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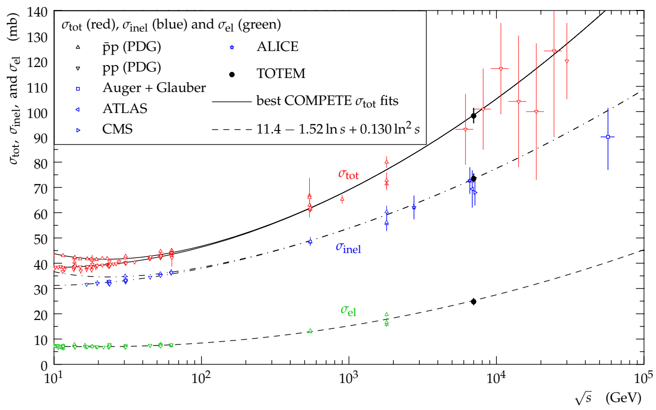
Highlights from the previous volumes

First measurement of the total proton-proton cross-section at the LHC energy of $\sqrt{s} = 7$ TeV

The proton, one of the basic building blocks of the atomic nuclei, is a dynamic and complex system: its subcomponents and their interactions keep it together in a very dynamic way. The inner structure of protons can be studied by observing how they interact with each other, which implies measuring the total cross-section of the proton-proton interactions. To measure it, the TOTEM experiment uses the fact that the total cross-section can be related to the elastic forward scattering amplitude.

Due to the tiny scattering angles the protons have to be measured very close to the CERN LHC beams, requiring custom-designed silicon detectors with full efficiency up to the physical edge. The measurement was performed in a dedicated run with special beam optics that made the angular beam spread in the interaction point small compared to the scattering angles.

The TOTEM experiment has confirmed the increase with energy of the proton-proton total cross-section by a (98 ± 3) mbarn result at the so far unexplored energy of the LHC. This phenomenon was expected from previous measurements performed at energies 100 times smaller at the CERN ISR in 1972. It is remarkable that the early indirect cosmic-ray measurements are in good agreement with the new precise TOTEM value.



The TOTEM measurement of the total cross-section of the proton at the 7 TeV centre-of-mass energy of 98 ± 3 mbarn is shown together with results from previous measurements and from cosmic rays.

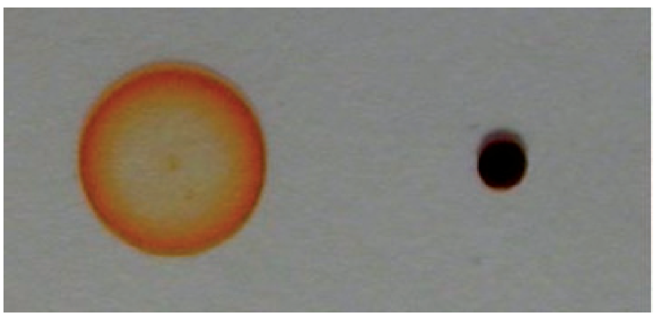
Original article by THE TOTEM COLLABORATION (ANTCHEV G. *et al.*)
EPL, **96** (2011) 21002

Slippery pre-suffused surfaces

Liquid drops most often stick to solids, which contributes to degrade these solids and affects their transparency. Slip can be induced by coating solids with hydrophobic textures: then, liquids only contact the texture tips, which dramatically decrease adhesion. On these superhydrophobic materials, water nicely recovers the mobility expected from its low viscosity.

Another way to make liquids mobile was proposed in this letter and by Wang *et al.* (*Nature*, 2011). It uses textures in a oleophilic situation: a solid coated with posts contacting oil can be spontaneously invaded by a film of this oil, the network of pillars acting as a kind of porous medium. At the texture scale (10 mm, typically), gravity is negligible compared to surface forces, so that the film gets trapped by the pillars, even when tilted. If now a drop contacts this substrate, it lands on a substrate mostly wet, and pinning can be strongly reduced. As an example, a coffee drop evaporating on a standard substrate leaves behind a coffee stain, primarily arising from the ability of the liquid to stick, while the coffee powder gets localized on these new slippery materials —making it easy to remove afterwards.

The condition for achieving these "floating" states was explored: the pre-suffused oil must wet the substrate with air above, but also with water (or another oil) above. Apart from its potential applications, this system is one of the very first explored where four phases (instead of three, in classical wetting) meet. It also has the interesting capacity to dissolve incoming liquid contaminants, again taking advantage of the mostly liquid nature of the substrate.



Two similar coffee drops after evaporation: a coffee stain is observed on a usual solid, while super-slippery oily surfaces concentrate the powder, demonstrating the absence of pinning.

