15 years of *Nature Physics*

Over the last 15 years, the content of *Nature Physics* has covered an enormous breadth of subjects at the forefront of physics. The journal's past and present editors recount their favourite papers and what made chaperoning them to publication special.

PHYSICS AND SOCIETY

A few of my favourite things

My favourite paper published in the fifteen-year history of *Nature Physics*? I couldn't possibly single out just one. But I can note a 'favourite thing' about *Nature Physics*: the exceptional collection of magazine material that has appeared alongside those research papers.

I had the privilege to be the first Chief Editor of *Nature Physics* for its launch in 2005, and I wanted the journal to follow the example of *Nature*, in carrying not only the latest and best research in the field, but also to feature comment, opinion and review on all matters physics. And that meant 'all matters', including the role of physics in history and in the arts.

In the October 2007 issue, on the fiftieth anniversary of the launch of the first artificial satellite, Joe Burns gave a remarkable personal account of the space race in 'Sputnik, space and me'[1]: from his teenage experience of hearing the satellite beep across the sky, Burns traced the line through the subsequent political and technological developments, which, he said, "altered the course of physics".

Also drawing on a moment of history, the second issue in 2005 offered an 'Appointment at Trinity'[2], a review by Jay and Naomi Pasachoff of the John Adams opera *Doctor Atomic*. Art reviews are an opportunity for rumination, and over the years we've pondered more opera (for example, *Einstein on the beach*[3], *Dr Dee*[4]), and also theatre (*The Life of Galileo*[5], *The Physicists*[6]), dance ($E=mc^2$, ref. [7]; *Tree of codes*[8]), film, books and the visual arts.

Back in 2009, we marked another anniversary: 50 years since C. P. Snow's famous essay, *The two cultures*. In 'Never the twain'[9], our regular Thesis writer Mark Buchanan revisited Snow's contention that "a yawning gulf separates the two cultures of science and the humanities, making communication between the two all but impossible". Mark's own conclusion was more positive: "These differences are so set in the subject matter of the two cultures — one exploring everything human, and the other aiming for what is outside the merely human — that it is difficult to imagine the two cultures ever coming together. Even so, scientists remain human, and artists live in a world described by laws of inspiring beauty. There will always be innumerable points of contact."

My hope is that *Nature Physics* has been, and will remain, one of those vital points of contact.

Alison Wright was Chief Editor of Nature Physics *from 2005 to 2014.*

GRAPHENE

One plus one equals 2π

Science is about challenging our assumptions. And often in a science editor's life, we are challenged to reassess our assumptions not only about the natural world but about how the whole editorial process works. For instance, we say that for a paper to make the grade at a journal like *Nature Physics*, it must be novel — which is usually assumed to mean it must report new results that lead us to new insights about the world. But what about old results that lead us to new insight?

15 years ago, I got a distressed phone call from Andre Geim that posed this exact question. He had only just published his seminal *Nature* paper demonstrating that the charge carriers in single layers of graphene possess a Berry phase of π. The idea of Berry phase is now commonplace but at the time it was mindboggling and arcane. He had expected that bilayer graphene would either exhibit a half-integer quantum Hall effect — which would make it like a single layer of graphene — or an integer quantum Hall effect — which would make it boring. At first glance, it looked like the latter, so he included the bilayer results in an inset of his *Nature* paper for comparison.

What Geim hadn't noticed was that the conductance plateau that should have been at a transverse Hall conductance of zero just wasn't there. This suggested a Berry phase of 2π, which was entirely unexpected! But he had already published the results — in *Nature* no less — minus the insight. So, he wanted to know from me, "is new insight enough?" Of course, I said yes. And it turned out to be one of the most influential papers[10] *Nature Physics* ever published.

Ed Gerstner was an editor at Nature Physics *from 2005 to 2012.*

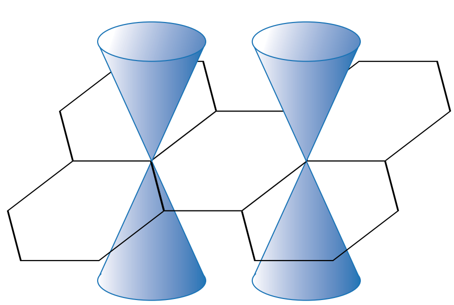


Figure reproduced with permission from ref. [33], Springer Nature Ltd.

QUANTUM SIMULATION

Light but strong

As a young condensed matter theorist studying coupled light–matter systems in the late 2000s, it was difficult not to be jealous of my colleagues working on ultracold atoms. The achievements of the previous decade had established dilute quantum gases as a platform for analogue simulation of quantum many-body physics. For instance, several experimental groups had already realized the Mott insulator phase of the Bose–Hubbard model: when atoms move on a lattice, sufficiently strong repulsive interactions can suppress their motion. The frozen atoms form a strongly correlated state with a fixed integer number of particles on each site.

