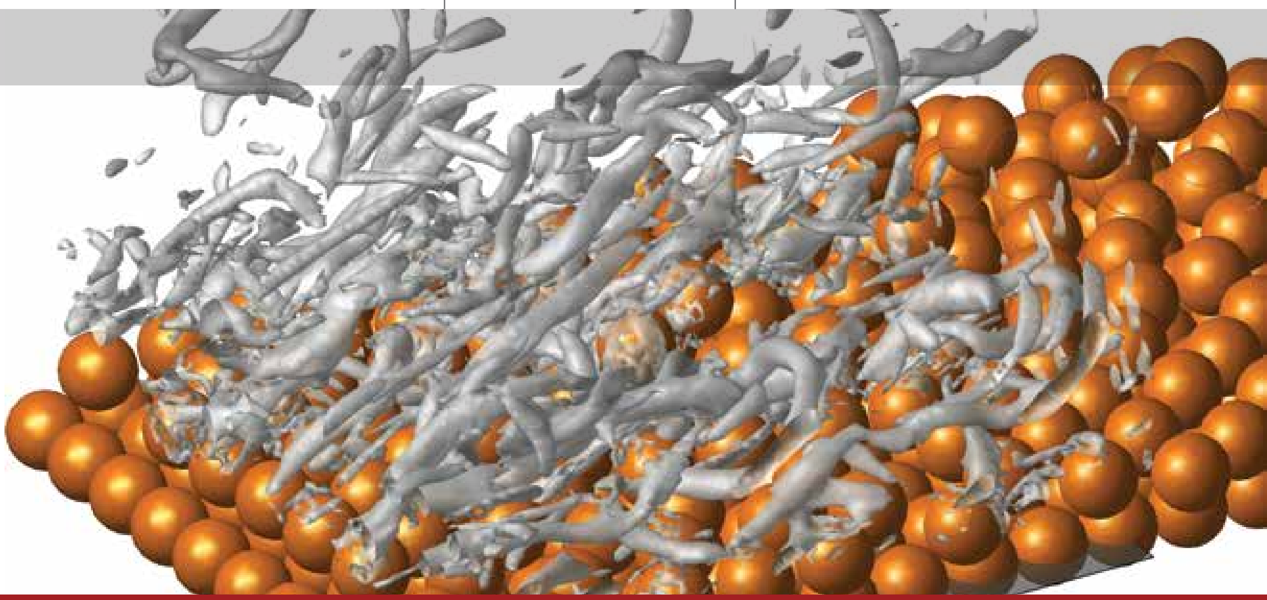
Department of Physics



Colloquia

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Surprises in particle sedimentation

day	location	time
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ABSTRACT

Colloid sedimentation has played a seminal role in the development of statistical physics thanks to the celebrated experiments by Perrin, which provided a concrete demonstration of molecular reality and gave strong support to Einstein's theory of Brownian motion. A lot more can be learnt both from the sedimentation equilibrium and from the particle settling dynamics of a wide class of systems, ranging from simple colloids to active particles and biological fluids, from foams to depletion gels. After briefly reviewing these issues, however, I shall rather focus on two rather surprising effects we recently investigated:

(a) What buoyancy really is. Usually, a settling process involves several disperse species, either because natural and industrial dispersions display a wide size distribution, or because additives are put in on purpose to allow for density-based fractionation of the suspension. Such a "macromolecular crowding", however, may have surprising effects on sedimentation: even the Archimedes' principle, arguably the oldest physical law, is in fact at stake. By performing targeted equilibrium measurements on binary particle mixtures, we show that the standard Archimedes' expression is just a limiting approximation, valid only for mesoscopic objects settling in a molecular fluid, and we provide a fully general expression for the actual buoyancy force. This "Generalized Archimedes Principle" allows to explain the occurrence of unexpected effects, such as denser particles floating on top of a lighter fluid, which we actually observe and quantify.

(b) Colloidal swarms can settle faster than isolated particles. Usually the settling velocity of a colloidal suspension decreases with concentration. This well-known effect is called "hindered" settling. By experimenting on model colloids where depletion forces can be carefully tuned, we have conversely shown that attractive interactions consistently "promote" particle settling, so much that the sedimentation velocity of a moderately concentrated dispersion can even exceed its single-particle value. This result proves to be relevant to the investigation of protein association effects by ultracentrifugation.

Roberto Piazza obtained a Master Degree in Physics from the University of Milan and a PhD in Quantum Electronics from the University of Pavia, with V. Degiorgio as advisor. After having worked with W. Goldburg at the University of Pittsburgh, he became Lecturer in Pavia and then Reader in Politecnico di Milano where, since 2005, he is full professor in Condensed Matter Physics. He has also being invited professor at the École Normale Supérieure in Lyon (2011), Leverhulme professor in Cambridge (2013), and Debye professor at Utrecht University (2015). He is currently section editor of the Journal of Physics Condensed Matter for liquids, soft matter and biological physics, and member of the European Space Science Committee of the ESF. His research activity, mostly devoted to the experimental study of soft matter and complex fluids, has covered several topics ranging from colloidal suspensions to surfactant and protein solutions. The results of these studies have been the subject of about 100 paper published on international peer-reviewed journals, which obtained over 3000 citations. He is also author of a popular book on Soft Matter, published in Italian, English and Chinese.

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