THEORETICAL PHYSICS

Bounded diffusion

Phys. Rev. Lett. (in the press); preprint at http://arxiv.org/abs/1706.00019

In relativistic systems, information propagation is bounded by the speed of light, giving rise to the light-cone structure in Minkowski spacetime. A similar constraint exists in non-relativistic local quantum spin systems, known as the Lieb–Robinson bound. This provides a maximum propagation speed of entanglement and correlation, in turn leading to an effective spacetime light-cone. Now Thomas Hartman and colleagues have shown that consistency of diffusive transport with this light-cone places an upper bound on diffusivity.

Relating three independent quantities — diffusivity, equilibration timescale and light-cone velocity — this upper bound is found to hold in a variety of physical systems in both regimes of strong and weak coupling. The result has wide implications, including a generalization of the Drude formula giving the lower bound of electrical resistivity in the absence of long-lived quasiparticles, and a relation between hydrodynamic and leading non-hydrodynamic modes in black holes. It will also motivate more systematic studies — for example, using ultracold quantum gases and unconventional metals, for simultaneous determination of the three quantities involved in setting the bound. *YL*

NUCLEAR MAGNETIC RESONANCE

From strength to strength

J. Magn. Reson. http://doi.org/cc98 (2017)

The scientific history of nuclear magnetic resonance (NMR) has, in good part, been shaped by the ability to produce ever-stronger and yet exquisitely homogeneous magnetic fields. Higher fields typically mean improved sensitivity and resolution, but they also facilitate the emergence of new physical phenomena. Zhehong Gan and colleagues now describe a magnet design that enabled them to perform high-resolution NMR at 35.2 tesla — a field 50% stronger than that state-of-the-art equipment can produce in comparable quality.

Modern NMR systems are based on superconducting magnets, but at high field strength the materials involved have low current densities, limiting the achievable fields to around 23.5 T. Alternatively, resistive NMR magnets producing fields of up to 41 T are available, but their fields are usually too unstable for high-resolution NMR.

Gan *et al.*, working at the National High Magnetic Field Laboratory in Florida, have now constructed a hybrid device in which resistive and superconducting coils are connected in series. With their novel design they produced fields exceeding 35 T with a stability within 0.2 ppm — enough to acquire high-resolution spectra of solid and dissolved samples. *AHT*

SUPERMASSIVE BLACK HOLES

Enshrouded in dust

Nature **549,** 488–491 (2017)

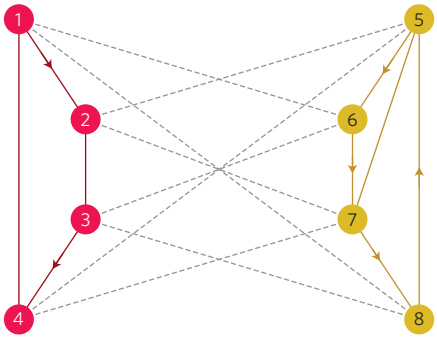
Shy monsters lurk at the centres of galaxies. Such accreting supermassive black holes, or active galactic nuclei, lie concealed behind thick curtains of gas and dust. But the origin and exact location of these obscuring shrouds has long been debated, and different physical mechanisms leading to their formation have been proposed. Using a multi-wavelength survey of over eight hundred accreting supermassive black holes, Claudio Ricci and colleagues uncovered the role of radiation pressure as the main driving force responsible for shaping the density and distribution of dust and gas haze.

From the observational data, Ricci *et al.* could estimate the gas and dust densities and the black hole X-ray luminosities. These suggest a relation between the degree of obscuration and the black hole accretion rates. Ricci and co-workers also found that the bulk of gas and dust material lies a few to tens of parsecs from the black hole, where its gravitational potential is stronger than the galactic one. This explains how sometimes black holes can shed their shroud to peek out, unobscured. *IG*

QUANTUM PHYSICS

Going random

Phys. Rev. A **96,** 032305 (2017)



APS

Most of us are familiar with the concept of a random walk — a classic example is provided by a pollen particle suspended in water. But what if we replace the pollen with a quantum system, to produce a so-called quantum walk? Interference effects between the possible trajectories of the walker substantially modify the resulting dynamics — for example, that's what makes quantum searches so efficient.

Running a random walk over a graph (pictured) allows some of the graph's geometrical features to be probed. And it's conjectured that a quantum walker could do this even better. Unfortunately, there is a caveat: quantum systems need to satisfy unitarity, and this means that quantum walks have been limited to undirected (symmetric) graphs.

Now, Josh Izaac *et al.* show that this needn't be the case: by taking advantage of parity–time (PT)-symmetry, which emerges in non-Hermitian systems with gain and loss, they have demonstrated that the more general class of PT-symmetric quantum walks generates viable dynamics on directed graphs, and can be used to calculate network centrality performing as well as PageRank, the algorithm behind many of today's search engines. *FL*

MULTIFERROICS

In rare form

Phys. Rev. B **96,** 104104 (2017)

Multiferroic materials that exhibit both ferromagnetism and ferroelectricity and are coupled through magnetoelectric effects offer the tantalizing prospect of enabling electric field control of magnetism. Such materials have enormous technological potential but, unfortunately, there are relatively few of them — the most well-known of which is bismuth ferrite. Elzbieta Gradauskaite and colleagues now add a new material into the mix, showing that lead palladium titanate exhibits room-temperature magnetoelectric multiferroicity.

In the search for a new multiferroic, Gradauskaite *et al.* shifted away from iron-based systems, and turned their attention to palladium. Palladium is a fairly rare element, and is not usually associated with ferromagnetism, but ferromagnetism can be induced under certain conditions. By substituting palladium into the ferroelectric perovskite oxide lead titanate, at both the lead and titanium sites, the authors show that the material exhibits magnetoelectric multiferroicity all the way up to 400 K, despite the system containing some small quantities of other minor phases. Once optimized, they expect this material to exhibit even stronger piezoelectric properties than bismuth ferrite. *LF*

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