SAPIENZA
UNIVERSITÀ DI ROMA

Writing Better Scientific Papers

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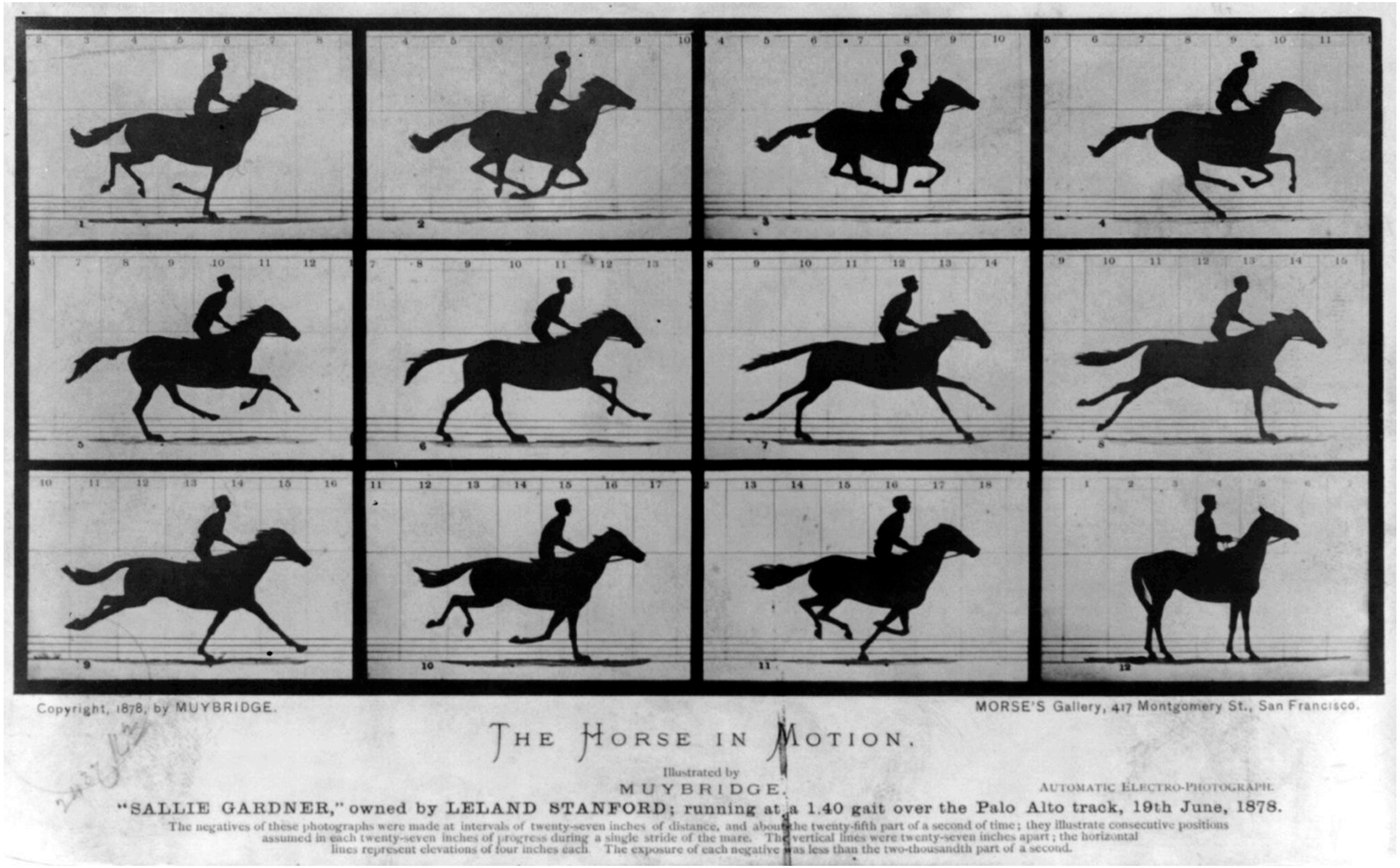
As a scientist you are a professional writer

Why write well?