In 2006, Andrew Greentree and co-workers showed that a similar phase could be created from photons[11]. Starting from a model of fixed two-level systems coupled to photons freely moving in a two-dimensional lattice, they showed that light could also form a Mott insulator state like the one in the established Bose–Hubbard model. But there are also important differences arising from the composite light–matter nature of the excitations, which are richer than simple bosons. In principle, the model can be experimentally realized in a number of ways, for instance, using arrays of superconducting devices or ultracold atoms in coupled cavities. Greentree and co-workers' predicted phase diagram gave a colourful

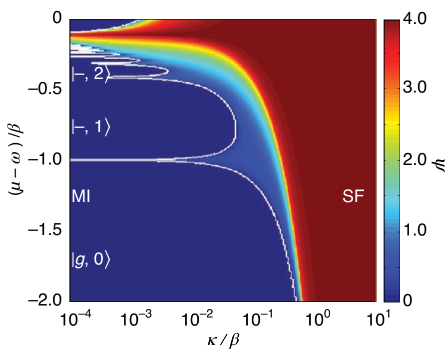


Figure reproduced with permission from ref. [11], Springer Nature Ltd.

visualization of what might be possible in light–matter systems.

In practice, actual photons are less forgiving than theoretical ones and an experimental realization has been difficult. Creating sufficiently strong photon nonlinearities at large scales while coping with the effects of continuous dissipation is a significant engineering challenge. But strongly interacting photons have come a long way and in the last few years several different correlated states have been successfully created. Another 15 years down the line we may be looking back at many more dazzling achievements.

Richard Brierley has been an editor at Nature Physics *since 2020.*

QUANTUM INFORMATION
Greater than the sum of its parts

The role of an editor is often that of a midwife. Every now and then, though, you see a paper through to publication that fills you with almost parental pride. For me, one of those is Matthew Hastings's counter-example to the additivity conjecture in quantum information theory[12].

The additivity conjecture relates to the question of whether classical information can be sent more reliably through a communication channel when the input states are entangled. The conjecture says no. Disappointing as that may be, it also conveniently opens the door to explicitly calculating the capacity of a quantum channel, one of its most basic specifications. The conjecture had long been assumed to be true, but there has been no proof.

Along came Hastings. In an intriguingly effective way, he showed that the conjecture must be false — by constructing a random counter example. That brought down four additivity conjectures, whose equivalence Peter Shor had shown earlier, now only widening the ramifications of Hastings's work. So, entanglement can increase channel capacity, at least in principle. At the same time, the prospect of finding a simple expression for the information capacity of a quantum channel faded.

Shor, writing in the accompanying News & Views piece[13], praised the work as giving "a resolution to what is considered the most important question in quantum information theory today" — and that in a single-author paper of fewer than two and a half pages. The joy of seeing this work in *Nature Physics* was all the greater as in the formative years of the journal, we worked hard to attract papers from the boundary between quantum physics and computer science. And even now, years after checking out from the editorial team, I find myself occasionally checking up on the 'Hastings paper' and other favourites of mine — trusting that they are doing just fine.

Andreas Trabesinger was an editor at Nature Physics *from 2005 to 2012.*

ANTIMATTER
Wright place at the right time

On 14 April 2011, we received a manuscript from the ALPHA collaboration at CERN. They were able to trap 309 antihydrogen atoms for up to 1000 s (ref. [14]). Normally, our then-particle-physicist and Chief Editor, Alison Wright, would have handled the paper. But she had an extended trip booked over Easter, so I wound up handling my first particle physics paper. Although I wasn't a fan of the film *Angels & Demons* — which featured a canister of antimatter as a bomb — the paper sounded interesting to me. Time to sift fact from fiction.

Back in 2010, the ALPHA collaboration had confined 38 antihydrogen atoms for 172 ms. That was already a technical feat. Because matter and antimatter annihilate on contact, the antiparticles are magnetically trapped. To reach the lifetimes reported in the new paper, the collaboration employed an auto-resonance technique to very gently force the pre-cooled antiprotons through a positron plasma, yielding cooler and more trappable antihydrogen atoms. With these extended lifetimes, some antimatter particles would be able to reach the atomic ground state — a requirement for precision tests of charge–parity–time reversal symmetry. Within the Standard Model, the physical laws remain the same under an inversion of charge (matter to antimatter), parity (reflection of all objects by an imaginary plane) and time (reversal of momenta). The paper sailed through peer review and we put it on the cover, looking not unlike the canister featured in the film.

Since then, the ALPHA collaboration has started testing antihydrogen particles in freefall to directly probe the gravitational effects on antimatter. More recently, they have examined the quantum effects of antihydrogen. In high precision measurements of the energy gap between the 1*s* ground state and the $2p_{1/2}$ and $2p_{3/2}$ excited states of antihydrogen, the ALPHA collaboration were able to measure the fine-structure splitting of the $2p_{1/2}$ and $2p_{3/2}$ states from quantum effects. Their measurement falls within 2% of predictions from quantum electrodynamics. So far so good for the Standard Model.

