Short-Time Brownian Motion

Mark Raizen (University of Texas-Austin, US)

Brownian motion has been the benchmark for classical transport in a disordered system for many years, and is characterized by diffusion. In 1907, Albert Einstein predicted that particle motion should be ballistic on very short time scales, rather than diffusive. Einstein concluded that this instantaneous velocity would be impossible to measure in practice, a prediction that held for over 100 years.

We report experiments with micron-sized beads held in optical tweezers. We developed novel methods for fast, shot-noise limited detection of laser-beam deflection. Using this system, we have resolved the instantaneous velocity of a Brownian particle in air and in liquid [1, 2]. We use the velocity measurements to test the energy equipartition theorem. In liquid, we observe complex effects such as memory loss, and an anti-correlated thermal force. Future work will include a precision test of energy equipartition in a liquid, the short-time study of non-equilibrium phenomena and turbulence, and the onset of the arrow of time.

[1] T. Li, S. Kheifets, D. Medellin, and M. G. Raizen, Science 328, 1673 (2010).
[2] S. Kheifets, A. Simha, K. Melin, T. Li, and M. G. Raizen, Science 343, 1493 (2014).