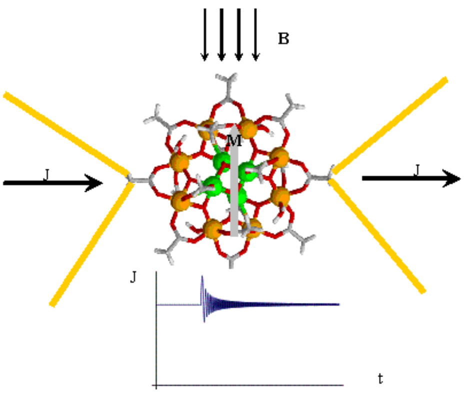
Highlights from the previous volumes

Single magnetic molecule between conducting leads: Effect of mechanical rotations

A magnetic molecule is an ultimate limit of a nanomagnet that one day can become a computer memory unit. Such molecular nanomagnets also exhibit a field-controlled quantum tunneling of the magnetic moment. This effect adds magnetic molecules to the list of candidates for qubits – elements of quantum computers. The search for a fast electric control of magnetic states of a nanomagnet has inspired a number of experiments with a single magnetic molecule between conducting leads, see figure below.

The magnetic moment of a molecule is made by electron spins. The change of the spin angular momentum, due to, *e.g.*, the reversal of the magnetic moment, generates a mechanical torque. In macroscopic magnets this effect is known as Einstein-de Haas effect. Quantum mechanics makes it special: if one tries to reverse the magnetic moment of a molecule by the magnetic field, the probability of the reversal oscillates in time before the molecule settles with its magnetic moment along the direction of the field. This effect is known as Landau-Zener effect. The theory of Jaafar, Chudnovsky, and Garanin combines the Landau-Zener effect with the Einstein-de Haas effect. It shows that the oscillating expectation value of the magnetic moment makes the expectation value of the torque oscillate as well. This leads to the wiggling of the molecule inside the electrical contact. *As in a tunneling microscope capable of detecting very small displacements of individual atoms, the tunneling current through a molecular contact must be extremely sensitive to the orientation of the molecule.* The current should, therefore, develop an ac component that follows quantum-mechanical oscillations of the molecule. This suggestion poses an interesting challenge to experimentalists.



Quantum reversal of the magnetic moment of the molecule causes oscillation of the tunneling current through the molecule.

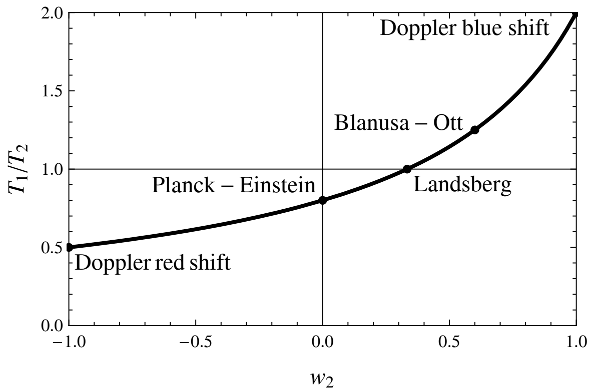
Original article by Jaafar R. *et al.*
EPL, **89** (2010) 27001

About the temperature of moving bodies

By confronting relativity theory with thermodynamics the question of the proper transformation of the absolute temperature is most exciting. To this several answers have been historically offered, practically including all possibilities. In 1907 Planck and Einstein concluded that moving bodies appear cooler by a Lorentz factor. Following some preceding claims Ott has challenged this opinion in 1963 by stating that such bodies are hotter. Landsberg argued for unchanged values of the temperature in 1966. Several authors observed that for a thermometer in equilibrium with black-body radiation the temperature transformation is related to the Doppler formula.

Coming to the era of fast computers, a renewed interest emerged in such questions by modeling relativistic stochastic phenomena. Dissipative hydrodynamics applied to high-energy heavy-ion collisions also requires the proper identification of temperature and entropy.

The physical root of the paradox lies in the fact that the momentum exchange cannot be separated from the energy exchange at relativistic speeds. *Beyond the two velocities of the interacting thermodynamic bodies the energy and momentum equilibration accentuates two additional velocities.* By a Lorentz transformation only one of the four velocities can be eliminated. The remaining three reflect physical conditions on the system. The requirement of observer-independent thermodynamic equilibrium leads us to a generalized Doppler formula. It depends on two physical velocities, the relative velocity of the bodies and the relative velocity of the energy flows inside the bodies. We reproduce the formulae of Einstein and Planck, Ott and Doppler according to respective physical assumptions on the energy flow.



