TOPOLOGICAL INSULATORS

Makes your head spin

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Despite being the first of now many classes of exciting materials whose properties are enriched by the topology of the electronic states, topological insulators still pose a number of challenges. Eric de Vries and colleagues have given us a hint of the sort of problem we're facing.

Ideally insulating in the bulk, but with topologically protected conducting surface states, topological insulators have a number of properties that could be exploited in devices. For the spintronics community, the direct coupling between the spin and momentum of the charge carriers in the surface states offers the prospect of injecting and detecting spin currents without the need for ferromagnetic materials.

But de Vries *et al.* showed that simply measuring the signals due to spins in the surface states of topological insulators is not so easy. With devices capable of measuring the spin signals due to spin–momentum locking in different geometries, they were able to see clear evidence for a spin polarization of the surface state. The problem is that they can see these signals when spin–momentum locking was clearly not the cause. *LF*

PRECISION MEASUREMENTS

Charge conservation

Phys. Rev. Lett. (in the press); preprint at http://arxiv.org/abs/1509.01223 (2015)

Electric charge is conserved on timescales significantly longer than the age of the Universe, more precisely 6.6×10^{28} years, according to the results of the Borexino experiment at Laboratori Nazionali del Gran Sasso (LNGS) in Italy. This improves the limit on the hypothetical decay of the electron into a neutrino and a 256 keV photon by two orders of magnitude.

To put a limit on electron decay one has to look for the decay products. And the obvious way to do that is by using a neutrino detector. A previous bound was set by the Counting Test Facility — also at LNGS — more than a decade ago. To get a tighter limit, the Borexino Collaboration took advantage of the large volume (100 t) of very pure liquid scintillator. In addition, the sensitivity was improved by higher statistics made possible by more than one year's worth of data and a thorough data analysis complemented by simulations.

The violation of charge conservation seems very unlikely, but such studies are important as they test the limits of existing theories. After all, what better place to look for new physics? *IG*

STELLAR ASTROPHYSICS

Planet meets star

Mon. Not. R. Astron. Soc. (in the press); preprint at http://arxiv.org/abs/1511.02230 (2015)

Saturn's rings are striking but not unique; Jupiter, Uranus and Neptune are similarly girded, as are white dwarf stars. Although we cannot observe the formation of rings within our Solar System, which may be as old as the planets, with white dwarfs this becomes possible. Indeed, Christopher Manser *et al.* imaged the white dwarf SDSS J1228+1040 over twelve years to understand the origin and evolution of rings.

To be precise, 'rings' are flat disks that stretch far into space. For SDSS J1228+1040, the gap between the star and the inner edge of the disk is around 700,000 km. The Doppler tomography scans taken from different angles reveal a non-circular inner edge of the disk. Moreover, the disk precesses. These observations are consistent with the disk being recently formed from a planet that got too close and was torn apart by gravity, precessing due to general relativity. This should be a short-lived phase, as radiation forces will eventually push the material inwards and symmetrize the debris disk.

One day this may happen to the Solar System. *MC*

PLANETARY SCIENCE

Martian dune dynamics

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With Curiosity roving Mars and probing its surface and atmosphere — the latter via the Rover Environmental Monitoring System (REMS) — Martian climatology has come of age. Indeed, the REMS provides a wealth of weather data such as humidity, pressure, temperature and wind speed.

However, compared with how the Earth's weather is monitored, Martian *in situ* meteorological data remains extremely scarce. An alternative handle on understanding winds on Mars is provided by looking at sand dunes — specifically, how ripple patterns evolve and dune orientations change over time.

Derek Jackson and colleagues investigated a dunefield in the Proctor Crater area, located in the southern highlands of Mars. The authors performed computational fluid dynamics modelling and reverse engineered the occurring dune dynamics by comparing photos of the area taken two Mars years (3.8 Earth years) apart by the HiRISE camera onboard the Mars Reconnaissance Orbiter satellite. The main finding is a poor correlation between dune ridge orientation and sand-transporting winds (inferred from ripple migration): the overall dune shapes are mostly unaffected by the prevailing winds. In other words, dunes steer the winds, rather than vice versa. The formation of dunes must therefore be due to earlier, different climate conditions — suggesting Martian climate change. *BV*

SELF-ASSEMBLY

Cubist architecture

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Sara Mehdizadeh Taheri and colleagues have uncovered a surprising geometry-dependent ordering principle in assemblies of magnetic nanocubes. The team showed that they could use a magnetic field to wrangle small nanocubes in solution into one-dimensional chains, two-dimensional sheets and three-dimensional cuboids — all with surprisingly regular internal order. But the same was not true of spherically shaped nanoparticles, which showed no such tendencies to order.

The group posited that the difference lay with the fact that spheres have much lower contact area than their cuboid counterparts. The cubes assembled for particle sizes so small that the particle–particle and particle–field interactions were on the order of the thermal energy and van der Waals forces. The external field induced dipole moments in the particles, bringing them close enough that the short-range interactions could facilitate highly regular ordering. The local interactions between spherical particles were therefore even weaker, and incapable of stabilizing the assemblies. Despite the fact that the cube assemblies showed remarkable regularity, they had unusually small magnetization given their size. *AK*

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