May Chiao was an editor at Nature Physics *from 2005 to 2016.*

QUANTUM PHYSICS
An elegant result

On my first day in the job as editor of *Nature Physics*, two printed-out manuscripts were waiting on my otherwise pristine desk. One was a very thick pile of paper, because it came with a bit of history and correspondence. As if that was not enough to intimidate (and excite) the new starter, the topic of the manuscript was no light matter: it tackled the reality of the quantum state. Reading the manuscript, I had second thoughts about my new editorial career.

The manuscript[15] — known as the PBR theorem, from the initials of the three authors — is now a well-established result (and the only article I ever handled that has its own Wikipedia page). The PBR paper showed that considering the wavefunction purely as the information about a quantum system (epistemic view) leads to a fundamental contradiction with quantum theory. Therefore, the quantum state must be more than the knowledge one has about the system, it must be a representation of reality. The elegant simplicity of the result made me hope that it would help clear up the murky waters of various interpretations of quantum mechanics.

Back in 2012, when the paper was published, the PBR result received media attention and was hotly debated in the quantum community. This prompted Scott Aaronson to comment[16] that the theorem was "interesting and possibly important — although your take on its importance may depend on whether the ideas ruled out by the theorem ever appealed to you in the first place". Eight years on, it seems that the PBR theorem has deepened the investigation of some directions of research in the foundations of quantum mechanics. Contrary to my expectations, epistemic interpretations are not entirely extinct. But, interestingly and unexpectedly, it turns out that the PBR theorem is related to the complexity of certain quantum communication tasks.

The job of an editor has its rewards; the one I cherish most is being surprised by the directions that articles you published lead to — or don't.

Iulia Georgescu was an editor at Nature Physics *from 2012 to 2017.*

FLUIDS
An inspirational bounce

The ultimate reason why a paper is published in *Nature Physics* is that, in some way, it inspires. At least, that's the idealistic opinion of this former editor of the journal. In reality, of course, the inspirational power of the journal's papers varies.

When the manuscript 'Pancake bouncing on superhydrophobic surfaces' by Yahua Liu and colleagues[17] landed on my desk in March 2014, the initial editorial decision was straightforward: here was a novel phenomenon, 'nice' underlying physics and application potential. In other words, a perfect fit for *Nature Physics*.

The paper dealt with drop impact: how liquid droplets bounce back (or not) after impinging on a solid surface. The practical motivation for this kind of research traditionally comes from potential applications like printing or spray coating. Liu and colleagues reported that an originally spherical droplet of water can be made to bounce off a surface in a flat, disc-like form — 'pancake bouncing' is what the authors called it. The trick lies in the surface: an array of conical micropillars coated with a superhydrophobic layer. When the dimensions and the geometry of the pillars are just right, the capillary force is such that the impacted droplet lifts off exactly when it has attained a pancake shape. The associated fourfold reduction in contact time is promising for eventual applications.

The manuscript sailed smoothly through the review process, was quickly accepted and published, accompanied by a News & Views[18], in June 2014. End of story? Not exactly — enter inspiration.

Months later, I was contacted by Tina Hecksher, a physics professor at Roskilde University, Denmark, asking for permission to show the paper in a video. It turned out that Hecksher and some of her students had tried to reproduce pancake bouncing on the macroscale[19]. The droplet was replaced by a water-filled balloon and the pillar surface by a bed of nails. A gracefully executed pancake bounce ensued. The publication of these findings led to more publicity. Several international newspapers picked up the story, and Hecksher and one of her students appeared on Danish national TV to demonstrate and talk about the pancake bounce.

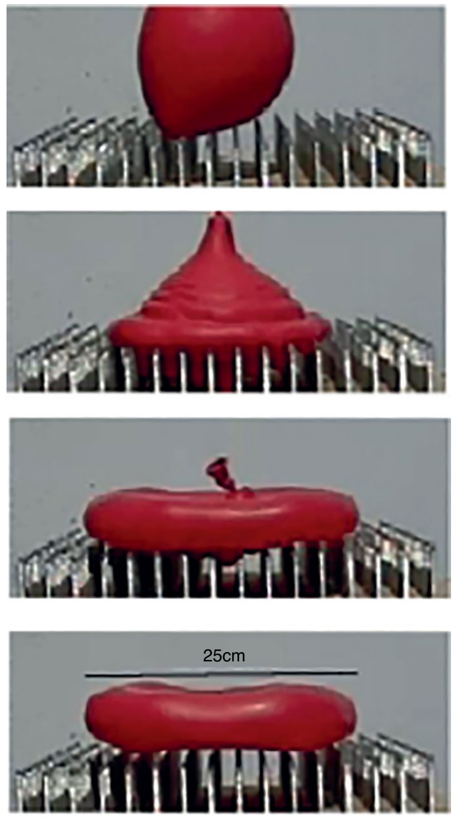


Figure © European Physical Society, reproduced with permission from ref. [19], IOP Publishing. All rights reserved.

