

nature physics

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Steering waves in metamaterials

DIAMOND QUBITS

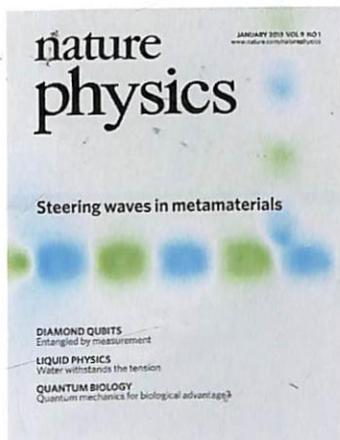
Entangled by measurement

LIQUID PHYSICS

Water withstands the tension

QUANTUM BIOLOGY

Quantum mechanics for biological advantage?



COVER IMAGE

Photonic crystals efficiently control wave propagation on a wavelength scale, but can become very large when long wavelengths are involved. Metamaterials made of resonant unit cells can, however, confine and guide waves even at scales far below their wavelength.

Article p55

IMAGE: FABRICE LEMOULT

COVER DESIGN: ALLEN BEATTIE

ON THE COVER

Diamond qubits
Entangled by measurement
Letter p29

Liquid physics
Water withstands the tension
Letter p38; News & Views p7

Quantum biology
Quantum mechanics for biological advantage?
Review Article p10

EDITORIAL

- 1 Work in progress
- 1 A life among the stars

THESIS

- 3 Gamble with time
Mark Buchanan

RESEARCH HIGHLIGHTS

- 4 Our choice from the recent literature

NEWS & VIEWS

- 5 Photonic qubits: A quantum delivery note
A. I. Lvovsky
- 6 Astronomy: Three for two
May Chiao
- 7 Physics of water: Stretched to the limit
Pablo G. Debenedetti
- 8 Spin ice: Flaws curb the flow
Peter Holdsworth
- 9 Ultrafast phenomena: Attosecond beacons
Iulia Georgescu

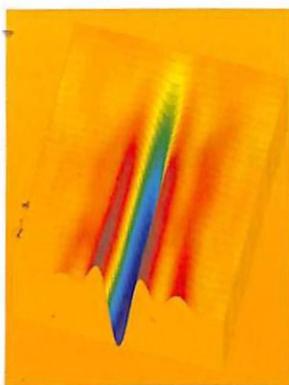
REVIEW ARTICLE

- 10 Quantum biology
Neill Lambert, Yueh-Nan Chen, Yuan-Chung Cheng, Che-Ming Li, Guang-Yin Chen and Franco Nori

LETTERS

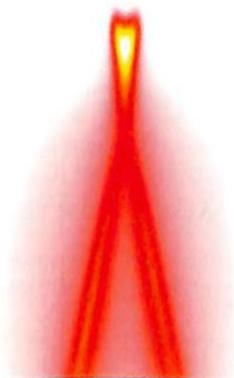
- 19 Three-photon energy-time entanglement
L. K. Shalm, D. R. Hamel, Z. Yan, C. Simon, K. J. Resch and T. Jennewein
- 23 Heralded noiseless amplification of a photon polarization qubit
S. Kocsis, G. Y. Xiang, T. C. Ralph and G. J. Pryde
→N&V p5
- 29 Demonstration of entanglement-by-measurement of solid-state qubits
Wolfgang Pfaff, Tim H. Taminiau, Lucio Robledo, Hannes Bernien, Matthew Markham, Daniel J. Twitchen and Ronald Hanson
- 34 Evidence of impurity and boundary effects on magnetic monopole dynamics in spin ice
H. M. Revell, L. R. Yaraskavitch, J. D. Mason, K. A. Ross, H. M. L. Noad, H. A. Dabkowska, B. D. Gaulin, P. Henelius and J. B. Kycia
→N&V p8





Different experimental probes have found different bosonic modes in the iron-based superconductors. A scanning tunnelling spectroscopy study of two separate superconductors now links the tunnelling mode with the 'neutron resonance', both of which vanish when superconductivity disappears.

Article p42



The electronic properties of graphene are spatially controlled from metallic to semiconducting by patterning steps into the underlying silicon carbide substrate. This bottom-up approach could be the basis for integrated graphene electronics.

Article p49

38 A coherent picture of water at extreme negative pressure

Mouna El Mekki Azouzi, Claire Ramboz, Jean-François Lenain and Frédéric Caupin

→N&V p7

ARTICLES

42 Close relationship between superconductivity and the bosonic mode in $\text{Ba}_{0.6}\text{K}_{0.4}\text{Fe}_2\text{As}_2$ and $\text{Na}(\text{Fe}_{0.975}\text{Co}_{0.025})\text{As}$

Zhenyu Wang, Huan Yang, Delong Fang, Bing Shen, Qiang-Hua Wang, Lei Shan, Chenglin Zhang, Pengcheng Dai and Hai-Hu Wen

49 A wide-bandgap metal-semiconductor-metal nanostructure made entirely from graphene

J. Hicks, A. Tejada, A. Taleb-Ibrahimi, M. S. Nevius, F. Wang, K. Shepperd, J. Palmer, F. Bertran, P. Le Fèvre, J. Kunc, W. A. de Heer, C. Berger and E. H. Conrad

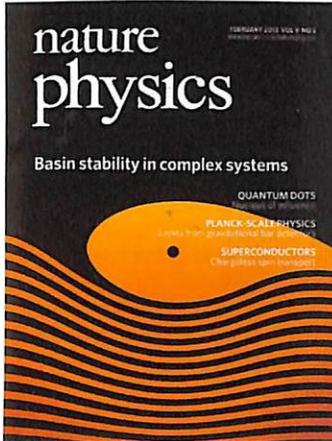
55 Wave propagation control at the deep subwavelength scale in metamaterials

Fabrice Lemoult, Nadège Kaina, Mathias Fink and Geoffroy Lerosey



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COVER IMAGE

Linear-stability measures for assessing the state of a dynamical system are inherently local, and thus insufficient to quantify stability against substantial perturbations. The volume of a state's basin of attraction offers a powerful alternative — and points toward a plausible explanation for regularity in real-world networks. Letter p89; News & Views p69

IMAGE: PETER J. MENCK

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ON THE COVER

- Quantum dots**
Nucleus of influence
Letter p74; News & Views p65
- Planck-scale physics**
Limits from gravitational
bar detectors
Letter p71
- Superconductors**
Chargeless spin transport
Letter p84; News & Views p67

EDITORIAL

- 61 Capital investment
- 61 App-y days

THESIS

- 63 Going up, going down
Mark Buchanan

RESEARCH HIGHLIGHTS

- 64 Our choice from the recent literature

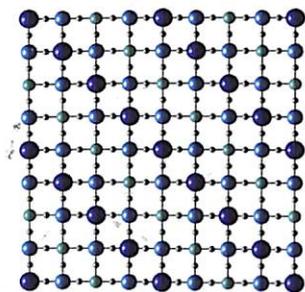
NEWS & VIEWS

- 65 Quantum dots: Reading the signs
Bernhard Urbaszek
- 66 Solar physics: Magnetic dance
Iulia Georgescu
- 67 Superconductors: No charge for spin transport
Nadya Mason and Martin Stehno
- 68 Ultracold gases: Atom SQUID
Mark Edwards
- 69 Nonlinear dynamics: New tricks for big kicks
Avi Gozolchiani and Shlomo Havlin

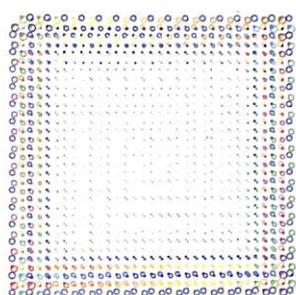
LETTERS

- 71 Gravitational bar detectors set limits to Planck-scale physics on macroscopic variables
Francesco Marin, Francesco Marino, Michele Bonaldi, Massimo Cerdonio, Livia Conti, Paolo Falferi, Renato Mezzena, Antonello Ortolan, Giovanni A. Prodi, Luca Taffarello, Gabriele Vedovato, Andrea Vinante and Jean-Pierre Zengri
- 74 Element-sensitive measurement of the hole-nuclear spin interaction in quantum dots
E. A. Chekhovich, M. M. Glazov, A. B. Krysa, M. Hopkinson, P. Senellart, A. Lemaître, M. S. Skolnick and A. I. Tartakovskii
→N&V p65
- 79 Thermodynamic phase diagram of static charge order in underdoped $YBa_2Cu_3O_y$
David LeBoeuf, S. Krämer, W. N. Hardy, Ruixing Liang, D. A. Bonn and Cyril Proust
- 84 Spin imbalance and spin-charge separation in a mesoscopic superconductor
C. H. L. Quay, D. Chevallier, C. Bena and M. Aprili
→N&V p67
- 89 How basin stability complements the linear-stability paradigm
Peter J. Menck, Jobst Heitzig, Norbert Marwan and Jürgen Kurths
→N&V p69





