

Optical tweezers to prove Einstein right

January 31 2005

100 years after Einstein's landmark paper, optical tweezer technology could confirm the theory of classical Brownian motion in details that Einstein missed when he first proposed it a century ago. This research is reported today in a special Einstein Year issue of the New Journal of Physics (www.njp.org) published jointly by the Institute of Physics and the German Physical Society (Deutsche Physikalische Gesellschaft).

"Optical tweezers" use a focused laser beam to trap and study microscopic objects, such as the individual bio-molecules that power muscle cells and propel sperm, and those that read the genetic code. The device is disturbed, however, by a subtle effect in Brownian motion known as the back-flow effect.

100 years ago in 1905, Einstein published a landmark paper on Brownian motion. He theorised that it is the constant buffeting of microscopic particles that goes on in any fluid as the fluid molecules randomly knock those particles around. He missed the subtle "back-flow effect" in which the very movement of a particle disturbs the water which ultimately bounces back to nudge the particle in return. "It's like a boat that tries to stop, and then is pushed by its stern wave when that wave catches up with the boat," explains Henrik Flyvbjerg of Risø National Laboratory in Denmark. "Optical tweezers sense the back-flow effect," adds Flyvbjerg, "but that also means it can be studied with them."

Einstein described Brownian motion as arising from the "white" noise of random molecular motion due to heat. But, the back-flow effect makes higher frequencies slightly more likely, making the white noise "bluey

white". Flyvbjerg and his colleagues demonstrate that optical tweezers technology is now at the point where this colour shift can be measured directly. He is collaborating with Stanford University's Steve Block to push the technology to do it. If successful, they will confirm Brownian motion's last unobserved trait, 100 years after Einstein's initial theory for it.

Citation: Optical tweezers to prove Einstein right (2005, January 31) retrieved 24 April 2024 from <https://phys.org/news/2005-01-optical-tweezers-einstein.html>

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