Original article by LAFUMA A. and QUÉRÉ D.
EPL, **96** (2011) 56001

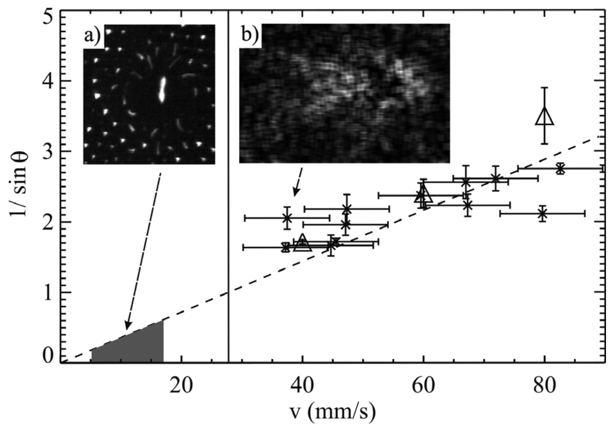
Direct measurement of the speed of sound in a complex plasma under microgravity conditions

Complex plasma experiments under microgravity conditions on the International Space Station ISS, complementing research on Earth, are very important for the progress in this field. Complex plasmas consist of micrometre-sized highly charged particles ("microparticles") embedded in an ionized gas ("plasma"). The microparticle ensemble resembles a classical system of interacting atoms. This system can form all of the classic phases, *i.e.*, crystalline, liquid and gaseous. It can also support the propagation of sound waves, solitons and shock waves.

In experiments carried out on Earth, gravity pulls the microparticles downwards resulting in two-dimensional structures. Under microgravity conditions it is possible to investigate big, three-dimensional systems. The PK-3 Plus laboratory provides ideal conditions for such experiments. It is installed in the Russian segment of the ISS and has been used repeatedly over the last 6 years.

We performed experiments to measure the speed of sound during two missions with cosmonauts Volkov and Skvortsov. In panels (a) and (b) of the figure below we show how a bigger "probe" particle penetrated a cloud of smaller microparticles. At a speed several times faster than the speed of sound it excited a Mach cone. A double cone structure is discernible in this "atomistic" system. While moving through the cloud, the probe particle is decelerated to subsonic speeds.

By measuring the Mach cone angle at several probe particle velocities, we determined the Mach relation. This allows us to directly measure the speed of sound and to infer the microparticle charge. In addition, the experimental results agree well with a 3D molecular-dynamics simulation, demonstrating in particular a double Mach cone structure.



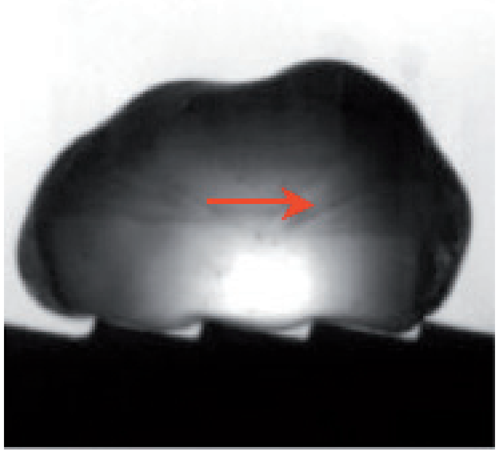
Mach cone relation linking the Mach cone angle θ with the probe particle speed v in experiments (crosses) and simulation (triangles). (a) Zoom showing the subsonic probe particle. (b) Smoothed difference between two successive frames, highlighting the Mach cone.

Original article by Schwabe M. *et al.*
EPL, **96** (2011) 55001

Viscous mechanism for Leidenfrost propulsion on a ratchet

The Leidenfrost phenomenon is observed when depositing liquids on solids much hotter than their boiling point. Liquids then levitate on a cushion of their own vapour, and slowly evaporate without boiling, due to the absence of contact with the substrate. The vapour cushion also makes liquids ultra-mobile, and Linke discovered in 2006 that Leidenfrost drops on a hot ratchet self-propel, in the direction of "climbing" the teeth steps. The corresponding forces were found to be 10 to 100 μN, much smaller than the liquid weight, yet enough to generate velocities of order 10 cm/s.

The origin of the motion was not really clear, despite stimulating propositions in Linke's original paper. As a first step, it was reported in 2011 by Lagubeau *et al.* that disks of sublimating dry ice also levitate and self-propel on hot ratchets: liquid deformations are not responsible for the motion. However, the levitating object in all these experiments squeezes the vapour below, and the resulting flow might be rectified by the asymmetric profile of the ratchet. The key question was not only to check this assumption, but also to determine in which privileged direction the vapour flows. By tracking tiny glass beads in the vapour, it was shown that rectification indeed takes place, along the descending slope of the teeth —the vapour escaping laterally once reaching the step of the teeth. Hence the levitating body is entrained by the viscous drag arising from this directional vapour flow. A similar conclusion was reached by Goldstein *et al.* in a paper to appear in the *Journal of Fluid Mechanics*. Many questions, however, remain: ratchets also generate special frictions (the liquid hits the teeth as it progresses), and the optimal ratchet (maximizing the speed of these little hovercrafts) has not yet been designed.



Levitating Leidenfrost drop self-propelling on a hot ratchet.

Original article by Dupeux G. *et al.*
EPL, **96** (2011) 58001