Till death do us part

Mon. Not. R. Astron. Soc. doi:10.1111/j.1365-2966.2010.17469.x (2010)

The pairing of brown dwarf ULAS 1459+0857 and white dwarf LSPM 1459+0851 stretches the concept of a long-distance relationship to cosmic scales: the two stars are separated by a distance of 2.5 trillion metres, or a quarter of a light-year. Unsurprisingly, sightings of widely separated dwarf binary stars are rare, as the brown dwarf companions tend to be cool and therefore faint. Brown dwarfs are thus difficult to characterize in terms of age, mass and composition.

Avril Day-Jones and co-workers were looking for such cool stars when they found this first binary system involving a 'class T' brown dwarf, also known as a methane star. Thanks to the brighter white-dwarf companion, the authors are able to estimate the age of the T dwarf to be more than 4.8 Gyrs, from which they can gauge its temperature to be 1,200–1,500 K and its mass to be 0.06–0.072 solar mass units.

Slowly the stars will drift further apart as they both lose mass and fade away. By the time our Sun becomes a white dwarf, the T dwarf will have cooled to room temperature.

Mechanical transparency

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Tiny mechanical resonators can act as all-optical switches — with one beam of light controlling the propagation of a second — as is now shown by Stefan Weis and colleagues.

Electromagnetically induced transparency (EIT) is an effect in which destructive interference between two possible excitation paths effectively turns off a particular absorption process. It can be seen in atomic systems that have three appropriate energy levels. An intense 'control' laser beam is used to strongly couple two of the levels such that, over a narrow band of frequencies at least, 'probe' light that is resonant with the other allowed transition passes through without attenuation.

Weis *et al.* show the same type of effect in a toroid-shaped microresonator rather than an atomic vapour. Light is trapped in an optical mode that runs the circumference of the structure, travelling round and round the edge. In analogy to EIT, the radiation pressure from a control laser couples this optical mode to the next, and thereby enables the transmission of light at a wavelength that would otherwise become trapped.

Spectroscopy at the edge

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As electronic devices get smaller, the electronic structure at a material's edge becomes ever more important. This is particularly so for graphene, whose edge states are expected to be useful in their own right. Kazu Suenaga and Masanori Koshino report a technique that enables them to determine the electronic structure at the edge of a sheet of graphene, atom by atom.

Using the beam of a scanning transmission electron microscope, the authors collect electron energy-loss spectra from individual regions of a graphene sheet only 0.1 nm in diameter. They observe pronounced differences between spectra collected from a region within about 1.5 nm of the edge and those further into the sheet.

And in spectra obtained at the very edge, they observe the emergence of two unexpected peaks. They tentatively attribute these to individual carbon atoms attached by a single atomic bond, in a structure known as a Klein edge.

Get real

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It's a dilemma — cooperate with a neighbour, or defect? Which course gives the better return? This common problem in game theory, known as the prisoner's dilemma, has formed the basis of many simulations of behaviour, including those for which a spatial dimension is added, with the 'players' distributed on a grid pattern.

But for Jelena Grujić and colleagues, the players are real. In their experiments, 169 volunteers, arranged as a 13 × 13 grid, played multiple rounds of the prisoner's dilemma game, each player interacting (virtually) with eight nearest neighbours. The first study of this size on real participants, it throws up some interesting features, particularly that behaviour turns out to be much more 'contextual' than has been seen in simulations — that is, many players were influenced by how much cooperation they observed, or by how they themselves behaved, in a previous round. At the same time, another significant fraction of the players created 'heterogeneity' in the system, by sticking round after round to the same strategy, be it defecting or cooperating.

Existing models do not describe well the results of this human study — results that should, say the authors, be a reference for more accurate modelling to come.

It's a wrap

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When a long piece of fabric is to be fitted around a narrow circumference, it's useful to fold the fabric over on itself, creating pleats, such as are seen in skirts or kilts. William Irvine and colleagues demonstrate that a similar concept helps two-dimensional crystals to cover curved surfaces.

Irvine *et al.* built a system in which micrometre-size particles that repel one another are bound to an oil–glycerol interface. In this set-up, both positive and negative curvatures can be created — the crystals were arranged either on droplets, or on capillary bridges where the circumference is narrower mid-way than at top and bottom (and the curvature therefore negative).

A flat interface can be covered perfectly by a crystal made of hexagons. But that configuration doesn't work for curved surfaces, on which the particles also form pentagons and heptagons. But such crystalline order comes with imperfections, such as 'scars'. Irvine *et al.* observe those known defects, but they also see the formation of pleat-like dislocations. These features are shown to allow a finer adjustment to curved surfaces than would be possible without them.