A thermodynamic probe of the recently discovered charge-density-wave order in $\text{YBa}_2\text{Cu}_3\text{O}_y$ reveals a biaxial modulation in magnetic fields up to 40 T.
Letter p79



Topological insulators are now shown to be protected not only by time-reversal symmetry, but also by crystal lattice symmetry. By accounting for the crystalline symmetries, further topological insulators can be predicted.
Article p98

ARTICLES

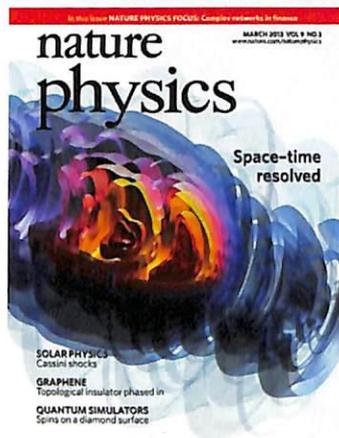
- 93 **Efimov effect in quantum magnets**
Yusuke Nishida, Yasuyuki Kato and Cristian D. Batista
- 98 **The space group classification of topological band-insulators**
Robert-Jan Slager, Andrej Mesaros, Vladimir Juričić and Jan Zaanen
- 103 **Photocurrent measurements of supercollision cooling in graphene**
Matt W. Graham, Su-Fei Shi, Daniel C. Ralph, Jiwoong Park and Paul L. McEuen
- 109 **Supercollision cooling in undoped graphene**
A. C. Betz, S. H. Jhang, E. Pallecchi, R. Ferreira, G. Fève, J-M. Berroir and B. Plaçais
- 113 **The role of non-equilibrium vibrational structures in electronic coherence and recoherence in pigment-protein complexes**
A. W. Chin, J. Prior, R. Föros, F. Caycedo-Soler, S. F. Huelga and M. B. Plenio

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See the back pages



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COVER IMAGE

An all-optical method to measure the space-time characteristics of an isolated attosecond pulse, without temporal and spatial averaging, is now demonstrated. The approach will provide further insight into the generation of ultrafast light, and may possibly be used to finely control the pulse characteristics.
Letter p159

IMAGE: KYUNG TAEC KIM

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ON THE COVER

Solar physics
Cassini shocks
Letter p164; News & Views p131

Graphene
Topological insulator phased in
Letter p154; News & Views p135

Quantum simulators
Spins on a diamond surface
Article p168

EDITORIAL

119 Net gains

COMMENTARY

121 Network opportunity

Michele Catanzaro and Mark Buchanan

FOCUS

123 Complex derivatives

Stefano Battiston, Guido Caldarelli, Co-Pierre Georg, Robert May and Joseph Stiglitz

FOCUS

125 Reconstructing a credit network

Guido Caldarelli, Alessandro Chessa, Andrea Gabrielli, Fabio Pammolli and Michelangelo Puliga

FOCUS

126 The power to control

Marco Galbiati, Danilo Delpini and Stefano Battiston

FOCUS

THESIS

129 Size and supersize

Mark Buchanan

RESEARCH HIGHLIGHTS

130 Our choice from the recent literature

NEWS & VIEWS

131 Astrophysics: An unexpected shock

Ian G. Richardson

132 Astronomy: The wise hunter

May Chiao

133 Complex networks: Synchrony and your morning coffee

Ian Dobson

134 Biomechanics: Have legs will travel

Abigail Klopfer

135 Condensed matter: Graphene's topological insulation

Chun Ning (Jeanie) Lau

136 Quantum engineering: Diamond envy

Joshua Nunn

137 Quantum interferometry: Matter waves in a new light

Alexander D. Cronin and William F. Holmgren

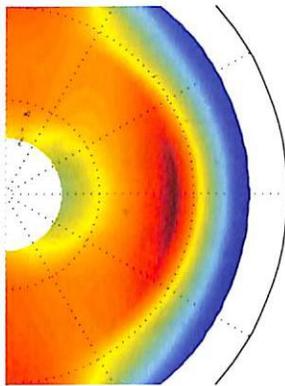
LETTERS

139 Room-temperature entanglement between single defect spins in diamond

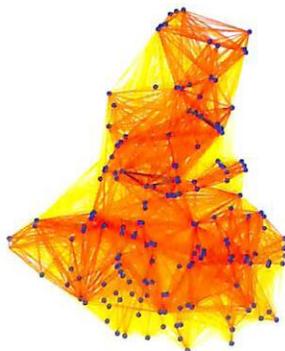
F. Dolde, I. Jakobi, B. Naydenov, N. Zhao, S. Pezzagna, C. Trautmann, J. Meijer, P. Neumann, F. Jelezko and J. Wrachtrup

→N&V p136





High-harmonic spectroscopy provides attosecond-scale information about optical processes in molecules. Present techniques, however, cannot simultaneously measure the phase as a function of molecular angle and photon frequency. An approach that retrieves both the amplitude and the phase of high-harmonic emission is now demonstrated, and could enable a full reconstruction of the molecular wavefunction.
Article p174



Power-grid networks must be synchronized in order to function. A condition for the stability of the synchronous state enables identification of network parameters that enhance spontaneous synchronization — heralding the possibility of smart grids that operate optimally in real-world systems.
Article p191; News & Views p133

144 A universal matter-wave interferometer with optical ionization gratings in the time domain

Philipp Haslinger, Nadine Dörre, Philipp Geyer, Jonas Rodewald, Stefan Nimmrichter and Markus Arndt
→N&V p137

149 Electrical tuning of valley magnetic moment through symmetry control in bilayer MoS₂

Sanfeng Wu, Jason S. Ross, Gui-Bin Liu, Grant Aivazian, Aaron Jones, Zaiyao Fei, Wenguang Zhu, Di Xiao, Wang Yao, David Cobden and Xiaodong Xu

154 Evidence for a spin phase transition at charge neutrality in bilayer graphene

P. Maher, C. R. Dean, A. F. Young, T. Taniguchi, K. Watanabe, K. L. Shepard, J. Hone and P. Kim
→N&V p135

159 Manipulation of quantum paths for space-time characterization of attosecond pulses

Kyung Taec Kim, Chunmei Zhang, Andrew D. Shiner, Sean E. Kirkwood, Eugene Frumker, Genevieve Garipey, Andrei Naumov, D. M. Villeneuve and P. B. Corkum

164 Electron acceleration to relativistic energies at a strong quasi-parallel shock wave

A. Masters, L. Stawarz, M. Fujimoto, S. J. Schwartz, N. Sergis, M. F. Thomsen, A. Retinò, H. Hasegawa, B. Zieger, G. R. Lewis, A. J. Coates, P. Canu and M. K. Dougherty
→N&V p131

ARTICLES

168 A large-scale quantum simulator on a diamond surface at room temperature
Jianming Cai, Alex Retzker, Fedor Jelezko and Martin B. Plenio

174 Linked attosecond phase interferometry for molecular frame measurements
J. B. Bertrand, H. J. Wörner, P. Salières, D. M. Villeneuve and P. B. Corkum

179 Slowing, advancing and switching of microwave signals using circuit nanoelectromechanics

X. Zhou, F. Hocke, A. Schliesser, A. Marx, H. Huebl, R. Gross and T. J. Kippenberg

185 A compact laser-driven plasma accelerator for megaelectronvolt-energy neutral atoms

R. Rajeev, T. Madhu Trivikram, K. P. M. Rishad, V. Narayanan, E. Krishnakumar and M. Krishnamurthy

191 Spontaneous synchrony in power-grid networks

Adilson E. Motter, Seth A. Myers, Marian Anghel and Takashi Nishikawa
→N&V p133

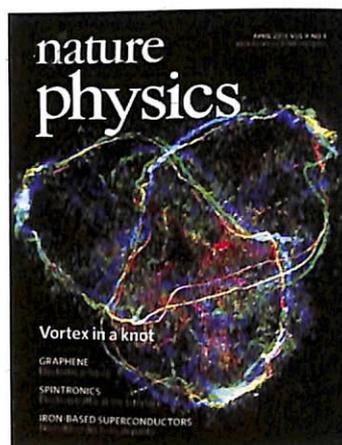
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COVER IMAGE