Beautiful physics, inspiring papers — at *Nature Physics*, that's as good as it gets.

Bart Verberck was an editor at Nature Physics *from 2013 to 2017.*

VALLEYTRONICS
On the double

Transition metal dichalcogenides are a class of material that can be thinned down to just one monolayer. Like graphene, which is a single layer of carbon atoms, they have a honeycomb structure and, in addition to the electron spin, their carriers possess a valley degree of freedom, related to valley-like features in the electronic structure, which have an associated magnetic moment.

In 2014, I handled two papers at *Nature Physics* — one by Grant Aivazian and colleagues[20] and one by Ajit Srivastava and colleagues[21] — both showing that magnetic fields could break the degeneracy for states with different valley indices in the transition metal dichalcogenide tungsten diselenide — a valley Zeeman splitting. Having worked in magnetism as a researcher, I was excited about the possibilities that this new type of Zeeman splitting could provide.

The enthusiasm for these papers was somewhat overcast by a discrepancy in the results of the two groups: the values of valley splitting differed by a factor of two, and I hoped that this could be explained during the peer review process. The two independent groups made use of an attractive property of transition metal dichalcogenide monolayers: their valleys can be selectively addressed using circularly polarized light, due to a combination of strong spin–orbit coupling and inversion symmetry breaking. Based on this material feature, the reviewers agreed that both works showed that magnetic fields lifted the degeneracy between valleys, reversing sign when the polarity of the magnetic field was flipped, even though the numbers didn't match.

We published the two papers back-to-back, alongside a News & Views piece[22] written by Bernhard Urbaszek and Xavier Marie, which discussed the possible reasons for the discrepancy. Since publication, dozens (if not hundreds) of studies have made use of this valley Zeeman effect. As transition metal dichalcogenides march towards commercial applications, it's only a matter of time before their valley degree of freedom comes to the fore.

Luke Fleet was an editor at Nature Physics *from 2014 to 2017.*

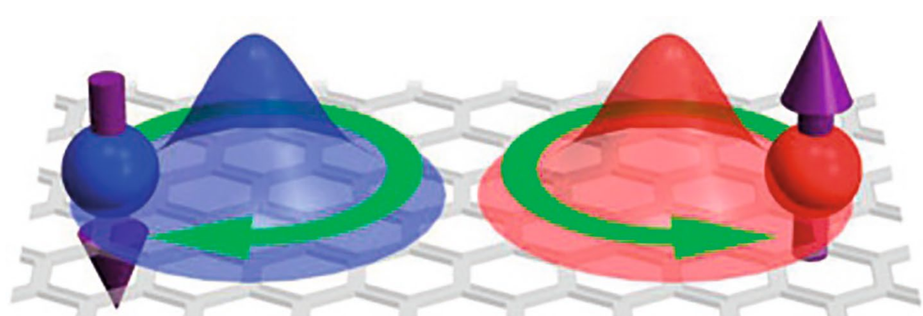


Figure reproduced with permission from ref. [20], Springer Nature Ltd.

BIOPHYSICS

Mind mechanics

There's no denying it: brains are cool. Quite apart from their computational heft, there are few shapes as iconic in the life sciences. And although it may seem a stretch to suppose that physical forces could explain so complicated a form, the prevailing theory for many years posited just that — albeit without any proof. It took some crafty 3D printing and a simple but elegant experiment to show that mechanics could indeed weigh in on the beauty of the brain.

In humans, the brain is a smooth little lump until about halfway through gestation, when it begins to mature into the wrinkled structure we know and love. By the time we hit adulthood, our brains are 20 times the size they were in week 22 of gestation, and the wrinkling has claimed a whopping 30-fold increase in surface area, minimizing the distance between a vast quantity of neurons. An idea put forward in the 1970s suggested that this process might involve a simple mechanical buckling arising from the fact that cortical layers grow at different rates. For want of some solid experimental proof, though, alternative theories abounded, claiming key roles for biochemical and genetic control.

Enter Tuomas Tallinen and co-workers, who devised an innovative way of testing the buckling proposal[23] The team took an MRI of a smooth fetal brain, 3D printed it as a layered gel, and immersed it in solvent to mimic its growth. The outer layer was designed to swell more than its underlying counterpart, effectively placing it under mechanical compression, and this difference proved enough to induce wrinkling. The result was remarkably close to MRI scans of adult brains — a soft-matter simulacrum with no living components had succeeded in reproducing the complicated morphogenesis of a human organ.

Abigail Klopper has been an editor at Nature Physics *since 2011.*

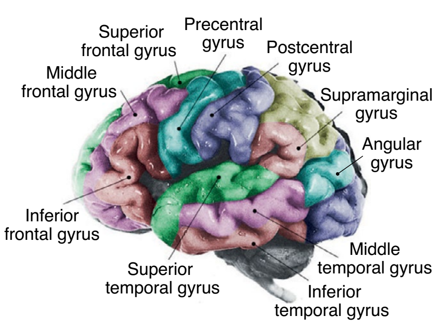


Figure reproduced with permission from ref. [23], Springer Nature Ltd.