- ✓ get published
- ✓ get cited
- ✓ get your proposals funded
- ✓ communicate with scientists from other fields
- ✓ develop communication skills useful in any career path



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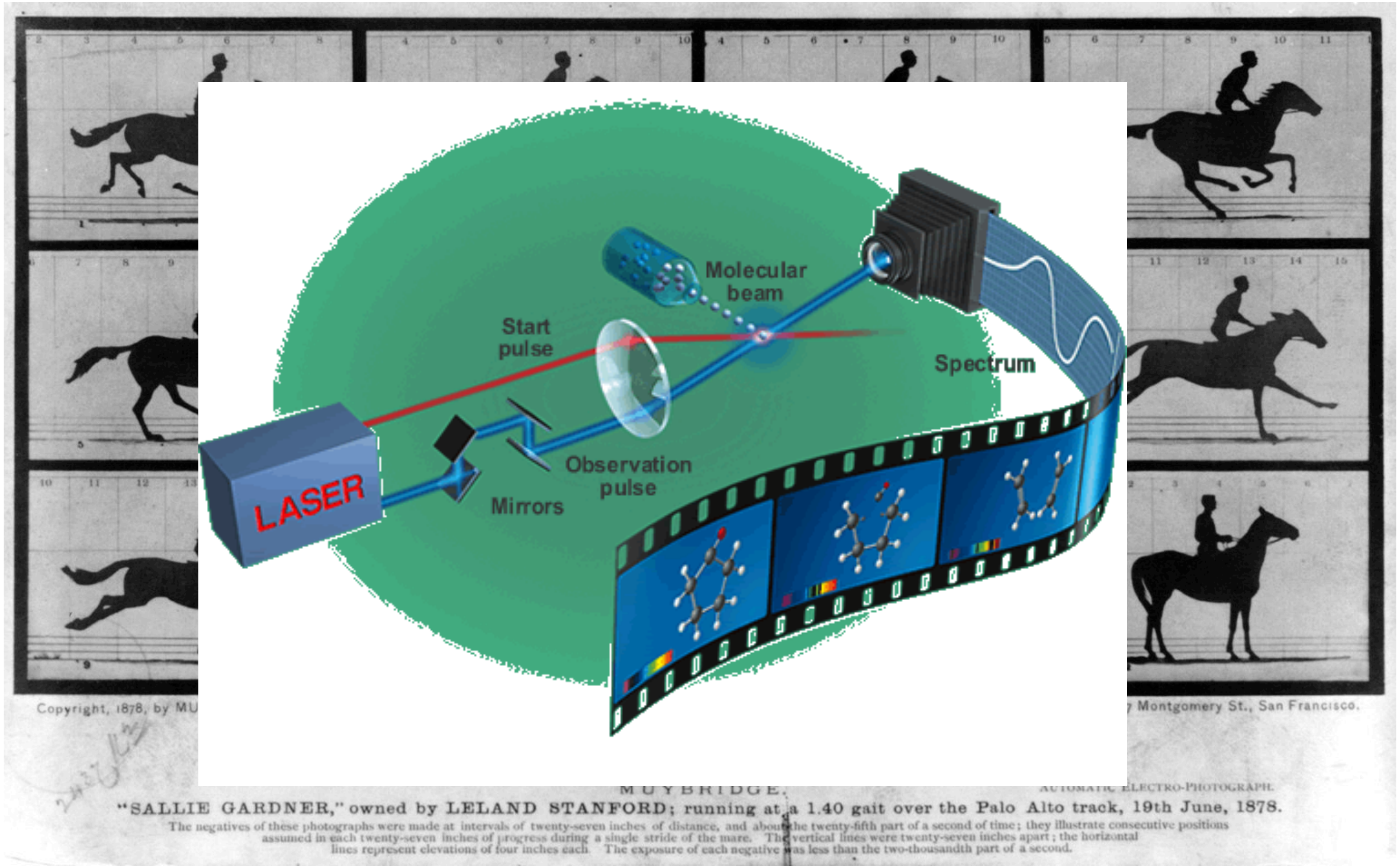
MORSE'S Gallery, 417 Montgomery St., San Francisco.
THE HORSE IN MOTION.
Illustrated by
MUYBRIDGE.
AUTOMATIC ELECTRO-PHOTOGRAPH.
"SALLIE GARDNER," owned by LELAND STANFORD; running at a 1.40 gait over the Palo Alto track, 19th June, 1878.
The negatives of these photographs were made at intervals of twenty-seven inches of distance, and about the twenty-fifth part of a second of time; they illustrate consecutive positions assumed in each twenty-seven inches of progress during a single stride of the mare. The vertical lines were twenty-seven inches apart; the horizontal lines represent elevations of four inches each. The exposure of each negative was less than the two-thousandth part of a second.


