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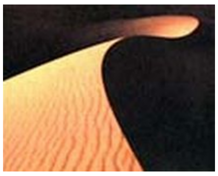
By: Vlad Tarko, Senior Editor, Sci-Tech News



Understanding liquids

The desert is an ocean in slow motion...

It may be hard to believe, but one of the most difficult problems in physics is the nature of liquids. Each time you look at water flowing down the drain you are watching a physical mystery. Why does the water flow the way it flows? Nobody can give you a definite answer right now. However, for the first time, the mystery and complexity of liquid behavior might begin to be unraveled. And the clue comes from the most unexpected places: the research of nano-structures and the study of sand.In order to understand why it is so difficult to create a general theory of liquids it is sufficient to see how the general theory of gases and the general theory of solids are constructed. They both start with an idealization: one invents an ideal gas or an ideal solid (crystal). The real gases or the real solids are not ideal but they resemble these idealizations in some aspects. The ideal gas and the ideal crystal represent *the first approximation* of a real gas or solid. Their advantage is that they are very simple models that afterwards can be made increasingly complex, thus mimicking more and more the real gases and solids. An ideal gas is an ensemble of molecules that don't interact with each other in any way, the molecules just fly around at random. An ideal solid is a network of molecules that are fixed in a definite regular structure, the molecules cannot leave their place in the structure, they can only vibrate. The model of the ideal gas can be made more complex by adding various types of interactions between molecules. The ideal solid can be made more complex by adding various types of irregularities in the structure. However, no ideal liquid has been invented. At first, it was believed the liquids are some sort of gases which have very strong interactions between the molecules. When X-ray spectroscopy was invented, a technique designed for determining the crystal structure of solids, and scientists used it also on liquid samples, they didn't expect to find anything. Instead, they discovered that the X-ray "photographs" of liquids resemble the X-ray "photographs" of solids. This didn't fit the idea that liquids are some sort of gases. Thus, many began believing that a liquid is more like a solid that has very unstable crystal structure.There are many other models but none of them really fits all liquids. There are some incredibly complex mathematical models that manage to describe only very simple liquids (such as mercury). In other words, nobody really has a good idea about how to describe a liquid.One nano-structure is a very tiny crystal, nonetheless around 10 to 1000 times bigger than a molecule. When researchers synthesized many such tiny structures they obtained a so-called nano-dust or a nano-sand. Imagine sand which has each grain of sand incredibly small, so small that you cannot even see it with the naked eye. But the thing is: as a whole, this dust does not behave like dust, it behaves exactly like a liquid! The sole difference between these nano-sands and the regular liquids is that we know exactly what the structure of the nano-sands is (because we have created them), while we don't know what structure regular liquids have. But, given they behave exactly in the same way, we can infer that regular liquids are nano-sands themselves. Another clue comes from the study of real sands and the study of sand dunes. If one looks at sand dunes for a long period of time one finds that they behave much like ocean waves. The desert landscape is not at all stable; it is in a continuous change. The only difference from a desert landscape and an ocean landscape is that the time scale of the desert is much longer - the desert is an ocean in slow motion. Thus, scientists now have a clue to what an ideal liquid should be: it is simply a set of tiny spheres that crumble onto each other under gravitation and that are hold together by friction. It remains to be seen where this new insight into the nature of liquids will lead to but chances are that this may be one of the first major breakthroughs in liquid theory.