By: Gabriel Gache, Science News Editor
1 February 2008

The Sound of Quantum Drums

Two differently-shaped drums can give off an identical sound!

Two different drums should in fact produce two different sound spectrums, which pretty much means that if one were to identify one of the two, then he/she could do it just by listening for the unique sound it gives off. It may not seem like a very important property for most of us, but the truth is that we rely on to make accurate spectroscopy measurements, in order to study the composition of distant stars just by observing the light it gives off. Then, mathematician Mark Kac came and asked "Can one really hear the shape of a drum?" But if we don't, then it would mean we have been using a method that has no scientific value to us and we would suddenly realize that all the studies we've conducted over the years are flawed and we know just about nothing about stars. The 1990s didn't bring too much assurance either, as mathematicians demonstrated, against general belief, that two differently-shaped drums could in fact produce the same sound. Physical experiments conducted by observing the vibrations on the surface of soap bubble showed that the theory was correct; one cannot hear the shape of a drum. You can imagine what followed next, as physicists started raising questions related to the spectroscopy techniques people have been using for decades. Stanford physicist Hari Manoharan, on the other hand, had other worries, such as investigating whether the model still applied to quantum interactions and what effect would that have on nano-electronic systems. He decided to test the theory with the help of a scanning tunneling microscope, by moving individual carbon monoxide molecules on a given metal surface, in a microscopic device with walls only one-molecule high, shaped into a nine-sided enclosure that could resonate like a drum. Each so-called 'quantum drum' had about 30 electrons, containing 100 carbon monoxide molecules. Not surprisingly, the result was the same, with both nanostructures resonating at the same frequency, ranging in the terahertz spectrum. Manoharan argues that his result will ultimately affect the computer microchip industry, as you can see in the upper paragraph, one is able to create two differently-shaped nanostructures, which have the same role. Quantum computing may have something to gain by using such effect, but it is not the only one. Researchers say that the isospectrality may also provide experiments to test the string theory and a set of other cosmological models that study the structure of the universe, such as the possibility of existence of extra spatial dimensions. The study carried out by Manoharan brings significant findings into quantum mechanics physics as well, because observations such as quantum phase of the wave functions ,which is impossible to observe directly, could in fact be extracted from measurements of two isospectral quantum drums, through a process called quantum transplantation, a method heavily dependent on interferometry.