QUANTUM MATERIALS

Let's take a look inside

A vivid memory I have from my post-doc days was an e-mail I was sent by a colleague. It was about a project *Nature* had just done on the historical milestones in spin — the intrinsic quantum mechanical property of many particles, not the nefarious art of portraying an event or situation in a heavily biased way. The fact that *Nature* was interested in recounting the history of a topic I was interested in — as opposed to only publishing ludicrously prestigious papers I was unlikely to ever write myself — somehow made an impression on me: this struck me as something I wanted to do.

So when I did join Nature Publishing Group (as it was then known), first at *Nature Communications*, then at *Nature Materials* and finally, preposterously, as Chief Editor of *Nature Physics*, large-scale editorial projects such as Insights, Focus issues and Milestones became my editorial raison d'être. Where else could I do anything similar?

The project that really stands out for me is the Insight on quantum materials[24] that we commissioned together with *Nature Materials* in 2017. The term 'quantum materials' is now commonly used to identify the study of properties of systems that are uniquely defined by quantum mechanical effects that remain manifest at high temperatures and macroscopic length scales, but even after it started gaining currency from the mid-2010s onwards, there were plenty of cynics that viewed it merely as a cosmetic rebranding of condensed-matter physics.

The Insight explored the principal lines of enquiry in quantum materials: the physics they give rise to, their synthesis and design, the control over their properties, and the functionality that emerges from these properties. In turn, these effects can be driven and manipulated to provide novel functionalities and transformative technologies.

Perhaps it was lucky timing, and certainly the support of two fantastic partners that believed in the project from the very outset — the Simons Foundation and the Gordon & Betty Moore Foundation — also helped, but I like to think this Insight helped sway some of the sceptics. There is more to quantum materials than meets the eye.

Andrea Taroni has been Chief Editor of Nature Physics *since 2014.*

ATOMIC CLOCKS

Go take it on the mountain

Where do you draw the line between physics and engineering? This may sound like an artificial question but it's one that editors of a journal like *Nature Physics* have to ponder nonetheless — a source of endless conversations. During my tenure at the journal, I had to grapple with this issue in the context of quantum technologies, a field which is starting to see encouraging applied results after decades of fundamental research.

The submission by Jacopo Grotti and colleagues was precisely one of those cases. The manuscript reported a geodetic field measurement campaign with a portable atomic clock[25]. It represented the demonstration of a simple idea: general relativity makes it possible to measure altitude, provided one has an accurate enough clock.

The manuscript told a rather practical tale of scientists overcoming the many technical challenges of loading an atomic clock onto a trailer, carrying out frequency measurements in a mountain environment that is very different from a clean metrology lab (the team even had to put up with nearby explosions!) and then comparing against a reference at sea level with sufficient precision to resolve the difference in height. The result built on a collection of small improvements rather than on one specific technological leap.

With the exception of Einstein sceptics, nobody doubted that such a feat would be possible in principle. Indeed, at the time of the submission there had been some preliminary demonstrations of height measurement through atomic clock frequency shifts in a laboratory environment, as well as of portable atomic clock prototypes. So, was the first successful measurement campaign enough of a scientific advance to warrant publication in *Nature Physics*? The editorial office was divided on the matter, although it was certainly a nice story.

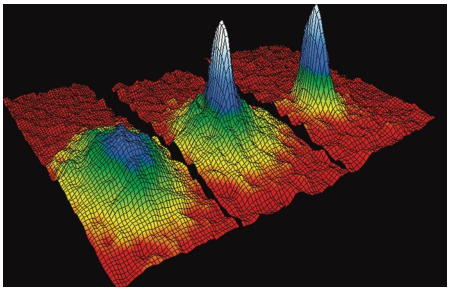
What ultimately tipped the balance was our resolve to represent physics not only when it stays neatly in the lab, but also when it is put to practical use. After all, measuring altitude with atomic clocks was a long-standing goal of this community, and it seemed appropriate to celebrate this achievement in our pages. In our job, decisions are rarely right or wrong in a broader sense, but this is one I would take again.

Federico Levi was an editor at Nature Physics *in 2014 and from 2017 to 2019.*

ATOMIC PHYSICS

A ghost-like quasiparticle

Among all quasiparticles, the roton is one of the most bizarre. It was introduced by Lev Landau to explain the superfluid behaviour observed in liquid helium at very low temperatures. The name 'roton'



Credit: Science History Images / Alamy Stock Photo.

suggests a relation with rotation, and indeed, Landau originally postulated it as an elementary excitation related to local vorticity. But for decades, this postulation remained just that, earning the roton its famous title — 'the ghost of a vanishing vortex ring'.