Linking two smoke rings or tying a single ring into a knot is no easy feat. Now, however, such topological vortices are created in water using 3D-printed hydrofoils. High-speed imaging shows how the linked rings spontaneously separate, and the knots are able to free themselves. Similar fluid dynamics may also be relevant in plasmas, quantum fluids and optics. Article p253; News & Views p207

IMAGE: DUSTIN KLECKNER AND WILLIAM IRVINE

COVER DESIGN: ALLEN BEATTIE

ON THE COVER

Graphene

Electrons in focus
Letter p225

Spintronics

Electron traffic at the interface
Article p242; News & Views p210

Iron-based superconductors

Nematic order from dopants
Letter p220

EDITORIAL

199 All must have prizes

COMMENTARY

200 The parallel approach
Massimiliano Di Ventra and Yuriy V. Pershin

THESIS

203 What happens if...?
Mark Buchanan

RESEARCH HIGHLIGHTS

204 Our choice from the recent literature

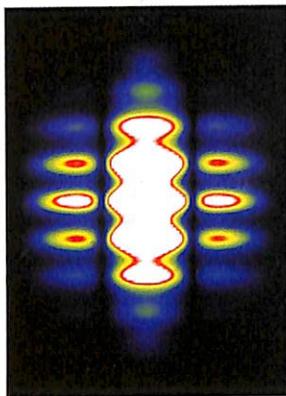
NEWS & VIEWS

- 205 Particle physics: Theory with a twistor
Andrew Hodges
- 206 Robert C. Richardson: Cool new world
May Chiao
- 207 Fluid dynamics: Lord Kelvin's vortex rings
Daniel P. Lathrop and Barbara Brawn-Cinani
- 208 Donald A. Glaser: Brilliant bubbles
Alison Wright
- 209 Quantum transport: Spins on the move
Patrick Windpassinger
- 210 Organic spintronics: Inside the interface
Valentin Alek Dediu
- 211 Fundamental physics: All the world's a lab
David Gevaux
- 212 Complex networks: A winning strategy
Raissa M. D'Souza

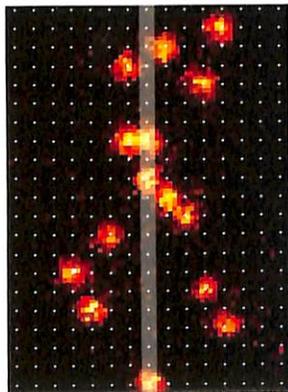
LETTERS

- 215 Nanoscale magnetic imaging of a single electron spin under ambient conditions
M. S. Grinolds, S. Hong, P. Maletinsky, L. Luan, M. D. Lukin, R. L. Walsworth and A. Yacoby
- 220 Anisotropic impurity states, quasiparticle scattering and nematic transport in underdoped $\text{Ca}(\text{Fe}_{1-x}\text{Co}_x)_2\text{As}_2$
M. P. Allan, T.-M. Chuang, F. Masee, Yang Xie, Ni Ni, S. L. Bud'ko, G. S. Boebinger, Q. Wang, D. S. Dessau, P. C. Canfield, M. S. Golden and J. C. Davis
- 225 Electrically tunable transverse magnetic focusing in graphene
Thiti Taychatanapat, Kenji Watanabe, Takashi Taniguchi and Pablo Jarillo-Herrero
- 230 Successful strategies for competing networks
J. Aguirre, D. Papo and J. M. Buldú
→N&V p212





When CaFe_2As_2 is lightly doped with Co an electronic liquid-crystalline state emerges, which becomes the 'parent' state of high-temperature superconductivity in this ferropnictide. A spectroscopic imaging study shows that the 'nematic' order is likely to be an artefact of the doping itself.
Letter p220



Understanding the propagation of spin excitations is a difficult problem in quantum magnetism. Using site-resolved imaging in a one-dimensional atomic gas, it is possible to track the dynamics of a moving spin impurity through the Mott-insulator and superfluid regimes.
Article p235; News & Views p209

ARTICLES

235 Quantum dynamics of a mobile spin impurity

Takeshi Fukuhara, Adrian Kantian, Manuel Endres, Marc Cheneau, Peter Schauf, Sebastian Hild, David Bellem, Ulrich Schollwöck, Thierry Giamarchi, Christian Gross, Immanuel Bloch and Stefan Kuhr
→N&V p209

242 Spin-dependent trapping of electrons at spinterfaces

Sabine Steil, Nicolas Großmann, Martin Laux, Andreas Ruffing, Daniel Steil, Martin Wiesenmayer, Stefan Mathias, Oliver L. A. Monti, Mirko Cinchetti and Martin Aeschlimann
→N&V p210

248 Photoexcitation cascade and multiple hot-carrier generation in graphene

K. J. Tielrooij, J. C. W. Song, S. A. Jensen, A. Centeno, A. Pesquera, A. Zurutuza Elorza, M. Bonn, L. S. Levitov and F. H. L. Koppens

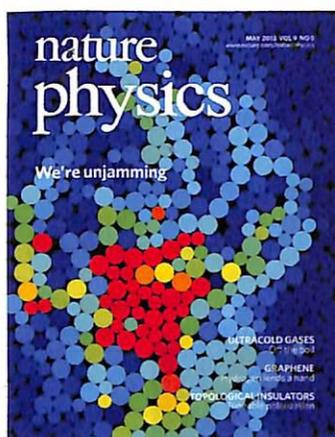
253 Creation and dynamics of knotted vortices

Dustin Kleckner and William T. M. Irvine
→N&V p207



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**COVER IMAGE**

Free-flowing granular media can quickly become jammed above a critical density. Nonlinear dynamical systems analysis now suggests that jamming arises from the interaction between the density of instabilities and the propagation of disturbances throughout the material.

Letter p288; News & Views p263

IMAGE: DAVID EGOLF, EDWARD BANIGAN, MATTHEW ILLICH AND DERICK STACE-NAUGHTON

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ON THE COVER

Ultracold gases

Off the boil

Letter p271; News & Views p266

Graphene

Hydrogen lends a hand

Letter p284

Topological insulators

Tuneable polarization

Letter p293; News & Views p265

EDITORIAL

259 The importance of being Ernest

THESIS

260 Let there be fluid light

Mark Buchanan

BOOKS & ARTS

261 The Quantum Divide: Why Schrödinger's Cat is Either Dead or Alive

by Christopher C. Gerry and Kimberley M. Bruno

Reviewed by Iulia Georgescu

RESEARCH HIGHLIGHTS

262 Our choice from the recent literature

NEWS & VIEWS

263 Granular matter: The movable and the jammed

Troy Shinbrot

264 Cosmology: Across the Universe

Alison Wright

265 Topological insulators: Full spin ahead for photoelectrons

Qi-Kun Xue

266 Non-equilibrium quantum gas: How not to boil

Jörg Schmiedmayer

267 Nanotechnology: The can-opener effect

Bart Verberck

268 Particle physics: A Higgs is a Higgs

Herbi Dreiner

269 Electron spin: The long and winding road

Masaya Kataoka

LETTERS

271 A superheated Bose-condensed gas

Alexander L. Gaunt, Richard J. Fletcher, Robert P. Smith and Zoran Hadzibabic

→N&V p266

275 Macroscopic quantum self-trapping and Josephson oscillations of exciton polaritons

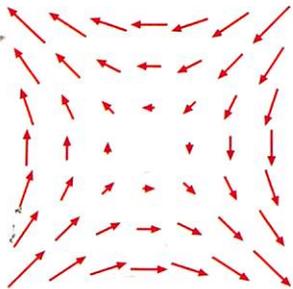
M. Abbarchi, A. Amo, V. G. Sala, D. D. Solnyshkov, H. Flayac, L. Ferrier, I. Sagnes, E. Galopin, A. Lemaître, G. Malpuech and J. Bloch

280 Manipulation of mobile spin coherence using magnetic-field-free electron spin resonance

H. Sanada, Y. Kunihashi, H. Gotoh, K. Onomitsu, M. Kohda, J. Nitta, P. V. Santos and T. Sogawa

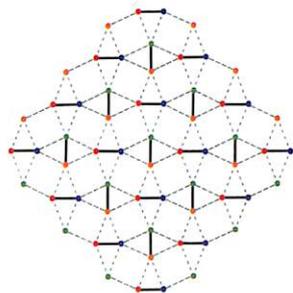
→N&V p269





In traditional electron spin resonance techniques external magnetic fields are required. Now the electron spin can be manipulated in the absence of an applied magnetic field, by a technique that exploits the spin-orbit coupling of electrons travelling on surface acoustic waves.

