Once again we bring a selection of the top papers of the year to give an impression of the diversity, range and scientific quality of papers in Journal of Physics: Condensed Matter. The choice is difficult because JPCM has succeeded in attracting many excellent and innovative authors. Our very fair but rigorous referees have ensured a consistently high standard of papers in the journal. Many more papers were singled out with the support of referees (identifying work of the very highest importance), of readers (through high numbers of full-text downloads) and of our Board members (through recommending articles they found especially valuable) than could be featured here.

All these papers have been chosen for their excellent science. We should never forget, though, that popular appeal is also important. This year our most downloaded papers have discussed the search for a Spiderman suit and the use of laser Raman scattering to inactivate viruses. In both cases, the impact in the popular press has greatly outweighed that from the journal alone. While some may disavow it, the excitement that can be transmitted to the population at large through such publicity is often important for drawing more young people into science.

Picking these two papers for inclusion in this year’s top papers was easy. It would be nice if the rest of the selection process were as easy, but of course it isn’t. In the end, it is hoped that our choice of exciting papers from 2007 are also of great interest to you, the readers. Moreover, we hope that these papers give a fair flavour of the range of topics that are published in JPCM. Clearly they reflect the vigour that exists in the condensed matter world.

David Ferry
Editor-in-Chief
Taming Gd ions in fullerene cages

Encapsulating Gd within C₆₀ enhances its correlation energies

Water-soluble Gd-based endohedral metallofullerenes (Gd@C₆₀(OH)₉, Gd@C₆₀(OH)₅, and Gd@C₆₀[COOH]₅) are possible new magnetic resonance imaging (MRI) contrast agents. The toxic Gd ions are completely enclosed inside the fullerene, located at an off-centre position within the cage.

A large group headed by R F Sabirianov (University of Nebraska) explored the electronic properties of Gd@C₆₀ through a comparison of ab initio calculations with photoemission spectroscopy and resonant photoemission (constant initial state spectroscopy).

In comparing their calculations based on the local spin density approximation and the Hubbard model description with the observed photoemission spectra, they observed a strong correlation effect, which manifests itself in the shift of the Gd 4f state to higher binding energy, and correlation energy U of about 7.6 eV, which is larger than normally detected in gadolinium compounds. They attributed this to a lack of screening of the encapsulated Gd. In addition, they noticed prominent resonant intensity features, due to the Gd 5s and 5p cores in the resonant photoemission spectra taken from 6 eV below the Fermi level, which indicate strong hybridization between the Gd valence states and the fullerene cage. All the above phenomena are explained using the LSDA + U calculation.

Correlation effects and electronic structure of Gd@C₆₀
R F Sabirianov et al

Improvements in electrowetting

Interfaces between two immiscible electrolytic solutions offer improved electrowetting

When a liquid/liquid interface contacts a solid substrate, applied voltages can cause the interface to change shape. This electrowetting (EW) phenomenon can be applied in devices requiring no internal machinery. Also, interfaces in these devices self-assemble and are difficult to destabilize. Applications include portable lenses, microfluidic devices and electronic displays.

Charles Monroe and Alexei A Kornyshev (Imperial College London) and Michael Urbakh (Tel Aviv University) propose that interfaces between two immiscible electrolytic solutions (ITIES), which are impermeable to ion transfer over a large potential range, offer immensely better opportunities for fine shape control at low voltages than current EW systems. Also, ITIES can be described by a theoretical model with few free parameters.

Their paper gives full details of a theory that can be used to describe EW equilibrium. Families of curves are presented to show how the contact angle between an ITIES and an electrode varies with voltage, to gauge expectations for laboratory measurements. They provide a detailed analysis of the system construction to illustrate how undesired artefacts due to experimental geometry can be avoided. To contrast the case of ITIES, they also give an analysis for systems with a completely ion-permeable liquid/liquid interface. Although the latter system is very difficult to engineer, its comparison to ITIES illustrates the unique features that the ion-impermeability of a liquid/liquid interface adds to its EW response.

The distinctive electrowetting properties of ITIES
Charles W Monroe, Michael Urbakh and Alexei A Kornyshev

Frieder Mugele and colleagues from the University of Twente report improvements in conventional electrowetting.

Droplet-based microfluidic research has potential applications in biochemical reactions, material synthesis, single-cell analysis and novel fluid logical devices. Commonly pressure-driven flows are used to create droplets continuously, providing high throughput capability, but it cannot generate individual drops on demand nor provide dynamic control of surface wettability, which can dramatically affect the dynamics of two-phase microflows. Alternatively, the EW-on-dielectric approach is used to digitally manipulate drops, providing exquisite control over individual drops and surface wettability, but with low throughput and it cannot readily be integrated with existing channel-based technologies.

Mugele et al adopt a unified approach to create a soft microfluidic platform combining the advantages of both methods. They incorporate EW into a flow-focusing device and demonstrate EW-controlled drop formation. They identify experimentally the range of voltages and driving pressures that yields EW-induced droplet generation. A theoretical description based on the balance of external pressures and voltage-controlled capillary pressures quantitatively accounts for the observations. They show that with this unification the smaller the geometric scales the more efficient the EW control of drop generation.

Electrowetting-controlled droplet generation in a microfluidic flow-focusing device
Florent Malloggi, Siva A Yanapalli, Hao Gu, Dirk van den Ende and Frieder Mugele