Mind the map

Proc. Natl Acad. Sci. USA http://doi.org/ngr (2013)

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At first sight, the London Underground ('the Tube') and interacting polymers don't have a lot in common. Yet Chi Ho Yeung and colleagues apply some of the theoretical machinery developed for describing intertwined polymer structures to optimize the Tube's operation.

The Tube obviously represents a network — stations (nodes) connected by rails (segments). A polymer is a chain of monomers, so an arrangement of many polymers can be seen as a set of nodes connected by segments. Yeung *et al.* considered polymers with fixed ends: the path between a polymer's endpoints is variable, but segments have to connect through neighbouring nodes, and one polymer cannot go through a node more than once. The authors introduced an energy function that can either penalize or encourage polymer overlap.

Translating this to the Tube, polymers correspond to passenger source–destination pairs, and overlap to traffic congestion. When concentration is penalized, the algorithm distributes traffic uniformly. The authors processed actual Tube data to propose optimal network usage and suggest differential pricing. Solutions that favour congestion may be relevant when the network is required to operate a reduced service — for example, during a strike. *BV*

Acceleration from within

Science http://doi.org/ngs (2013)

Electrons trapped in the Van Allen radiation belt surrounding the Earth can have several megaelectronvolts of energy. Scientists believe that either these charged particles originate from the outer magnetosphere where the magnetic fields are weaker (so-called radial acceleration), or low-energy electrons within the belt itself are accelerated to ultrarelativistic velocities — by resonating with electromagnetic waves, for example. NASA's Van Allen Radiation Belt Storm Probes (RBSP) have now been able to separate the signatures of these two different processes, indicating that local acceleration dominates.

Geoff Reeves and co-workers analysed data collected during an intense period of electron acceleration on 9 October 2012 in which the flux of megaelectronvolt electrons increased by three orders of magnitude. Measuring this flux in the conventional terms of energy, pitch and position does not distinguish between local and a radial acceleration. The RBSP instead sees the radiation belt in terms of 'magnetic coordinates'. For example, the radial location of an electron measured from the centre of the Earth changes during radial acceleration, but is almost constant for local acceleration. It was this latter signature that the RBSP spacecraft observed on 9 October. *DG*

Kinky strings

Nature Commun. **4,** 2290 (2013); *Nature Commun.* **4,** 2291 (2013)

Topological defects can form in a system that is undergoing a symmetry-breaking phase transition at a finite rate. This scenario — described by the Kibble–Zurek mechanism — may explain the origin of the large-scale structure in the early Universe. The same mechanism was found at work in liquid crystals, superfluid helium and superconductors, but the predicted power-law scaling for the defect density was hard to confirm. Using strings of trapped ions, Stefan Ulm and colleagues, and Karsten Pyka and co-workers, observe the formation of defects as expected from the Kibble–Zurek theory.

The two groups use laser-cooled ions that are confined by electric potentials to linear strings, known as Coulomb crystals. The individual positions of the ions can be accurately monitored through their fluorescence, revealing the crystal configuration. Increasing the confinement strength forces the ion string to undergo a structural phase transition to a zig-zag. During this transition defects appear in the form of kinks in the zig-zag. The rate at which kinks are created depends on the quench of the confining potential, and follows the power law predicted by the Kibble–Zurek mechanism. *IG*

Comeback comets

Mon. Not. R. Astron. Soc. http://doi.org/ngv (2013)

Comets are chunks of rock and ice that, when sublimated by the Sun's radiation, form a distinctive tail of dust and gas. Some have hyberbolic orbits that bring the comet into the Solar System before being sling-shot back into deep space. Other comets originate in the Kuiper belt beyond Neptune and have short-period orbits — the most famous of these is Halley's comet. A small population of active comets is also mixed in with the main asteroid belt between Mars and Jupiter. A solution to their mysterious origin is proposed by Ignatio Ferrín and collaborators.

Certain comets are classed as 'extinct', having sublimated all of their ice content, or 'dormant' when any remaining ice is buried deep within. The authors argue that millions of years ago there were thousands of active comets, which eventually lost their surface ice and fell dormant. Should a comet's position become perturbed by planetary influences, however, any change that would bring the comet closer to the Sun could cause thermal waves to reach the ice and therefore 'rejuvenate' the comet. *MC*

Ice baby

Phys. Rev. D **88,** 013013 (2013)

Buried deep in Antarctica is the neutrino observatory known as IceCube: more than 5,000 basketball-size 'digital optical modules' (DOMs) threaded through a cubic kilometre of ice. IceCube collects signals created in the ice by high-energy neutrinos from astrophysical sources — and has recently reported the detection of a couple of neutrinos at PeV energies, the highest energies observed so far.

But plans are afoot to equip IceCube for detection of atmospheric neutrinos at much lower energies, by upping the density of DOMs in just a small sub-volume of the existing detector. The first stage would be 'DeepCore', which could be followed by a second stage called 'Precision IceCube Next Generation Upgrade' — PINGU.

And, Walter Winter proposes, PINGU could provide data to determine the neutrino mass hierarchy: although neutrinos are known to have mass and the differences between their squared mass values are also measured, the order of the mass eigenstates is still a mystery. The operation of PINGU over three years could, reckons Winter, establish the hierarchy at least at the 90% confidence level or even up to as much as four-sigma. *AW*

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