Letter p280; News & Views p269



A crystal is a band insulator if the energy bands are filled with electrons. Partially filled bands result in a metal, or sometimes a Mott insulator when interactions are strong. A study now shows that for many crystalline structures, the Mott insulator is the only possible insulating state, even for filled bands.

Article p299

284 Colossal enhancement of spin-orbit coupling in weakly hydrogenated graphene

Jayakumar Balakrishnan, Gavin Kok Wai Koon, Manu Jaiswal, A. H. Castro Neto and Barbaros Özyilmaz

288 The chaotic dynamics of jamming

Edward J. Banigan, Matthew K. Illich, Derick J. Stace-Naughton and David A. Egolf
→N&V p263

293 Photoelectron spin-flipping and texture manipulation in a topological insulator

Chris Jozwiak, Cheol-Hwan Park, Kenneth Gotlieb, Choongyu Hwang, Dung-Hai Lee, Steven G. Louie, Jonathan D. Denlinger, Costel R. Rotundu, Robert J. Birgeneau, Zahid Hussain and Alessandra Lanzara
→N&V p265

ARTICLES

299 Topological order and absence of band insulators at integer filling in non-symmorphic crystals

Siddharth A. Parameswaran, Ari M. Turner, Daniel P. Arovas and Ashvin Vishwanath

304 Extreme-ultraviolet light generation in plasmonic nanostructures

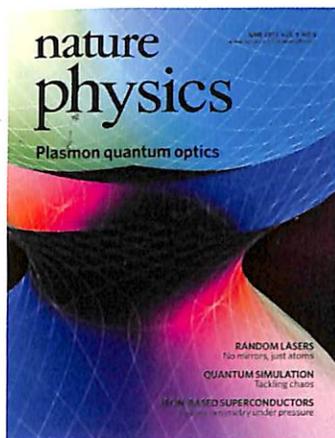
M. Sivis, M. Duwe, B. Abel and C. Ropers

310 Non-equilibrium glass transitions in driven and active matter

Ludovic Berthier and Jorge Kurchan



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COVER IMAGE

Surface-plasmon polaritons are hybrid particles that result from strong coupling between light and collective electron motion on the surface of a metal. This Review presents an overview of the quantum properties of surface plasmons, their role in controlling light-matter interactions at the quantum level and potential applications.

Review Article p329

IMAGE: MARK TAME

COVER DESIGN: ALLEN BEATTIE AND ALEX WING

ON THE COVER

Random lasers
No mirrors, just atoms
Letter p357; News & Views p325

Quantum simulation
Tackling chaos
Article p361

Iron-based superconductors
Pairing symmetry under pressure
Letter p349

EDITORIAL

315 National science furore

THESIS

317 What has econophysics ever done for us?
Mark Buchanan

BOOKS & ARTS

318 The Devotion of Suspect X
by Keigo Higashino
Reviewed by Iulia Georgescu

319 Exhibition: Light, the Universe and everything
Reviewed by May Chiao

RESEARCH HIGHLIGHTS

320 Our choice from the recent literature

NEWS & VIEWS

321 Organic materials: Graphene gets molecules into order
Friedrich Reinert

322 Materials science: Crack scene investigation
Bart Verberck

323 Negative refraction: Imaging through the looking-glass
Rupert F. Oulton and John B. Pendry

324 Artificial spin ice: The heat is on
Christopher Marrows

325 Lasers: Amplified by randomness
Vladan Vuletic

326 Magnetic monopoles: Entropy lost
Nic Shannon

REVIEW ARTICLE

329 Quantum plasmonics
M. S. Tame, K. R. McEnery, Ş. K. Özdemir, J. Lee, S. A. Maier and M. S. Kim

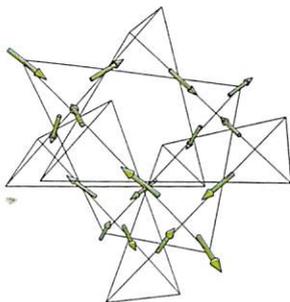
LETTERS

341 Ideal *n*-body correlations with massive particles
R. G. Dall, A. G. Manning, S. S. Hodgman, Wu RuGway, K. V. Kheruntsyan and A. G. Truscott

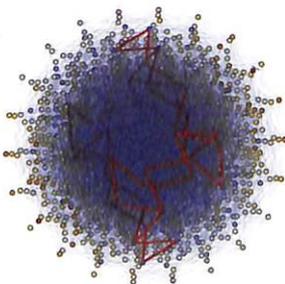
345 Correlations, indistinguishability and entanglement in Hong-Ou-Mandel experiments at microwave frequencies
C. Lang, C. Eichler, L. Steffen, J. M. Fink, M. J. Woolley, A. Blais and A. Wallraff

349 Sudden reversal in the pressure dependence of T_c in the iron-based superconductor KFe_2As_2
F. F. Tafti, A. Juneau-Fecteau, M-È. Delage, S. René de Cotret, J-Ph. Reid, A. F. Wang, X-G. Luo, X. H. Chen, N. Doiron-Leyraud and Louis Taillefer





Early specific-heat measurements of the archetypal spin ice $\text{Dy}_2\text{Ti}_2\text{O}_7$ showed a residual entropy at low temperatures similar to that found in water ice. A technique exploiting slow thermal equilibration now reveals an absence of this entropy—calling into question the nature of $\text{Dy}_2\text{Ti}_2\text{O}_7$ at low temperatures. Letter p353; News & Views p326



Artificial spin ice promises a means of probing dynamics in frustrated systems, but samples typically only shift between low-lying energy states under an external field. Exploring the energy landscape is now possible, through exquisite control over the thermal fluctuations of mesoscopic magnetic dipoles. Article p375; News & Views p324

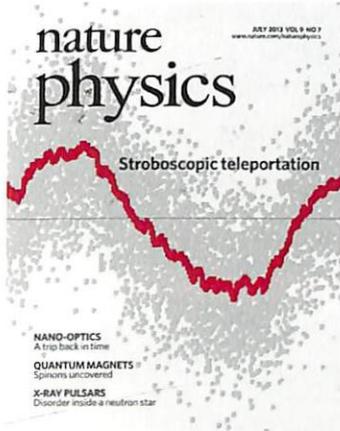
- 353 Absence of Pauling's residual entropy in thermally equilibrated $\text{Dy}_2\text{Ti}_2\text{O}_7$**
D. Pomaranski, L. R. Yaraskavitch, S. Meng, K. A. Ross, H. M. L. Noad, H. A. Dabkowska, B. D. Gaulin and J. B. Kycia
→N&V p326
- 357 A cold-atom random laser**
Q. Baudouin, N. Mercadier, V. Guarrera, W. Guerin and R. Kaiser
→N&V p325

ARTICLES

- 361 Quantum simulation of dynamical maps with trapped ions**
P. Schindler, M. Müller, D. Nigg, J. T. Barreiro, E. A. Martinez, M. Hennrich, T. Monz, S. Diehl, P. Zoller and R. Blatt
- 368 Long-range magnetic order in a purely organic 2D layer adsorbed on epitaxial graphene**
Manuela Garnica, Daniele Stradi, Sara Barja, Fabian Calleja, Cristina Díaz, Manuel Alcamí, Nazario Martín, Amadeo L. Vázquez de Parga, Fernando Martín and Rodolfo Miranda
→N&V p321
- 375 Exploring hyper-cubic energy landscapes in thermally active finite artificial spin-ice systems**
A. Farhan, P. M. Derlet, A. Kleibert, A. Balan, R. V. Chopdekar, M. Wyss, L. Anghinolfi, F. Nolting and L. J. Heyderman
→N&V p324
- 382 Corrigendum**



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**COVER IMAGE**

An experiment now demonstrates the deterministic continuous-variable teleportation between two atomic ensembles at room temperature. This protocol makes it possible to teleport time-evolving quantum states from one ensemble to the other.