In the late twentieth century, an alternative view of the roton's origin emerged, which was inspired by neutron scattering measurements on the excitation spectrum of liquid helium. Unlike usual quasiparticles, the energy of the roton has a minimum at finite momentum, implying that a certain wavelength of the excitation is favourable. Based on this, it was suggested that the roton is actually a precursor to crystallization instability. If this is the case, then what is the new state of matter behind this instability? This is among the many open questions about liquid helium.

The study of another archetype of superfluidity — a Bose–Einstein condensate of a dilute atomic gas — recently shed some light on these problems. Compared with liquid helium, these quantum gases are weakly interacting and highly controllable, which makes them easy to handle, both theoretically and experimentally. The search had long been on for an excitation of a gaseous superfluid that could be understood as the analogue of the roton in liquid helium. Theory had indicated that nontrivial interactions, such as the dipole–dipole interaction between highly magnetic atoms, can provide the key ingredient.

A dipolar quantum gas was first created in 2012, and six years later, Lauriane Chomaz and colleagues eventually reported the observation of the roton excitation[26]. What I like about this paper is that it was more than just a successful detection of a long-sought quasiparticle: the results immediately stimulated the search for the new quantum state that can emerge from the crystallization instability. Just over a year later, the signatures of such a state in a dipolar quantum gas were reported by three independent groups.

Yun Li has been an editor at Nature Physics *since 2017.*

OPTICS

Topsy-turvy velocities

Most people are familiar with the change in pitch of a passing ambulance siren, and every physicist knows about the classical Doppler effect that explains this frequency shift that occurs when a wave source is moving relative to an observer. But the Doppler effect is not just one of the fundamental observations in physics, it has also found practical applications in science and technology.

Owing to the wave nature of light, it also applies to light sources that move relative to an observer. However, while they will have experienced the ambulance example, most people outside the physics community won't be aware that there are multiple versions of the optical Doppler effect, although similar radiation effects led to a Nobel Prize in 1958.

Expanding the current collection of optical Doppler effects in various media, Xihang Shi and co-workers have recently picked up the topic again, proposing the existence of a previously excluded 'superlight' Doppler effect; this time with inverted sign with respect to the conventional version[27]. In short, the twist in their theory is that the source's velocity is larger than the wave's phase velocity.

This ratio is experimentally accessible, which allows the manipulation of Doppler-induced frequency shifts. This may sound trivial but it's really not, and the theory still awaits experimental verification. But light propagation in various materials offers the perfect playground for the manipulation of wave properties, as an enormous range of refractive indices can be exploited and tuned. It is thus not surprising that Shi and co-workers proposed the effect for the propagation of plasmon–polaritons in graphene.

This study can then be viewed as the sort of fundamental research that is accessible for a wider audience paired with a contemporary and visionary angle that one expects from a *Nature Physics* paper.

Jan Philip Kraack was an editor at Nature Physics *in 2018.*

ARTIFICIAL SYSTEMS

Fractal electrons

Everybody has probably heard of graphene, where electrons live in a space that is effectively two-dimensional. They've also probably heard of carbon nanotubes, where the space is one-dimensional. But is it possible to make a material where electrons live in a space with non-integer dimensions?

This question was answered with an emphatic 'yes' by Sander Kempkes and colleagues, who managed to confine electrons to a third-generation Sierpiński triangle[28]. This is a fractal that, as the generation goes to infinity, has an effective dimension of roughly 1.58. They did this by placing carbon monoxide molecules on a copper surface, so that the molecules provide a potential that pushes electrons at the surface into the desired shape. The team then used a scanning tunnelling microscope to probe those electrons and showed that they had formed a self-similar pattern with an effective dimension that was, to within error bars, correct for that fractal.

One of the most interesting questions that this work might help to answer is about how electrons interact with each other. In one dimension, it is known that they form a Luttinger liquid and this phase of matter shows features such as spin-charge separation. Conversely, interactions in two dimensions generically give a Mott insulator phase, but can also form exotic phases, such as the fractional quantum Hall effect, when they are placed into a magnetic field. What is the crossover between these two physically very different regimes? We don't yet know, but this paper might give us a platform to investigate it.

I think this paper is an example of the wonderful freedom we sometimes have at *Nature Physics*, to publish something that is simply 'cool'. The idea is easy to understand, the implementation is technically challenging but also intuitive, and the possibilities that are opened by

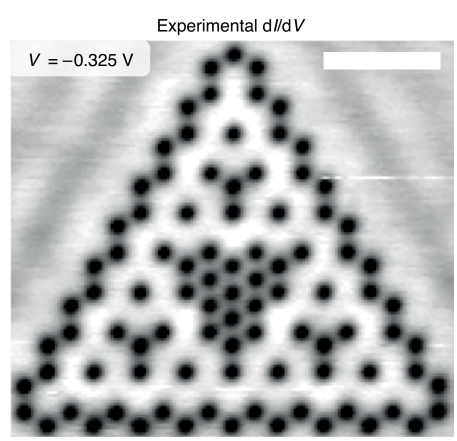


Figure reproduced with permission from ref. [28], Springer Nature Ltd.

having a fractional-dimensional material are intriguing.