The ratio of the temperatures shown by an ideal thermometer, T_1, and of the observed body, T_2, as a function of the speed of the heat current in the body, w_2. The relative velocity is $v = -0.6c$.

Original article by Bíró T. S. and Ván P.
EPL, **89** (2010) 30001

Generic anisotropy of particle ensembles

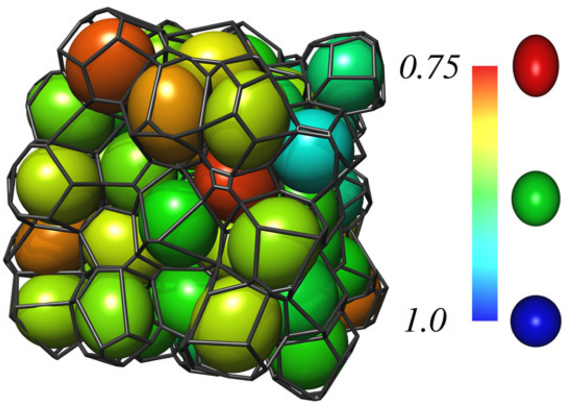
For granular media, liquid crystals, glass-forming liquids and other particle ensembles the concept of *free volume (Voronoi) cells*, that is the space available to each particle, is the principal geometric determinant of physical behavior. For example, global stability of static packings or flow through the cavities in granular media are evidently results of the local structure. This emphasises the need to understand the local structure and geometry of these structures.

Our study of static disordered granular bead packs shows that the average Voronoi cell in static jammed packs is substantially anisotropic, universally in real experiments imaged by tomography and simulations with and without gravity and friction. Static bead packs are thus globally isotropic structures composed of locally anisotropic environments.

The degree of anisotropy in bead packs is a structural measure that shows a clear signature of both the transition from mechanically unstable to stable configurations ("jamming") and of the onset of partial crystallisation at the random close packing limit. This suggests that the degree of anisotropy may be an order parameter for granular systems.

The local anisotropy of packings of *isotropic* particles may also explain the properties of packings of *anisotropic* particles. If generic packing considerations imply locally anisotropic environments it is a simple leap to assume that anisotropic particles can make more efficient use of this anisotropic space. Indeed, the hypothetical substitution of the bead positions with ellipsoids that match the cell anisotropy gives almost non-overlapping packings with packing fractions similar to those observed experimentally.

The novel *Minkowski Tensor* method to quantify anisotropy applies to arbitrary spatial structure. Code is available at `www.theorie1.physik.uni-erlangen.de/karambola`.



Voronoi partition of a static disordered packing of spherical beads. The beads are replaced by ellipsoids that match the anisotropy of the cells. (Colours indicate the ratio of smallest to largest half-axis.)

Original article by Schröder-Turk G. E. *et al.*
EPL, **90** (2010) 34001

No classical diamagnetism for particles on a closed surface

In thermal equilibrium, the Bohr-van Leeuwen theorem predicts null magnetic moment for a system of classical charged particles in an external time-independent magnetic field. To understand this surprising result physically, it is often pointed out that the boundary of a system plays a subtle role: the charged particles in the bulk undergo orbital motion which gives rise to a nonzero diamagnetic moment, but there is also a paramagnetic moment arising due to incomplete orbits of particles which bounce off the boundary in a cuspidal manner. This paramagnetic contribution exactly cancels the diamagnetic one so that the net magnetic moment vanishes. Recently, based on this intuitive picture and supported by numerical simulations, Kumar and Kumar concluded that there exists a nonzero classical diamagnetic moment for a particle moving on the surface of a sphere where, due to the absence of any boundary, no such cancellation occurs and hence the nonzero diamagnetic moment.

However, we show analytically that, in the long time limit, a classical system consisting of particles moving on a closed curved surface is indeed described by the equilibrium (canonical or microcanonical) distribution, and therefore the average magnetic moment is zero. This demonstrates that the previously claimed role of the boundary for having a zero magnetic moment is a misleading one because the average magnetic moment, as argued by us, must vanish even for a finite boundaryless system which has been shown to have an equilibrium distribution. In principle, one can understand the reason for vanishing of the magnetic moment as following. In thermal equilibrium, the velocity distribution of a particle depends neither on the position nor on the direction of the velocity. Therefore, the corresponding magnetic moment, which is proportional to the average of the vector product between position and velocity, is zero.

Original article by Pradhan P. and Seifert U.
EPL, **89** (2010) 37001