Space constraints

Rev. Sci. Instrum. **82,** 023901 (2011)

The majority of artificial satellites circulate in a low Earth orbit — that is, between 200 and 1,000 km altitude. There they have to cope with a harsh environment: orbital debris and micrometeorites tend to get in their way, but there is also considerable radiative and chemical stress on the satellite structures. The degradation of the materials that make up the satellites is evaluated typically by retrieving samples and inspecting them back on Earth. Ronen Verker, Eitan Grossman and Irina Gouzman now propose a method for measuring the degradation of 'space materials' in orbit.

There are certain devices that are part of every satellite: photovoltaic cells. Verker and colleagues propose covering several of these cells with different semitransparent materials, while having other, uncoated cells for reference. The differences in output power will then depend on how much the covering material has been degraded.

In a simulated low-Earth-orbit environment, Verker *et al.* tested a range of films and obtained encouraging results. Amorphous carbon, for example, turned out to be sensitive to fluxes of atomic oxygen, whereas in cells coated with a material known as Kapton the output was also correlated with morphology changes.

Positive discrimination

Phys. Rev. Lett. **106,** 062301 (2011)

Brookhaven's Relativistic Heavy Ion Collider (RHIC), and now CERN's Large Hadron Collider, facilitate the study of the very hot, dense phase of matter thought to have existed in the early history of the Universe. Data from RHIC have suggested charge asymmetry fluctuations among the particle debris of the heavy-ion collisions — something is happening to cause an uneven distribution of electric charge. A possible culprit is the chiral magnetic effect (CME): solving the Dirac equation in a magnetic field reveals that the lowest Landau level is chiral; if some of these levels are filled, then a current is induced.

If the CME is proved to be at work in the RHIC data, then this would be a direct observation of a topological effect in quantum chromodynamics, and indicate that chiral symmetry is restored in the plasma. But the picture is blurred by the likely presence of a chiral vertical effect (CVE), arising from the combination of vorticity and baryon chemical potential.

Dmitri Kharzeev and Dam Son think there is a way to tell the two apart. It means measuring, event by event, the baryon asymmetry — the distribution of three-quark particles formed in the aftermath of the collisions — as well as the charge asymmetry. The magnitude of their ratio, which should increase as the centre-of-mass energy decreases, is quite different (by an order of magnitude) for the CME and the CVE.

In a trap, but not alone

Nature doi:10.1038/nature09721 (2011)
Nature doi:10.1038/nature09800 (2011)

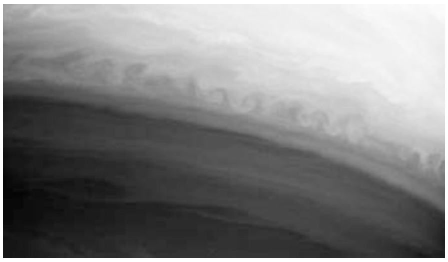
Quantum mechanical oscillators, such as ions caught in a trap, are one possible building block for quantum computers. Controlled coupling between two such systems enables the transfer of information between them, a vital process in quantum information processing. Such coupling has now been achieved independently by two groups of scientists.

Two ions trapped on a chip can interact with one another via the Coulomb effect: the closer the ions, the stronger the interaction. However, concentrating traps into a very small area leads to problems caused by heating, particularly once you take into account the effect of all the electrodes that are needed.

Kenton Brown and colleagues counteract this heating by cooling their ion 'chip' to 4.2 K in liquid helium. They observed energy transfer between two beryllium ions separated by 40 μm. Max Harlander and co-workers, on the other hand, used auxiliary trapped ions as an antenna to boost the interaction. In this way they were able to couple calcium ions over a distance of 54 μm.

The corona also rises

Astrophys. J. Lett. **729,** L8 (2011)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Coronal mass ejections release blasts of plasma and radiation from the Sun's corona. Particularly strong shock waves can damage satellites and bring down power grids on Earth, or allow Bostonians to read the newspaper at night by auroral light alone. In fact, the Sun will soon come out of its quiescent phase and our ability to predict solar activity will determine how prepared we are for any potential damage. Fortunately, the Solar Dynamics Observatory was launched in March 2010.

Studying images taken by the on-board Atmospheric Imaging Assembly, Claire Foullon and co-workers noticed some familiar wave patterns in images taken in the extreme ultraviolet band, at 11 million Kelvin. Just as two fluids flowing at different velocities lead to Kelvin–Helmholtz instabilities at the interface (like these ones, pictured, in Saturn's atmosphere), there are whirls with associated wavelength (18×10^6 m) and speed (833 km s^{-1}) in one flank of the ejecta. The presence of these instabilities will help researchers understand the kinematics of coronal mass ejections and the local nonlinear dynamics that drive them.

Higgs in 2D?

Phys. Rev. Lett. **106,** 045502 (2011)

One of the remarkable things about graphene is that its charge carriers behave as if they were massless. It's ironic, then, that researchers are now suggesting that the unusual process by which ripples develop in an initially flat graphene sheet is analogous to the Higgs mechanism, by which fundamental particles acquire their mass.

It's thought that, under the extreme temperatures of the early Universe, the electromagnetic and weak nuclear forces were unified and all elementary particles massless. Cooling of the Universe to below some critical temperature broke the initial symmetry of these forces, causing the so-called Higgs field to condense into a broken-symmetry state, a state in which fundamental particles that interact with the field gain mass.

When anchored to a substrate, graphene too exists in a high-symmetry state — that of a flat hexagonal lattice of carbon atoms. A free-standing graphene sheet, however, spontaneously buckles to form corrugations in its structure. Pablo San-Jose and colleagues argue that these arise from a quantum critical point whose mathematical topology is similar to that which describes the symmetry breaking of the Higgs field.