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1. Nondiffusive motion of a Brownian particle

On the short spacetime intervals, a Brownian particle ceases to move diffusively. According to the Langevin equation, the scale of the transition to ballistic straight-line motion is determined by three factors: the size of the particle, and the viscosity and density of a fluid. The trouble is that, while the Langevin equation is quite adequate in describing motions on large scales, it fails to take into account the accelerated motion of a particle at the instant of time when it acquires an additional momentum. Because of the inertia of the perturbed fluid, the force it exerts on the particle is not proportional to the particle velocity in this case. As a result, the character of motion on small scales changes in that particles move more slowly and the characteristic time scale for the transition to diffusive motion is larger than predicted by the Langevin equation. To improve things, E J Hinch in 1975 introduced corrections to this equation. Now, B Lukić and his colleagues from Switzerland, Germany, and the US have for the first time investigated this correction experimentally using extreme-precision optical trapping interferometry. In their experiment, the motion of individual micron-sized particles was monitored by watching their reflected laser light with nanometer spatial resolution and microsecond temporal resolution. In particular, the team examined the range of scales where the diffusive-to-ballistic transition occurs. Experiments performed in a range of particle sizes and liquid densities are in excellent agreement with calculations by Hinch. The technique used in the experiment is also suitable for studying motion of Brownian particles in heterogeneous media — for example, in living cells whose functioning crucially depends on diffusion processes.

Source: *Phys. Rev. Lett.* **95** 160601 (2005);
prl.aps.org

2. Jahn – Teller effect in a single molecule

M F Crommie and his colleagues of the University of California at Berkeley and the Lawrence Berkeley Laboratory used a low-temperature scanning tunnelling microscopy to study the Jahn – Teller effect in individual potassium-doped fullerene molecules. Working with K_xC_{60} monolayers on a silver substrate, the team looked at regions that differed in the potassium concentration — with the number x of potassium atoms per fullerene molecule varying from 3 to 4 — and measured the STM tip current as a function of the applied voltage. Molecules in regions with $x = 3$ were found to be spherical and in the conducting phase, whereas those in $x = 4$ regions were deformed and insulating. The experimentally found explanation lies in the fact that the shape distortion of a molecule removes the degeneracy of its electronic energy levels (the Jahn – Teller effect), and such degeneracy does exist in the spherically shaped K_4C_{60} molecules. While the influence of the Jahn – Teller effect has been studied in a variety of crystals, this is the first time the effect has been observed at the single-molecule level.

Source: *Science* **310** 468 (2005)
http://physicsweb.org/articles/news/9/10/11/1

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Translated by E G Strel'chenko

3. Carbon nanotubes

Quantization of heat flux. An experiment by M Bockrath and his colleagues at the California Institute of Technology has for the first time demonstrated the quantization of a heat flux flowing through a carbon nanotube. Working under low flux conditions, the team reached the quantum limit regime in which the magnitude of the heat flux increased by discrete amounts, or quanta. The measurements made use of the unique structure of carbon nanotubes. In such tubes, heat is transferred by phonons — quasiparticles, whose mean free path between scattering is about 1 μm at 900 °C. The high thermal conductivity of nanotubes gives high promise that they can be used as thermal conduits for heat removal purposes in microelectronic devices.

Source: *Physics News Update*, Number 752 (2005)
http://www.aip.org/pnu/2005/split/752-2.html

Nanotube switch. An electromechanical microswitch with carbon nanotube contacts has been developed for the first time by researchers from the UK and South Korea. The team started by lithographically depositing three nickel conductors onto a surface 100 nm in size and then attached to them three carbon nanotubes directed perpendicular to the surface. Applying an electric potential to one of the outer nanotubes via the conductor generated an electrostatic force which deflected the second tube to the point that it touched the third one, thus establishing an electrical contact. Another interaction mechanism between the nanotubes was via the van der Waals force. The ability of the device to switch between two states depended on the balance between the van der Waals force and the electrostatic force and could also be controlled by varying the length of the nanotubes.

Source: *Appl. Phys. Lett.* **87** 163114 (2005)
http://physicsweb.org/articles/news/9/10/9/1

4. Stars near a black hole

Several dozen young stars more than 40 times as massive as the Sun are seen in a gaseous disk less than 0.1 pc in width around the supermassive black hole Sgr A* at the center of our Galaxy. The origin of these stars was uncertain. According to some models, the stars were born directly in the accretion disk, while according to others they migrated into the disk from the star cluster around it. Now, S Nayakshin and R Sunyaev have used observations from the NASA's Chandra X-Ray Observatory to rule out the latter scenario. Assuming a standard initial mass function for forming stars, young X-ray-emitting solar-mass stars must also be present in the central cluster. Based on the X-ray flux limit, it is concluded that the total mass of such stars is at least an order of magnitude less than necessary for the migration model. On the other hand, a nonstandard initial mass function dominated by massive stars is at direct odds with the observations because the central cluster does not contain many such stars. It therefore follows that the disk itself is the birthplace of the massive stars it contains. The difficulty with this model was that tidal gravitational forces of the black hole should hinder star formation by destroying high-density protostar gaseous clumps. However, it has been shown by several authors that the gravitational field of the gaseous disk itself can stabilize the situation provided its mass exceeds about 1% of the black hole mass. Because massive stars rapidly evolve, undergo supernova explosions, and enrich the gas with heavy elements, their formation in accretion disks may be a crucial factor in determining the way in which matter in the centers of active galaxies and distant quasars evolves chemically.

Source: http://chandra.harvard.edu/photo/2005/sgra/

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