Molecular beam
Start pulse
Spectrum
LASER
Mirrors
Observation pulse
Copyright, 1878, by MU
Montgomery St., San Francisco.
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"SALLIE GARDNER," owned by LELAND STANFORD; running at a 1.40 gait over the Palo Alto track, 19th June, 1878.
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TODAY'S HEADLINES

July 21, 2003
Volume 81, Number 29
CENEAR 81 29 p. 7
ISSN 0009-2347

SCIENCE

TWO FAST STUDIES OF LIQUID WATER

Experiments explore ion solvation and proton transfer in water

LOUISA DALTON

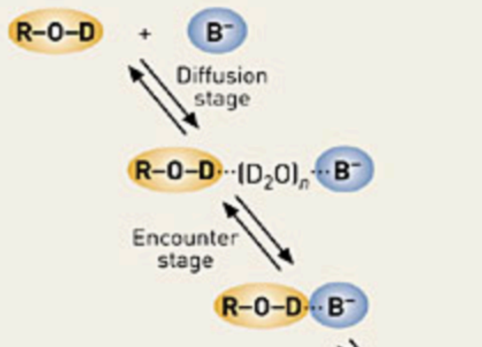
Water can be slippery. Despite centuries of study, experimental details about its rapidly shifting hydrogen-bond network remain elusive. Two reports this week make headway by using rapid-fire femtosecond spectroscopy to probe basic water phenomena: transferring a proton and dissolving a salt.

Researchers in Germany and Israel measured the speed of proton transfer from acid to base in water and propose a detailed mechanism [*Science*, **301**, 349 (2003)].

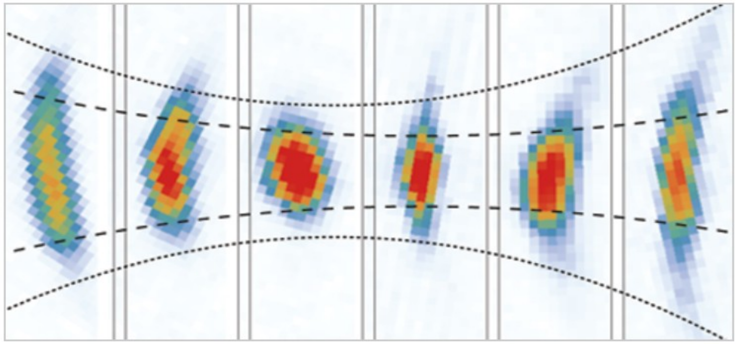
This "simple and elementary process" has historically been divided into three steps, notes coauthor Matteo Rini, a

BRIEF INTERLUDE

Proton-transfer model includes an extra encounter stage



Bringing Science to Politics

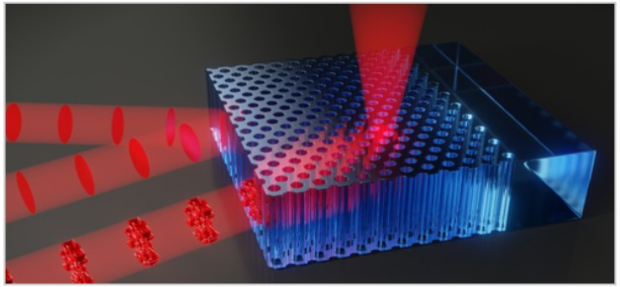


SYNOPSIS

How to Focus a Bose-Einstein Condensate in a Waveguide

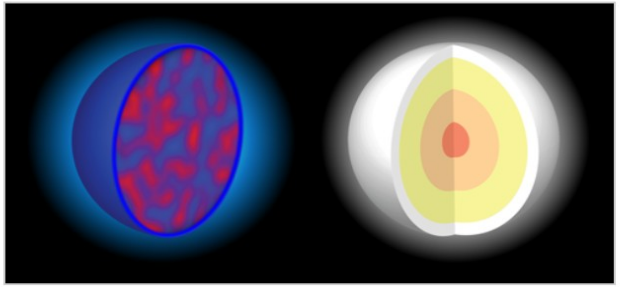
April 28, 2021

A new “lensing” technique counters the spreading of an ultracold cloud of atoms inside a tiny waveguide. **Read More »**