David Abergel has been an editor at Nature Physics *since 2017.*

LABORATORY ASTROPHYSICS

Here comes the Sun

Although most matter in the Universe is in a plasma state, I had known little about the breadth of plasma physics. Since high school, the term plasma physics had been a synonym for nuclear fusion — a view that changed with the first papers I handled on plasma-based accelerators or on astrophysical plasmas when starting at *Nature Physics*. One of the most memorable papers in this area brings together solar and plasma physics — not with in situ observations but in the lab.

Owing to the Sun's rotation, its magnetic field lines are twisted and swept away by the solar wind — a plasma stream originating from the Sun's upper atmosphere — into an Archimedean spiral. Ethan Peterson and colleagues created this so-called Parker spiral in their lab[29]. Inside a spherical plasma confinement vessel — the Big Red Ball — they spun a helium plasma around a dipole magnet mimicking the Sun.

The fast solar wind is known to originate from colder regions of the corona, but how the slow solar wind plasma is transported from the closed coronal to the open magnetic field lines of the Parker spiral remains unclear. By recreating the slow component of the solar wind in their laboratory, Peterson and colleagues found that plasmoids were generated and — similar to what had previously been seen in satellite observations — ejected from the tips of helmet streamers, which are closed loop-like magnetic field-line structures.

Because the parameters of the Sun and its lab equivalent differ vastly, the degree to which the insights gained in a simplified setting like the Big Red Ball are applicable to the slow solar wind is limited. Peterson and colleagues' findings will have to be confirmed by NASA's Parker Solar Probe, which will provide unprecedentedly detailed measurements of the solar wind. This comparison will teach us more about the role fundamental research in the lab can play for space missions.

Stefanie Reichert has been an editor at Nature Physics *since 2018.*

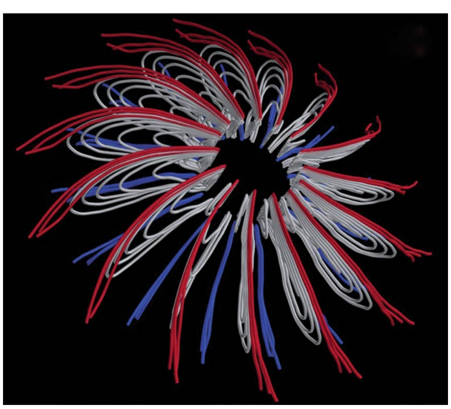


Figure reproduced with permission from ref. [29], Springer Nature Ltd.

LASER PHYSICS

All locked up

When optical physicists talk about laser specifications, the term 'mode-locking' is likely to make an appearance, at least if they are talking about pulsed lasers. It refers to the stable synchronization of different modes in a resonator via nonlinear interactions and is one of the processes that enable ultrashort laser pulses. It has been around for almost as long as lasers themselves, and most users spare it no thought. There are, in fact, different forms of mode-locking: the traditional one-dimensional version is temporal, but more recently a three-dimensional — spatiotemporal — version has been found in multi-mode fibres.

At first, the manuscript that described the theory behind this spatiotemporal mode-locking, which I found myself reading one day, may then not sound like a *Nature Physics* paper at all. After all, mode-locking is well-known and even spatiotemporal mode-locking had been experimentally realized. But what if the theory is the real challenge here?

When it comes to mode-locking, it is fair to say that its deceptively simple technical implementation obscures the complexity of the underlying physics. Laser physicists have a pretty good intuitive understanding of temporal mode-locking as the self-optimization of a complex system where different modes compete for optical gain, but they have only just started to explore its intricacies. The attractor dissection approach described by Logan Wright and colleagues[30], which extends this intuition to higher dimensions, is therefore most welcome.

A paper like this was sure to give many of our readers pause if we didn't provide a little more context. I therefore decided to commission a News & Views article, which, I have to say, surpassed my expectations. In explaining Wright and colleagues' paper, Ömer Ilday had written a useful primer on mode-locking theory for a general physicist[31].

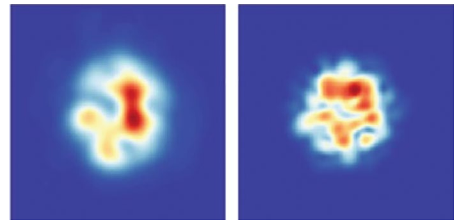


Figure reproduced with permission from ref. [30], Springer Nature Ltd.

It is papers like this that remind me of an important aspect of our job as editors at a *Nature Physics*: to represent a particular field of physics within the editorial team and to give a voice to this field within the pages of our journal.

