Physicist opens new window on glass puzzle

When most people look at a window, they see solid panes of glass, but for decades, physicists have pondered the mysteries of window glass: Is glass a solid, or merely an extremely slow moving liquid" An Emory University research team led by physicist Eric Weeks has yielded another clue in the glass puzzle, demonstrating that, unlike liquids, glasses aren't comfortable in confined spaces.

The Emory team's findings are reported in the paper "Colloidal glass transition observed in confinement," published in the *Physical Review Letters* July 13. The Emory research adds to the evidence that some kind of underlying structure is involved in glass transition, Weeks says. "This provides a simple framework for looking at other questions about what is really changing during the transition."

Weeks has devoted his career to probing the mysteries of "squishy" substances that cannot be pinned down as a solid or liquid. Referred to as "soft condensed materials," they include everyday substances such as toothpaste, peanut butter, shaving cream, plastic and glass.

Scientists fully understand the process of water turning to ice. As the temperature cools, the movement of the water molecules slows. At 32 F, the molecules form crystal lattices, solidifying into ice. In contrast, the molecules of glasses do not crystallize. The movement of the glass molecules slows as temperature cools, but they never lock into crystal patterns. Instead, they jumble up and gradually become glassier, or more viscous. No one understands exactly why.

"One idea for why glass gets so viscous is that there might be some hidden structure," says Weeks, associate professor of physics. "If so, one question is what size is that structure""

The Emory Physics lab began zeroing in on this question two years ago when Hetal Patel, an undergraduate who was majoring in chemistry and history, designed a wedge-shaped chamber, using glue and glass microscope slides that allowed observation of single samples of glassy materials confined at decreasing diameters.

For samples, the Emory lab used mixtures of water and tiny plastic balls Ð each about the size of the nucleus of a cell. This model system acts like a glass when the particle concentration is increased.

The samples were packed into the wedge-shaped chambers, then placed in a confocal microscope, which digitally scanned cross-sections of the samples, creating up to 480 images per second. The result was three-dimensional digital movies, showing the movement and behavior of the particles over time, within different regions of the chamber.

"The ability to take microscopy movies has greatly improved during the past five to 10 years," Weeks says. "Back in the mid-90s, the raw data from one two-hour data set would be four gigabytes. It would have completely filled up your hard drive. Now, it's just a tiny part of your hard drive, like a single DVD."

Two students collected and analyzed the data: Carolyn "Carrie" Nugent Ð an undergraduate from Bucknell University who worked in the Emory Physics Lab during two summers Ð and Kazem Edmond, currently an Emory graduate student in the Department of Physics.

The data showed that the narrower the sample chamber, the slower the particles moved and the closer they came to being glass-like. When the researchers increased the particle concentration in the samples, the confinement-induced slowing occurred at larger plate separations. The dimension between the plates at which the particles consistently slowed their movement was 20 particles across.

"It's like cars and traffic jams," Weeks says. "If you're on the highway and a few more cars get on, you don't really care because you can still move at the same speed. At 3 p.m., traffic gets worse and you may slow down a little bit. But at some point, your speed has to go from 40 mph to 5 mph. That's kind of what's happening with glass."

Previous research has shown groups of particles in dense suspensions move cooperatively. "Our work suggests glasses are solid-like because these groups can't move when the sample chamber is thinner than the typical size of these groups," Weeks says. "These experiments help us understand earlier work done with thin polymer films and other glassy materials, but as we use particles rather than atoms, we get to directly see how confinement influences the glass transition."

Source: Emory University