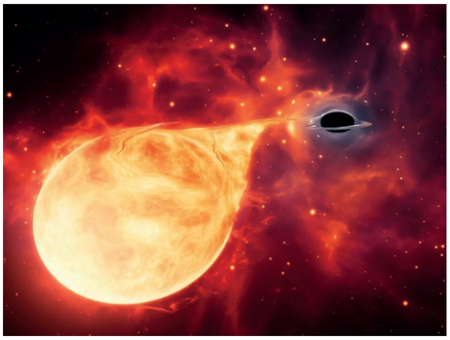
research highlights

BLACK HOLES

Death star

Nat. Astron. **1,** 0002 (2016)



ESO, ESA/HUBBLE, M. KORNMESSER

In June 2015 the All-Sky Automated Survey for Supernovae spotted a very bright flare: more than twice as bright as any known supernova. It was thought to be a superluminous supernova explosion, but after ten months of subsequent observations, Giorgos Leloudas and colleagues have suggested it is actually something else: a star torn apart by the tidal forces of a supermassive black hole (illustrated).

Leloudas *et al.* gathered evidence from various sources. Putting together data from the Hubble Space Telescope, the Swift Gamma-Ray Burst Mission and ground-based telescopes they concluded that the more likely scenario to explain the observations is a tidal disruption event: when a star comes up too close to the event horizon, the tidal forces due to the huge gravitational pull tear the star apart before it is swallowed by the black hole. The carnage is followed by a large energy release through a luminous flare. In the observed event, the particularly bright display is likely due to the very large mass of the black hole (over 10^8 solar masses) and its rapid spin. *IG*

PHILOSOPHY OF SCIENCE

Toy story

Stud. Hist. Phil. Mod. Phys. http://doi.org/bvzm (2016)

When Duncan Haldane published, in 1988, the model that would eventually win him a share of the 2016 Nobel Prize in Physics, it was clear to him that the model was "unlikely to be directly physically realizable" (even though it was implemented in experiment a quarter of a century later). Models that, unlike idealizations or approximations, do not directly represent physical systems often prove influential — the topological Haldane model is but a case in point. For all that, though, 'toy models' have so far received little attention from philosophers of science, argues Joshua Luczak, who sets out to change that.

Luczak defines toy models, roughly, as models that do not perform a representational function. Instead, they fulfil other functions, such as elucidating aspects of a theory, testing consistency between concepts and, not least, acting as 'hypothesis-generating tools'. Idealizations or approximations might do that as well, but always in relation to a target system they represent. Toy models, in contrast, lead to insights through arguments from analogy. These distinctly different routes to employing models might hold important lessons about how we are making discoveries. *AHT*

BISMUTH

Not a trivial matter

Phys. Rev. Lett. **117,** 236402 (2016)
Science http://doi.org/bvbj (2016)

Bismuth has been a central element in designing materials with topologically protected electronic states, largely due to its strong spin–orbit coupling. Despite this, the electronic topology of pure bismuth itself has remained somewhat controversial. This is partly due to its very small band-gap, which, along with some other features, makes it quite difficult to conclusively determine the topological nature of the electronic states.

By probing thin films of different thicknesses, exploiting quantum confinement effects to distinguish the surface and bulk electronic structures, Suguru Ito and co-workers believe that they have unambiguously proved that pure bismuth is topologically nontrivial. But just as one mystery of bismuth was being solved, a second emerged.

Due to a combination of factors, such as the low carrier density, pure crystals of bismuth were not expected to exhibit a superconducting state under ambient pressure. But experiments by Om Prakash and colleagues provide evidence that they can indeed become superconducting when cooled to low enough temperatures. As the adiabatic approximation of conventional Bardeen–Cooper–Schrieffer theory does not hold true for bismuth, the physics of this material seems to be far from trivial. *LF*

PHASE TRANSITIONS

Frozen in a tube

Nat. Nanotech. http://doi.org/bvpt (2016)

The phase diagram of water never ceases to amaze — and drive research forward. One of the many questions regarding water's behaviour is what happens when it's confined. With the advent of carbon nanotubes, which can be filled with water molecules, cylindrical nanoscale confinement can now be experimentally investigated.

Kumar Agrawal and colleagues looked at how the size of a nanotube affects the phase behaviour of encapsulated water molecules. They filled centimetre-long tubes of different diameters, ranging from 1.05 to 1.52 nm, with water and recorded Raman spectra. Specifically, they looked at the frequency of the so-called radial breathing mode (RBM): the vibrational mode of a tube where its diameter oscillates around the equilibrium value. When varying the temperature of their water-in-tube systems, the authors observed shifts of the RBM frequencies, which can be explained as liquid–solid transitions. The smallest tubes displayed melting around 105–151 °C, whereas the transition temperature for the largest tube was around 0 °C. *BV*

BIOPHYSICS

Pole dancing

eLife http://doi.org/bvpz (2016)

Ever wondered how to find your centre? Bacteria do it by exploiting the dynamics of Min proteins, which oscillate from pole to pole until the midplane of the cells' cylindrical geometry becomes clear. For *E. coli* and many other single-celled organisms, it's a question of utmost importance: they can't divide symmetrically unless they find their centre. And now, Yaron Caspi and Cees Dekker have undertaken the first *in vitro* study to fully confine the bacterial Min protein system in three-dimensional microfluidic chambers, revealing a rich dynamics that is sensitively dependent on confinement.

Previous studies showed that Min proteins can form rotating spirals and travelling waves instead of the characteristic oscillations when studied *in vitro*. But theoretical models have had a hard time capturing *in vitro* and *in vivo* results simultaneously. Caspi and Dekker's experiments enabled them to construct a phase diagram indicating that spirals give way to pole-to-pole oscillations when confinement is tightened — and to travelling waves when it's relaxed. The study raises the possibility that *in vitro* and *in vivo* dynamics arise from fundamentally different symmetry-breaking mechanisms, rather than simply different geometries. *AK*

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