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# Smallest whirlpools can pack stunningly strong force

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Researchers studying physical and chemical processes at the smallest scales, smaller even than the width of a human hair, have found that fluid circulating in a microscopic whirlpool can reach radial acceleration more than a million times greater than gravity, or 1 million Gs.

By contrast, a pilot flying a fighter jet at high speed and in relatively tight circular patterns might experience a force of 10 to 12 Gs, making the force his body feels 10 to 12 times normal.

"From a physical perspective, it's not so surprising since the number of Gs goes up with an increase in velocity and the reduction in radius," said **Daniel Chiu**, a University of Washington assistant chemistry professor in whose laboratory the research was conducted.

What was surprising is just how much acceleration was achieved when the radius of the vortex -- the tight circular pattern in which tiny molecules were flying -- was reduced to such minute scales.

In this case, a tiny chamber one-third to one-half the width of a human hair was used to create a vortex in which less than a billionth of a liter of water reached an acceleration of more than 1 million Gs. The force was so strong that polystyrene beads a micron (1 millionth of a meter) in size, which the scientists were using to help visualize the flow of water, completely separated from the liquid in the vortex.

The finding by **Chiu**, doctoral student J. Patrick Shelby and research associates David Lim and Jason Kuo appears in the Sept. 4 edition of the journal Nature.

"It's just something neat that we stumbled upon," **Chiu** said. "You have a tiny volume of fluid and it is zipping around very rapidly."

The work, paid for by a grant from the National Science Foundation, could have future effects, as scientists and engineers explore microfluidics for a variety of applications. For instance, some researchers foresee a time when microfluidic systems can be used anywhere for quick analysis of biological samples. Some envision that a credit card-sized device with a microscopic needle could be applied painlessly to the body to obtain a particular sample, such as blood, and then microfluidic systems embedded in the card could profile the biochemical composition of the minute sample. That could mean a sick person in a remote location could receive a diagnosis in hours rather than waiting for days or weeks for samples to be sent to laboratories.

Chiu notes that there are large, high-powered commercial and government centrifuges that can achieve acceleration of several hundred thousand Gs, some possibly even exceeding 1 million. Materials that most humans are familiar with would be altered significantly or destroyed if exposed to such forces.

But that might or might not hold true at microscopic scales, **Chiu** said.

"The force would feel very small to us because the mass is so small at this microscopic scale, even though the acceleration is very high," he said. "But if you had humans living at that microscale, to them I imagine the force would feel very large."

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