STS-95

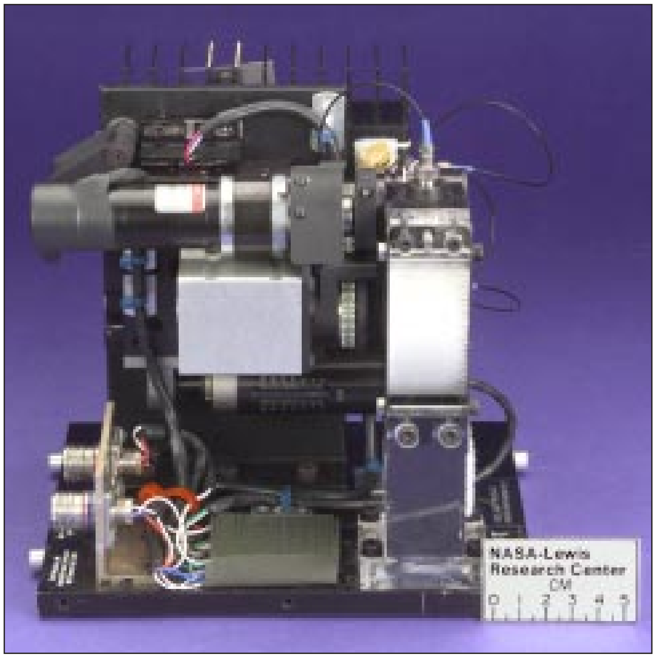
CDOT-2: A New Approach to Uncovering Atomic Behavior

Everything in the universe is made up of the same building blocks — atoms. All physical properties of matter, such as weight, hardness, and color, are determined by the kind of atoms present in a substance, the way they interact with each other, and the type of arrangements they form. The size of atoms and the complex ways groups of atoms organize themselves to form various states of matter make them very difficult to study. One way to overcome these problems is by studying systems of simple, larger particles that behave in similar ways. The second Colloidal Disorder-Order Transition (CDOT-2) experiment will test fundamental theories that describe atomic behavior. Colloids are systems of fine particles suspended in fluid. Milk, orange juice, and paint are some common examples. CDOT-2 uses colloidal suspensions of uniformly sized microscopic solid plastic spheres as a model of atomic interactions. On Earth, gravity causes the denser particles in a colloidal suspension to settle to the bottom, which is why some colloids, like orange juice and paint, must be stirred before use. This settling makes it difficult to study colloids in ground-based laboratories. Microgravity enables scientists to study colloids because the effects of density differences between particles and their surrounding fluids are decreased, thus eliminating settling and maintaining an even distribution of particles in the fluid.

On Earth (left), gravity causes the denser particles in a colloid to settle to the bottom of the sample cell. In microgravity (right), the effects of density differences between particles and their surrounding fluids are decreased; thus, the particles disperse evenly in the fluid.

The Loose Parts Box keeps small tools handy for astronauts during operation of the experiment on orbit.

During the STS-95 mission, researchers will use colloids to learn more about how the organization of atoms changes as they form into orderly solid structures. Researchers are using colloidal hard spheres suspended in liquid in varying concentrations to model this behavior. In samples with a certain level of concentration of hard spheres, crystal-like structures form. The behavior of these systems is similar to the changes in atomic structure that take place in the transition from liquid to solid, such as when water freezes and becomes ice. Initially, atoms in the water are randomly distributed. As the water freezes, atoms organize themselves into crystalline arrangements.



The CDOT experiment module is used to obtain light scattering data from the colloid samples. The module includes the laser light source and detector, as well as motors to rotate the sample under the laser beam.

CDOT-2 test samples will contain plastic spheres that are about one-tenth of the thickness of a human hair in diameter. In orbit, the samples will be allowed to sit for several days while the spheres organize themselves. The spheres, like atoms, will settle into an arrangement that gives each sphere the most space. A sample with a low concentration of spheres is expected to maintain fluid movement, like atoms in a liquid. Samples with higher concentration levels of hard spheres should form crystal-like structures. In samples with a very high concentration of spheres, no crystals will form. This last behavior is similar to the solidification of liquids into glass materials in which the atoms move so slowly that it takes millions of years for them to organize into crystalline structures.

Researchers will use laser light directed at the colloidal samples to study the arrangements of spheres that form in the samples. The laser light will be scattered off the surface of the structures, similar to the way sunlight "sparkles" on snowflakes. The scattered light will reveal information about the pattern the structures have taken. With this information, scientists gain insight into the validity of current theories of atomic behavior and will begin to answer questions of condensed matter physics regarding the transition between liquid and solid phases. A previous investigation during the October 1995 flight of CDOT on STS-73 yielded larger colloid crystals than can be grown on Earth. Dendritic arms, or branches, formed, which had never before been seen in ground-based studies of colloids.

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