Letter p400; News & Views p389

IMAGE: HANNA KRAUTER AND DANIEL SALART

COVER DESIGN: ALLEN BEATTIE

ON THE COVER

Nano-optics

A trip back in time

Letter p423; News & Views p393

Quantum magnets

Spinons uncovered

Article p435

X-ray pulsars

Disorder inside a neutron star

Article p431; News & Views p396

EDITORIAL

383 The joys of summer

383 Grand tour

COMMENTARY

384 Thinking outside the simulation box

Abraham Loeb

THESIS

387 Birds of a feather

Mark Buchanan

**RESEARCH HIGHLIGHTS**

388 Our choice from the recent literature

NEWS & VIEWS

389 Quantum teleportation: Getting complicated

Dzmitry Matsukevich

390 Hydrodynamics: Wake up

Bart Verberck

391 Quantum thermodynamics: Waiter, bring me $\pm\epsilon!$

Seth Lloyd

392 Biophysics: Critical contraction

Abigail Klopper

393 Nanophotonics: Optical time reversal with graphene

Yaroslav Urzhumov, Cristian Ciraci and David R. Smith

394 Quantum entanglement: Now you see it

Iulia Georgescu

395 Solid-state physics: The butterfly emerges

Dieter Weiss

396 Neutron stars: A taste of pasta?

William G. Newton

398 Multiferroics: Magnetic moments under stress

Annemieke M. Mulders

LETTERS

400 Deterministic quantum teleportation between distant atomic objects

H. Krauter, D. Salart, C. A. Muschik, J. M. Petersen, Heng Shen, T. Fernholz and E. S. Polzik

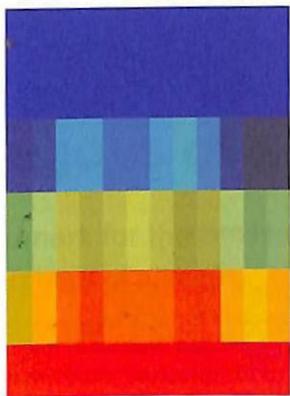
→N&V p389

405 Universal spin dynamics in two-dimensional Fermi gases

Marco Koschorreck, Daniel Pertot, Enrico Vogt and Michael Köhl

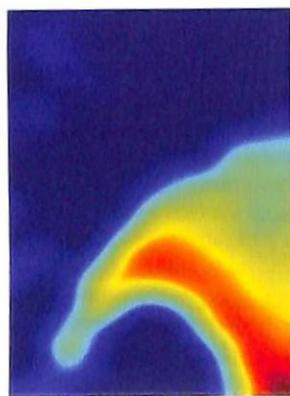
410 A sudden collapse in the transport lifetime across the topological phase transition in $(\text{Bi}_{1-x}\text{In}_x)_2\text{Se}_3$

Liang Wu, M. Brahlek, R. Valdés Aguilar, A. V. Stier, C. M. Morris, Y. Lubashevsky, L. S. Bilbro, N. Bansal, S. Oh and N. P. Armitage



Magnetic reconnection in the Earth's magnetosphere accelerates electrons. And yet energetic electrons are not created during reconnection in the solar wind. Observations from the Cluster spacecraft now suggest that electron acceleration is caused by repeated bursts of plasma flow, which only occur in situations where the magnetic reconnection is unsteady.

Letter p426



Magnetic excitations, or spinons, in a quasi-one-dimensional quantum magnet are investigated in an inelastic neutron-scattering experiment. The measurements confirm the existence of theoretically predicted higher-order spinons.

Article p435

415 Duality symmetry and its breakdown in the vicinity of the superconductor-insulator transition

Maoz Ovadia, David Kalok, Benjamin Sacépé and Dan Shahar

419 Charge-cluster glass in an organic conductor

F. Kagawa, T. Sato, K. Miyagawa, K. Kanoda, Y. Tokura, K. Kobayashi, R. Kumai and Y. Murakami

423 Controllable optical negative refraction and phase conjugation in graphite thin films

Hayk Harutyunyan, Ryan Beams and Lukas Novotny

→N&V p393

426 Energetic electron acceleration by unsteady magnetic reconnection

H. S. Fu, Yu. V. Khotyaintsev, A. Vaivads, A. Retinò and M. André

ARTICLES

431 A highly resistive layer within the crust of X-ray pulsars limits their spin periods

José A. Pons, Daniele Viganò and Nanda Rea

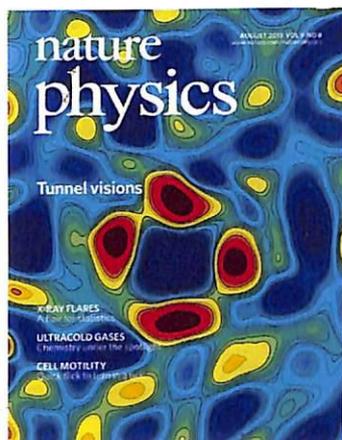
→N&V p396

435 Fractional spinon excitations in the quantum Heisenberg antiferromagnetic chain

Martin Mourigal, Mechthild Enderle, Axel Klöpperpieper, Jean-Sébastien Caux, Anne Stunault and Henrik M. Rønnow

442 Pseudogap state near a quantum critical point

K. B. Efetov, H. Meier and C. Pépin

**COVER IMAGE**

By means of low-temperature scanning tunnelling spectroscopy, a heavy fermion material in its superconducting and mixed states can be imaged. Besides probing the superconducting gap symmetry, the measurements also reveal a pseudogap.

Letters p468 and p474;
News & Views p458

IMAGE: BRIAN ZHOU AND A. YAZDANI

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ON THE COVER

X-ray flares

A flair for statistics
Letter p465

Ultracold gases

Chemistry under the spotlight
Article p512; News & Views p461

Cell motility

Quick flick to turn in a tick
Letter p494; News & Views p460

EDITORIAL

- 447 Strategic thinking
447 Hurray for Hubble

COMMENTARY

- 448 Dig deeper
Paul Newman and Anna Stasto

THESIS

- 451 'I think' doesn't mean 'I am'
Mark Buchanan

BOOKS & ARTS

- 452 Exhibition: The light through yonder window
Reviewed by May Chiao
- 452 The Milky Way: An Insider's Guide
by William H. Waller
Reviewed by Timothy C. Beers
- 453 The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality
by Dave Goldberg
Reviewed by Mario Livio

RESEARCH HIGHLIGHTS

- 454 Our choice from the recent literature

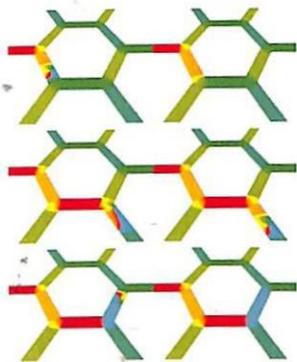
NEWS & VIEWS

- 455 Nanophotonics: Making light of tight corners
R. C. McPhedran
- 456 Solar physics: Flares caught in the act
Terry G. Forbes
- 457 Condensed matter: On thin ice
Bart Verberck
- 458 Heavy-fermion superconductivity: How the heaviest electrons pair up
Louis Taillefer
- 459 Ultracold gases: Waves and wiggles
Iulia Georgescu
- 460 Cell motility: Turning failure into function
Howard C. Berg
- 461 Molecular physics: Ultracold *ménage à trois*
Stefan Willitsch
- 462 Nanomechanical resonators: Spinning oscillators
Klemens Hammerer

LETTERS

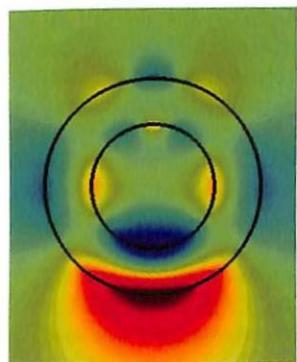
- 465 Self-organized criticality in X-ray flares of gamma-ray-burst afterglows
F. Y. Wang and Z. G. Dai





When a domain wall of a given chirality is injected into a magnetic nanowire, its trajectory through a branched network of Y-shaped nanowire junctions — such as a honeycomb lattice, for instance — can be pre-determined. This property has implications for data storage and processing.

Article p505



The modelling of plasmonic systems is complicated by the broad range of length scales involved: the physical dimensions of the structure might be as small as 1 nm, whereas the wavelength of the light involved can be a few hundred nanometres. It is now shown that transformation optics, a technique successfully used to design metamaterials, is also valuable for circumventing these problems.

