will either find them (along with possible other effects), or put higher limits for masses and length-scales.

Current research: Brane-worlds, the flying carpet and gauge theories at the end of the universe.

In the last years, it has been shown that string theory not only contains one-dimensional strings, but also higher dimensional objects, called "branes", a name generalizing the word "membrane" which describes a two-dimensional surface, (for example the surface of a drum).

In particular, there are several results that follow from this development, building on these special brane-objects. According to the so-called "brane-world" model, we are supposedly living on some type of "flying carpet" in a higher-dimensional space. New results show that the standard model of particle physics, which describes the hundreds of particles which are observed experimentally, can be qualitatively modeled with a brane-world model, in which we live on a three-brane in analogy with a "carpet that floats above the earth". Even though it might seem that the researchers have "lost contact with earth", there is optimism within the field.

Beyond the ambition to unify the fundamental forces, it has also been found that there are intimate relations, called "dualities" between the different forces. With these tools, one can consider two otherwise totally distinct types of forces as "two sides of the same coin". Also within cosmology, new surprising results been obtained. E.g. particles which experience gravity could move from our world into the six extra dimension, whereby energy will seem to disappear. This could maybe explain why gravity is so much weaker than the other forces.

Cosmological satellites, like the American WMAP and the european PLANCK, function as laboratories for the Big Bang and their measurements and will also be used to test predictions from string theory.

Finally in the last few years a deep and novel connection was uncovered among string theories in space-times with boundary and gauge theories living on the boundary. Such a correspondence seems far-reaching and promises to shed light on both gravity and gauge theories.

Related Web Links

- The conference Program *http://hep.physics.uoc.gr/RTN2004/*
- The webpage of the string theory group of the University of Crete *http://hep.physics.uoc.gr/*
- European RTN network "The quantum structure of space-time and the geometric nature of fundamental interactions", *http://itf.fys.kuleuven.ac.be/~tmr/rtn.html*
- "The Official String Theory Web Site*", http://www.superstringtheory.com*

Link for further information:

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