liquids don't behave like bulk liquids, and that their properties are different. The liquid isn't changing its chemical composition, so it must be changing how the molecules are arranged.

As reported in the March 15 issue of *Physical Review Letters*, Dutta and his coworkers bounced extremely brilliant x-rays off of a thin film of tetrakis(2-ethylhexoxy)silane, TEHOS, which had been applied to a solid surface of silicon. The reflected x-rays formed an "interference pattern" similar to the checkerboard light patterns created by shining light through a grating. With x-rays, such behavior indicates a molecular solid, and analysis of the pattern showed that the TEHOS molecules, which were used for the study because they are nearly spherical, were forming three solid-like layers, each one-molecule thick.

The layered TEHOS molecules were in an intermediate physical state between a bulk liquid and a solid, according to graduate student Chungjong Yu. He said that the physical state can be deduced from the shape of the reflectivity curve.

Yu said, "A very shallow ripple indicates a liquid, and sharp peaks indicate a solid. These are broad humps."

In regards to past research, Dutta said, "The question was, if you take a typical, garden-variety liquid, perfectly disordered, then when it starts flowing against a surface or being squeezed through pores, is it still a liquid? What we've now shown is no. It's one of these intermediate structures—the molecules are somewhat ordered—they're neither perfectly ordered nor disordered."

By using synchrotron radiation in this study, Dutta said, "This is a new application of synchrotron radiation. It's a first step to making rigorous measurements of how liquids organize near solid surfaces." As more studies are completed, he said, "we can use this body of knowledge to learn how to design molecules that would make better lubricants, to understand why lubricants behave the way they do, why they fail and how to prevent them from failing."

He said that the findings are also of interest from a theoretical standpoint, "There has been an enormous amount of work on the free surface of liquids, the liquid-air interface. Scientists worked for years to see if there is layering on the free surface. Well, there isn't. If you have a cup of a liquid, on the top layer, the air-liquid interface, it's a liquid." □

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