Article p518; News & Views p455

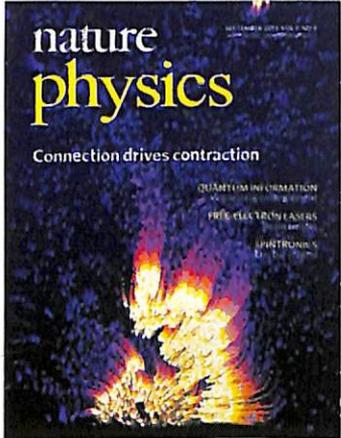
- 468 Imaging Cooper pairing of heavy fermions in CeCoIn₅**
M. P. Allan, F. Masee, D. K. Morr, J. Van Dyke, A. W. Rost, A. P. Mackenzie, C. Petrovic and J. C. Davis
→N&V p458
- 474 Visualizing nodal heavy fermion superconductivity in CeCoIn₅**
Brian B. Zhou, Shashank Misra, Eduardo H. da Silva Neto, Pegor Aynajian, Ryan E. Baumbach, J. D. Thompson, Eric D. Bauer and Ali Yazdani
→N&V p458
- 480 Coherent phonon manipulation in coupled mechanical resonators**
Hajime Okamoto, Adrien Gourgout, Chia-Yuan Chang, Koji Onomitsu, Imran Mahboob, Edward Yi Chang and Hiroshi Yamaguchi
→N&V p462
- 485 Coherent control of a classical nanomechanical two-level system**
T. Faust, J. Rieger, M. J. Seitner, J. P. Kotthaus and E. M. Weig
→N&V p462
- 489 Imaging coronal magnetic-field reconnection in a solar flare**
Yang Su, Astrid M. Veronig, Gordon D. Holman, Brian R. Dennis, Tongjiang Wang, Manuela Temmer and Weiqun Gan
→N&V p456
- 494 Bacteria can exploit a flagellar buckling instability to change direction**
Kwangmin Son, Jeffrey S. Guasto and Roman Stocker
→N&V p460

ARTICLES

- 499 Mapping the orbital wavefunction of the surface states in three-dimensional topological insulators**
Yue Cao, J. A. Waugh, X-W. Zhang, J-W. Luo, Q. Wang, T. J. Reber, S. K. Mo, Z. Xu, A. Yang, J. Schneeloch, G. D. Gu, M. Brahlek, N. Bansal, S. Oh, A. Zunger and D. S. Dessau
- 505 Domain wall trajectory determined by its fractional topological edge defects**
Aakash Pushp, Timothy Phung, Charles Rettner, Brian P. Hughes, See-Hun Yang, Luc Thomas and Stuart S. P. Parkin
- 512 Population distribution of product states following three-body recombination in an ultracold atomic gas**
A. Härter, A. Krükow, M. Deiß, B. Drews, E. Tiemann and J. Hecker Denschlag
→N&V p461
- 518 Capturing photons with transformation optics**
J. B. Pendry, A. I. Fernández-Domínguez, Yu Luo and Rongkuo Zhao
→N&V p455



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COVER IMAGE

A study of an actomyosin active gel now demonstrates the importance of the crosslinking density of actin polymers in enabling myosin motors to internally drive contraction and rupture the network into clusters.

This indicates the central role played by the cytoskeleton in cell division and tissue morphogenesis.

Article p591

IMAGE: JOSE ALVARADO,
DIRK-JAN SPAANDERMAN,
HENK-JAN BOLUIJT AND KOTA MIURA

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ON THE COVER

Quantum information
Witnessing entanglement
Article p559

Free-electron lasers
Beam twister
Letter p549; News & Views p531

Spintronics
Electric control
Article p563; News & Views p532

EDITORIAL

523 The Hubbard model at half a century

THESIS

525 Brain teaser
Mark Buchanan

BOOKS & ARTS

526 Exhibition: The great rogue wave
Iulia Georgescu

526 Brilliant Blunders: From Darwin to Einstein
by *Mario Livio*
Reviewed by Liesbeth Venema

RESEARCH HIGHLIGHTS

528 Our choice from the recent literature

NEWS & VIEWS

- 529 Quantum optics: Micro meets macro
Fabio Sciarrino
- 530 Quantum point contacts: Double or nothing?
Adam Micolich
- 531 Free-electron lasers: Twisted light from an electron beam
Marie-Emmanuelle Couprie
- 532 Spintronics: Gate control of spin-valley coupling
Alberto F. Morpurgo
- 533 Neuronal networks: Focus amidst the noise
John M. Beggs
- 535 Zero-temperature classical liquids: A cool liquid that does not freeze
Jeppe C. Dyre
- 536 Quantum materials: Shape resonances in superstripes
Antonio Bianconi
- 538 Quantum dots: To the source of the noise
Hendrik Bluhm

LETTERS

- 541 Observation of micro-macro entanglement of light
A. I. Lvovsky, R. Ghobadi, A. Chandra, A. S. Prasad and C. Simon
→N&V p529
- 545 Displacement of entanglement back and forth between the micro and macro domains
N. Bruno, A. Martin, P. Sekatski, N. Sangouard, R. T. Thew and N. Gisin
→N&V p529
- 549 Coherent optical vortices from relativistic electron beams
Erik Hemsing, Andrey Knyazik, Michael Dunning, Dao Xiang, Agostino Marinelli, Carsten Hast and James B. Rosenzweig
→N&V p531

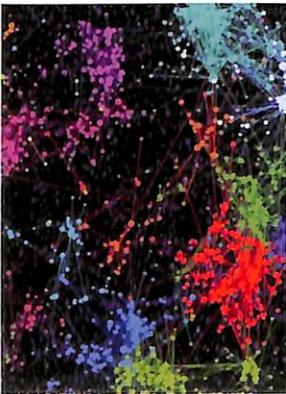


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A Wigner molecule — a localized pair of interacting electrons — is now created in a carbon nanotube. The high-quality, electronically pristine tubes enable a full characterization of the energy spectrum, laying the groundwork for future studies of interacting fermion systems in one and two dimensions.

Article p576



Neuronal networks can spontaneously exhibit periodic bursts of collective activity. High-resolution calcium imaging and computer modelling of *in vitro* cultures now reveal that this behaviour is a consequence of noise focusing — an impulsive concentration of spontaneous activity due to the interplay between network topology and intrinsic neuronal dynamics.

Article p582; News & Views p533

554 Liquids more stable than crystals in particles with limited valence and flexible bonds

Frank Smallenburg and Francesco Sciortino

→N&V p535

ARTICLES

559 Demonstration of genuine multipartite entanglement with device-independent witnesses

Julio T. Barreiro, Jean-Daniel Bancal, Philipp Schindler, Daniel Nigg, Markus Hennrich, Thomas Monz, Nicolas Gisin and Rainer Blatt

563 Zeeman-type spin splitting controlled by an electric field

Hongtao Yuan, Mohammad Saeed Bahramy, Kazuhiro Morimoto, Sanfeng Wu, Kentaro Nomura, Bohm-Jung Yang, Hidekazu Shimotani, Ryuji Suzuki, Minglin Toh, Christian Kloc, Xiaodong Xu, Ryotaro Arita, Naoto Nagaosa and Yoshihiro Iwasa

→N&V p532

570 Charge noise and spin noise in a semiconductor quantum device

Andreas V. Kuhlmann, Julien Houel, Arne Ludwig, Lukas Greuter, Dirk Reuter, Andreas D. Wieck, Martino Poggio and Richard J. Warburton

→N&V p538

576 Observation and spectroscopy of a two-electron Wigner molecule in an ultraclean carbon nanotube

S. Pecker, F. Kuemmeth, A. Secchi, M. Rontani, D. C. Ralph, P. L. McEuen and S. Ilani

582 Noise focusing and the emergence of coherent activity in neuronal cultures

Javier G. Orlandi, Jordi Soriano, Enrique Alvarez-Lacalle, Sara Teller and Jaume Casademunt

→N&V p533

591 Molecular motors robustly drive active gels to a critically connected state

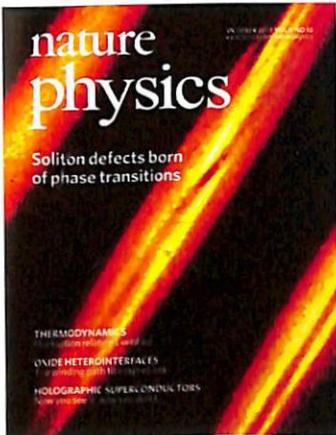
José Alvarado, Michael Sheinman, Abhinav Sharma, Fred C. MacKintosh and Gijssje H. Koenderink

598 Erratum



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**COVER IMAGE**

The Kibble-Zurek mechanism describes the spontaneous formation of defects in systems that are undergoing a second-order phase transition at a finite rate. Familiar to cosmologists and condensed-matter physicists, this mechanism is now found to be responsible for the spontaneous creation of solitons in a Bose-Einstein condensate. Article p656; News & Views p605

