31 July 2007

By: Stefan Anitei, Science Editor

Dali Time

Does Time Really Exist?

Combining relativity theories with quantum physics would eliminate time

The more advanced the science, the more difficult puzzles emerge. Now, the shortest time intervals ever have been observed.

Ferenc Krausz in his lab at the Max Planck Institute of Quantum Optics in Garching, Germany, has managed to do this by using ultraviolet laser pulses to detect the absurdly brief quantum leaps of electrons within atoms, an event lasting roughly 100 attoseconds (100 quintillionths of a second). Like a second in 300 million years.

But even so, on the Planck scale, attoseconds would be like eons. The scale would define a region where distances and intervals are so short that the concepts of time and space start to disappear.

Planck time, the smallest time unit with any physical meaning, would be 10-43 from a second, less than a trillionth of a trillionth of an attosecond. And furthermore? Tempus incognito at the limits of the current physics. But this run touches the very basics of the problem: time may not exist in physical reality. Then, what is time and why are we its slaves?

"The meaning of time has become terribly problematic in contemporary physics. The situation is so uncomfortable that by far the best thing to do is declare oneself an agnostic." said Simon Saunders, a philosopher of physics at the University of Oxford.
One hundred years ago, Einstein's theories of relativity eliminated the concept of time as a universal constant. The past, present and future would not be absolute. But these theories, aiming for gravity and the large-scale structure of the cosmos, do not match quantum physics, the realm of the tiny.

40 ago, John Wheeler, at Princeton and Bryce DeWitt, at the University of North Carolina, tried to combine them through an equation that turned the concept of time into a more confusing one.

"One finds that time just disappears from the Wheeler-DeWitt equation. It is an issue that many theorists have puzzled about. It may be that the best way to think about quantum reality is to give up the notion of time—that the fundamental description of the universe must be timeless," said Carlo Rovelli, a physicist at the University of the Mediterranean in Marseille, France.

Many physicists believe that Wheeler-DeWitt equation rather describes a timeless universe. Another strange law of physics is that time always points to the future. All the physics laws could be applied as well if time ran backward. But for the moment, time is a one-way process; it never goes in reverse, even if no laws impede it.

"The usual explanation of this is that in order to specify what happens to a system, you not only have to specify the physical laws, but you have to specify some initial or final condition." said Seth Lloyd, a quantum mechanical engineer at MIT.

"The mother of all initial conditions was the Big Bang. Physicists believe that the universe

started as a very simple, extremely compact ball of energy. Although the laws of physics themselves don't provide for an arrow of time, the ongoing expansion of the universe does. As the universe expands, it becomes ever more complex and disorderly. The growing disorder—physicists call it an increase in entropy—is driven by the expansion of the universe, which may be the origin of what we think of as the ceaseless forward march of time." said Loyd.

But as Einstein showed, time is a component of the universe. Our clocks don't measure something independent of the universe.

"In fact, clocks don't really measure time at all. I recently went to the National Institute of Standards and Technology in Boulder. (NIST is the government lab that houses the atomic clock that standardizes time for the nation.) I said something like, 'Your clocks measure time very accurately.' They told me, 'Our clocks do not measure time.' I thought, Wow, that's very humble of these guys. But they said, 'No, time is defined to be what our clocks measure.' Which is true. They define the time standards for the globe: Time is defined by the number of clicks of their clocks." said Loyd.

"We say we measure time with clocks, but we see only the hands of the clocks, not time itself. And the hands of a clock are a physical variable like any other. So in a sense we cheat because what we really observe are physical variables as a function of other physical variables, but we represent that as if everything is evolving in time," said Rovelli.

"Is time a fundamental property of reality or just the macroscopic appearance of things? I would say it's only a macroscopic effect. It's something that emerges only for big things."

"Big things" would be anything above the mysterious Planck scale.

Even if physicists ever make it to join quantum theory and general relativity, space and time will be assessed by some changed quantum mechanics, in which space and time would be clearly separated and no longer smooth and continuous.
They would be made of tiny building blocks, quanta, just like light is made of photons, individual bundles of energy.
"In quantum mechanics all particles of matter and energy can also be described as waves." said Rovelli.

A peculiar trait of the waves is that they can exist in an infinite number in the same location. Quanta could be piled together in just one dimensionless point.

"Space and time in some sense melt in this picture. There is no space anymore. There are just quanta kind of living on top of one another without being immersed in a space," said Rovelli.