Nina Meinzer has been an editor at Nature Physics *since 2019.*

SOFT MATTER

Particles assemble

In February 2019, I was walking through the gallery of posters at a Gordon Research Conference when my attention was caught by Serim Ilday's poster. I walked over and asked her to tell me about her research. She started showing me videos of her group's experiments and telling me the story of her work with infectious enthusiasm. As I watched particles suspended in a liquid film self-assemble under laser irradiation that was driving the system out of equilibrium, I was intrigued. I thanked her for the interesting presentation, scribbled down some key point for myself and made a mental note to look out for this article when it was published.

Figure reproduced with permission from ref. [32], Springer Nature Ltd.

A few months later, as I had just moved to *Nature Physics*, I was delighted to find Serim Ilday's submission[32] in my inbox of assigned papers. The dissipative self-assembly method described in the paper worked for particles ranging from tiny synthetic ones — such as 3-nm quantum dots — to large biological ones — such as 15-μm human cells. The growth curves of the clusters of these different types of particles all collapsed onto a single S-shaped curve. Not only did this self-assembly method work for a wide range of materials in out-of-equilibrium conditions, but it also led to a universal scaling behaviour of particle cluster growth.

The high level of control demonstrated by the self-assembly method promises applications such as separation of different bacterial cells from a homogeneously mixed population or creation of aggregates with complex shapes. From a fundamental perspective, it will be intriguing to see if this method will help to provide insight into the physics of far-from-equilibrium processes that occur in biological and active matter systems.

Elizaveta Dubrovina was an editor at Nature Physics *from 2019 to 2020.* ❐

Published online: 1 October 2020
https://doi.org/10.1038/s41567-020-01051-9

References

1. Burns, J. A. *Nat. Phys.* **3**, 664–668 (2007).
2. Pasachoff, J. M. & Pasachoff, N. *Nat. Phys.* **1**, 74–75 (2005).
3. Gnodtke, C. & Klopper, A. *Nat. Phys.* **8**, 440–441 (2012).
4. Wright, A. *Nat. Phys.* **8**, 578–579 (2012).
5. Webb, R. *Nat. Phys.* **2**, 498–499 (2006).
6. Wright, A. *Nat. Phys.* **8**, 508–509 (2012).
7. Wright, A. *Nat. Phys.* **5**, 857 (2009).
8. Dubrovina, E. & Persechini, L. *Nat. Phys.* **13**, 417 (2017).
9. Buchanan, M. *Nat. Phys.* **5**, 310 (2009).
10. Novoselov, K. S. et al. *Nat. Phys.* **2**, 177–180 (2006).
11. Greentree, A. D., Tahan, C., Cole, J. H. & Hollenberg, L. C. L. *Nat. Phys.* **2**, 856–861 (2006).
12. Hastings, M. B. *Nat. Phys.* **5**, 255–257 (2009).
13. Shor, P. W. *Nat. Phys.* **5**, 247–248 (2009).
14. Andresen, G. et al. *Nat. Phys.* **7**, 558–564 (2006).
15. Pusey, M. F., Barrett, J. & Rudolph, T. *Nat. Phys.* **8**, 475–478 (2012).
16. Aaronson, S. *Nat. Phys.* **8**, 443–444 (2012).
17. Liu, Y. et al. *Nat. Phys.* **10**, 515–519 (2014).
18. Vollmer, D. & Butt, H.-J. *Nat. Phys.* **10**, 475–476 (2014).
19. Bro, J. A., Jensen, K. S. B., Larsen, A. N., Yeomans, J. M. & Hecksher, T. *Eur. J. Phys.* **38**, 015006 (2017).
20. Aivazian, G. et al. *Nat. Phys.* **11**, 148–152 (2015).
21. Srivastava, A. et al. *Nat. Phys.* **11**, 141–147 (2015).
22. Urbaszek, B. & Marie, X. *Nat. Phys.* **11**, 94–95 (2015).
23. Tallinen, T. et al. *Nat. Phys.* **12**, 588–593 (2016).
24. Insight: quantum materials. *Nat. Phys.* https://go.nature.com/3gLkNTd (2017).
25. Grotti, J. et al. *Nat. Phys.* **14**, 437–441 (2018).
26. Chomaz, L. et al. *Nat. Phys.* **14**, 442–446 (2018).
27. Shi, X. et al. *Nat. Phys.* **14**, 1001–1005 (2018).
28. Kempkes, S. N. et al. *Nat. Phys.* **15**, 127–131 (2019).
29. Peterson, E. E. et al. *Nat. Phys.* **15**, 1095–1100 (2019).
30. Wright, L. G. et al. *Nat. Phys.* **16**, 565–570 (2020).
31. Ilday, F. Ö. *Nat. Phys.* **16**, 504–505 (2020).
32. Makey, G. et al. *Nat. Phys.* **16**, 795–801 (2020).
33. Keimer, B. & Moore, J. The physics of quantum materials. *Nat. Phys.* **13**, 1045–1055 (2017).