IMAGE: GABRIELE FERRARI

COVER DESIGN: ALLEN BEATTIE

ON THE COVER

Thermodynamics
Fluctuation relations verified
Letter p644

Oxide heterointerfaces
The winding path to magnetism
Letter p626; News & Views p610

Holographic superconductors
Now you see it, now you don't
Article p649; News & Views p609

EDITORIAL

599 The first hundred years

THESIS601 Intuition set free
Mark Buchanan**BOOKS & ARTS**

- 602 **Love, Literature, and the Quantum Atom: Niels Bohr's 1913 Trilogy Revisited**
by Finn Aaserud and J. L. Heilbron
Reviewed by Bart Verberck
- 603 **Beyond the God Particle**
by Leon Lederman and Christopher Hill
Reviewed by Tony Doyle

RESEARCH HIGHLIGHTS

604 Our choice from the recent literature

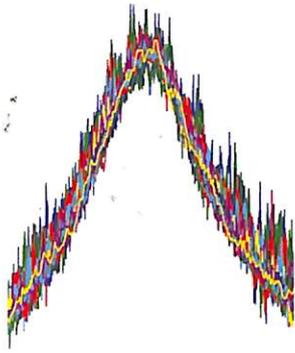
NEWS & VIEWS

- 605 **Ultracold gases: Shock cooling a universe**
Martin W. Zwierlein
- 606 **Electrochemistry: Discrete answer**
Erik Luijten
- 607 **Quantum gases: Relaxation dynamics**
Marc Cheneau
- 609 **Holographic duality: Stealing dimensions from metals**
Jan Zaanen
- 610 **Oxide heterostructures: Hund rules with a twist**
Marc Gabay and Jean-Marc Triscone
- 612 **Metal-insulator transitions: Orbital control**
Takashi Mizokawa

PROGRESS ARTICLE615 **Beyond Boltzmann-Gibbs statistical mechanics in optical lattices**
Eric Lutz and Ferruccio Renzoni**LETTERS**

- 621 **Fully gapped topological surface states in Bi_2Se_3 films induced by a d -wave high-temperature superconductor**
Eryin Wang, Hao Ding, Alexei V. Fedorov, Wei Yao, Zhi Li, Yan-Feng Lv, Kun Zhao, Li-Guo Zhang, Zhijun Xu, John Schneeloch, Ruidan Zhong, Shuai-Hua Ji, Lili Wang, Ke He, Xucun Ma, Genda Gu, Hong Yao, Qi-Kun Xue, Xi Chen and Shuyun Zhou
- 626 **Ferromagnetic exchange, spin-orbit coupling and spiral magnetism at the $\text{LaAlO}_3/\text{SrTiO}_3$ interface**
Sumilan Banerjee, Onur Erten and Mohit Randeria
→N&V p610





Cold atoms trapped in dissipative optical lattices can behave in ways that cannot be described within the framework of Boltzmann-Gibbs statistical mechanics. Recent theoretical and experimental developments may lead to a better understanding of these processes.

Progress Article p615



The relaxation mechanisms of isolated quantum many-body systems are insufficiently understood, but a one-dimensional quantum gas experiment uncovers the local emergence of thermal correlations and their cone-like propagation through the system.

Letter p640; News & Views p607

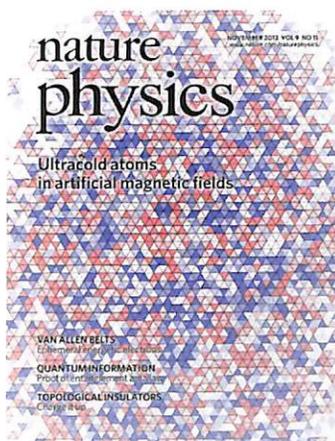
- 631 Harnessing nuclear spin polarization fluctuations in a semiconductor nanowire**
P. Peddibhotla, F. Xue, H. I. T. Hauge, S. Assali, E. P. A. M. Bakkers and M. Poggio
- 636 Spin heat accumulation and spin-dependent temperatures in nanopillar spin valves**
F. K. Dejene, J. Flipse, G. E. W. Bauer and B. J. van Wees
- 640 Local emergence of thermal correlations in an isolated quantum many-body system**
T. Langen, R. Geiger, M. Kuhnert, B. Rauer and J. Schmiedmayer
→N&V p607
- 644 Distribution of entropy production in a single-electron box**
J. V. Koski, T. Sagawa, O-P. Saira, Y. Yoon, A. Kutvonen, P. Solinas, M. Möttönen, T. Ala-Nissila and J. P. Pekola

ARTICLES

- 649 Interaction-driven localization in holography**
Aristomenis Donos and Sean A. Hartnoll
→N&V p609
- 656 Spontaneous creation of Kibble-Zurek solitons in a Bose-Einstein condensate**
Giacomo Lamporesi, Simone Donadello, Simone Serafini, Franco Dalfovo and Gabriele Ferrari
→N&V p605
- 661 Control of the metal-insulator transition in vanadium dioxide by modifying orbital occupancy**
Nagaphani B. Aetukuri, Alexander X. Gray, Marc Drouard, Matteo Cossale, Li Gao, Alexander H. Reid, Roopali Kukreja, Hendrik Ohldag, Catherine A. Jenkins, Elke Arenholz, Kevin P. Roche, Hermann A. Dürr, Mahesh G. Samant and Stuart S. P. Parkin
→N&V p612
- 667 The extreme vulnerability of interdependent spatially embedded networks**
Amir Bashan, Yehiel Berezin, Sergey V. Buldyrev and Shlomo Havlin
- 673 Universality in network dynamics**
Baruch Barzel and Albert-László Barabási
- 682 Erratum**



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**COVER IMAGE**

A quantum gas trapped in an optical lattice of triangular symmetry can now be driven from a paramagnetic to an antiferromagnetic state by a tunable artificial magnetic field.

Article p738

IMAGE: ROBERT HÖPPNER

COVER DESIGN: ALLEN BEATTIE

ON THE COVER

Van Allen belts
Ephemeral energetic electrons
Letter p699

Quantum information
Proof of entanglement area law
Article p721; News & Views p697

Topological insulators
Charge it up
Letter p704

EDITORIAL

683 Russian reformation

COMMENTARY

684 Russian science in danger
Sergei M. Stishov

PERSPECTIVE

686 The fate of statistical isotropy
Ralf Hofmann

THESIS

690 Change is good
Mark Buchanan

BOOKS AND ARTS

691 Buried Glory: Portraits of Soviet Scientists
by Istvan Hargittai
Reviewed by James F. Scott

RESEARCH HIGHLIGHTS

692 Our choice from the recent literature

NEWS & VIEWS

693 Quantum computation: Honesty test
Tomoyuki Morimae

694 Ultracold atoms: An exotic quantum object
Ennio Arimondo and Jun Ye

695 Majorana fermions: A quantum critical approach
Lucas Peeters and David Goldhaber-Gordon

697 Quantum information: From bits to solids
Renato Renner

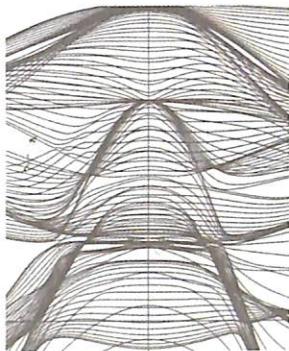
LETTERS

699 Unusual stable trapping of the ultrarelativistic electrons in the Van Allen radiation belts
Yuri Y. Shprits, Dmitriy Subbotin, Alexander Drozdov, Maria E. Usanova, Adam Kellerman, Ksenia Orlova, Daniel N. Baker, Drew L. Turner and Kyung-Chan Kim

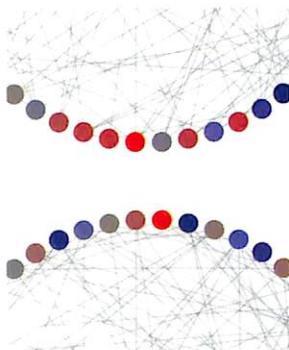
704 Discovery of a single topological Dirac fermion in the strong inversion asymmetric compound BiTeCl
Y. L. Chen, M. Kanou, Z. K. Liu, H. J. Zhang, J. A. Sobota, D. Leuenberger, S. K. Mo, B. Zhou, S.-L. Yang, P. S. Kirchmann, D. H. Lu, R. G. Moore, Z. Hussain, Z. X. Shen, X. L. Qi and T. Sasagawa

709 A large-energy-gap oxide topological insulator based on the superconductor BaBiO₃
Binghai Yan, Martin Jansen and Claudia Felser





An *ab initio* study suggests that a known oxide superconductor, BaBiO_3 , can be doped into a topologically insulating state. This would simplify topological insulator–superconductor structures for applications.
Letter p709



Real-world networks are rarely isolated. A model of an interdependent network of networks shows that an abrupt phase transition occurs when interconnections between independent networks are added. This study also suggests ways to minimize the danger of abrupt structural changes to real networks.
Letter p717

- 712 Nanomechanical coupling between microwave and optical photons**
Joerg Bochmann, Amit Vainsencher, David D. Awschalom and Andrew N. Cleland
- 717 Abrupt transition in the structural formation of interconnected networks**
Filippo Radicchi and Alex Arenas

ARTICLES

- 721 An area law for entanglement from exponential decay of correlations**
Fernando G. S. L. Brandão and Michał Horodecki
→N&V p697
- 727 Experimental verification of quantum computation**
Stefanie Barz, Joseph F. Fitzsimons, Elham Kashefi and Philip Walther
→N&V p693
- 732 Observation of Majorana quantum critical behaviour in a resonant level coupled to a dissipative environment**
H. T. Mebrahtu, I. V. Borzenets, H. Zheng, Y. V. Bomze, A. I. Smirnov, S. Florens, H. U. Baranger and G. Finkelstein
→N&V p695
- 738 Engineering Ising-XY spin-models in a triangular lattice using tunable artificial gauge fields**
J. Struck, M. Weinberg, C. Ölschläger, P. Windpassinger, J. Simonet, K. Sengstock, R. Höppner, P. Hauke, A. Eckardt, M. Lewenstein and L. Mathey
- 744 Vibrational and electronic dynamics of nitrogen-vacancy centres in diamond revealed by two-dimensional ultrafast spectroscopy**
V. M. Huxter, T. A. A. Oliver, D. Budker and G. R. Fleming

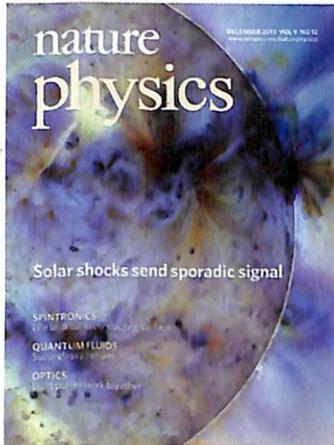
750 Corrigendum

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See the back pages



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**COVER IMAGE**

A combination of measurements from the Solar Dynamics Observatory and radiospectroscopy data from the Nançay Radioheliograph now details the mechanism that connects coronal mass ejections from the Sun and the acceleration of particles to relativistic speeds. A spatial and temporal correlation between a coronal 'bright front' and radio emissions associated with electron acceleration demonstrates the fundamental relationship between the two.
Article p811; News & Views p758

IMAGE: ATMOSPHERIC IMAGING ASSEMBLY
ON NASA'S SOLAR DYNAMICS OBSERVATORY

COVER DESIGN: ALLEN BEATTIE

ON THE COVER**Spintronics**

Life on a superconducting surface
Letter p765; News & Views p756

Quantum fluids
Superglassy helium
Letter p775

Optics
Light pulses work together
Letter p780; News & Views p755

EDITORIAL

- 751 Hot stuff
751 You know who

THESIS

- 752 Time to think

RESEARCH HIGHLIGHTS

- 753 Our choice from the recent literature

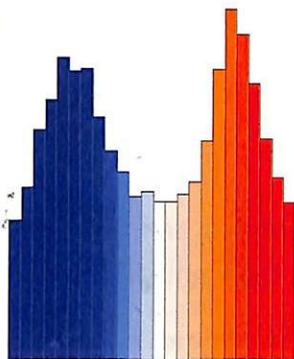
NEWS & VIEWS

- 754 **Magnetically confined plasma: Fusion's Eastern promise?**
William Morris
- 755 **Optics: Negative reaction**
Thomas Philbin
- 756 **Spintronics: How to live longer**
Cyrus F. Hirjibehedin
- 757 **High-temperature superconductors: Plane speaking**
Michael R. Norman
- 758 **Solar physics: Making waves**
Edward W. Cliver
- 759 **Condensed-matter physics: Picking up fine vibrations**
Peter Abbamonte

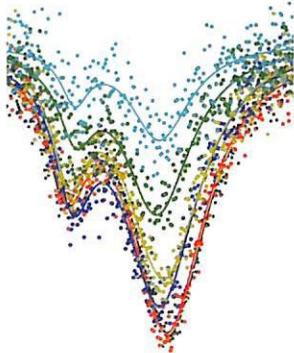
LETTERS

- 761 **Universal quantum oscillations in the underdoped cuprate superconductors**
Neven Barišić, Sven Badoux, Mun K. Chan, Chelsey Dorow, Wojciech Tabis, Baptiste Vignolle, Guichuan Yu, Jérôme Béard, Xudong Zhao, Cyril Proust and Martin Greven
→N&V p757
- 765 **Protection of excited spin states by a superconducting energy gap**
B. W. Heinrich, L. Braun, J. I. Pascual and K. J. Franke
→N&V p756
- 769 **Direct observation of effective ferromagnetic domains of cold atoms in a shaken optical lattice**
Colin V. Parker, Li-Chung Ha and Cheng Chin
- 775 **The superfluid glass phase of $^3\text{He-A}$**
J. I. A. Li, J. Pollanen, A. M. Zimmerman, C. A. Collett, W. J. Gannon and W. P. Halperin
- 780 **Optical diametric drive acceleration through action–reaction symmetry breaking**
Martin Wimmer, Alois Regensburger, Christoph Bersch, Mohammad-Ali Miri, Sascha Batz, Georgy Onishchukov, Demetrios N. Christodoulides and Ulf Peschel
→N&V p755
- 785 **Fast optical modulation of the fluorescence from a single nitrogen–vacancy centre**
Michael Geiselmann, Renaud Marty, F. Javier García de Abajo and Romain Quidant





Ultracold atoms in optical lattices are used to study various phenomena in condensed-matter physics, such as magnetism. A lattice-shaking technique can induce a strong effective spin-interaction, leading to the formation of ferromagnetic domains.
Letter p769



The intensity of optically-pumped fluorescence generated from a single atomic defect in diamond can be reduced by 80% in just 100 ns by applying infrared laser light. This result demonstrates the possibility of using these so-called nitrogen-vacancy centres to create optical switches that operate at room temperature.
Article p806

790 Fourier-transform inelastic X-ray scattering from time- and momentum-dependent phonon-phonon correlations

M. Trigo, M. Fuchs, J. Chen, M. P. Jiang, M. Cammarata, S. Fahy, D. M. Fritz, K. Gaffney, S. Ghimire, A. Higginbotham, S. L. Johnson, M. E. Kozina, J. Larsson, H. Lemke, A. M. Lindenberg, G. Ndabashimiye, F. Quirin, K. Sokolowski-Tinten, C. Uher, G. Wang, J. S. Wark, D. Zhu and D. A. Reis
→N&V p759

ARTICLES

795 Direct measurement of the Zak phase in topological Bloch bands

Marcos Atala, Monika Aidelsburger, Julio T. Barreiro, Dmitry Abanin, Takuya Kitagawa, Eugene Demler and Immanuel Bloch

801 Spintronic magnetic anisotropy

Maciej Misiorny, Michael Hell and Maarten R. Wegewijs

806 Thermal nonlinearities in a nanomechanical oscillator

Jan Gieseler, Lukas Novotny and Romain Quidant

811 Quasiperiodic acceleration of electrons by a plasmoid-driven shock in the solar atmosphere

Eoin P. Carley, David M. Long, Jason P. Byrne, Pietro Zucca, D. Shaun Bloomfield, Joseph McCauley and Peter T. Gallagher
→N&V p758

817 A long-pulse high-confinement plasma regime in the Experimental Advanced Superconducting Tokamak

J. Li, H. Y. Guo, B. N. Wan, X. Z. Gong, Y. F. Liang, G. S. Xu, K. F. Gan, J. S. Hu, H. Q. Wang, L. Wang, L. Zeng, Y. P. Zhao, P. Denner, G. L. Jackson, A. Loarte, R. Maingi, J. E. Menard, M. Rack and X. L. Zou
→N&V p754

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See the back pages



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