SYNOPSIS

Steering Light Within a Crystal



VIEWPOINT

Probing the Skin of a Lead Nucleus

RESEARCH NEWS

Crackdown on Spying Damages US Science, Says

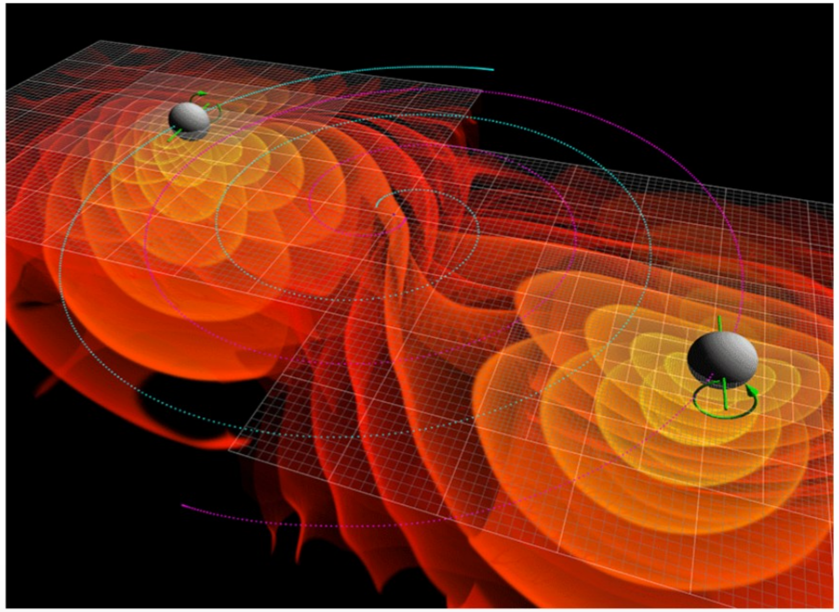
Physics

VIEWPOINT

The First Sounds of Merging Black Holes

Gravitational waves emitted by the merger of two black holes have been detected, setting the course for a new era of observational astrophysics.

by Emanuele Berti*,†



For decades, scientists have hoped they could "listen in" on violent astrophysical events by detecting their emission of gravitational waves. The waves, which can be described as oscillating distortions in the geometry of spacetime, were first predicted to exist by Einstein in 1916, but they have never been observed directly. Now, in an extraordinary paper, scientists report that they have detected the waves at the Laser Interferometer Gravitational-wave Observatory (LIGO) [1]. From an analysis of the signal, researchers from LIGO in the US, and their collaborators from the Virgo interferometer in Italy, infer that the gravitational waves were produced by the inspiral and merger of two black holes (Fig. 1), each with a mass that is more than 25 times greater than that of our Sun. Their finding provides the first observational evidence that black hole binary systems can form and merge in the Universe.

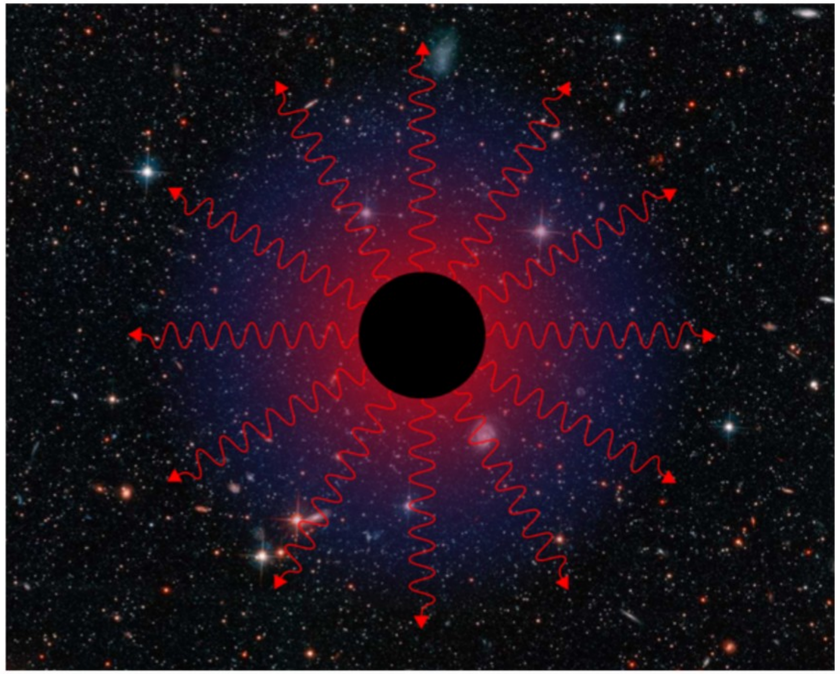
Physics

VIEWPOINT

Black Holes Have Soft Quantum Hair

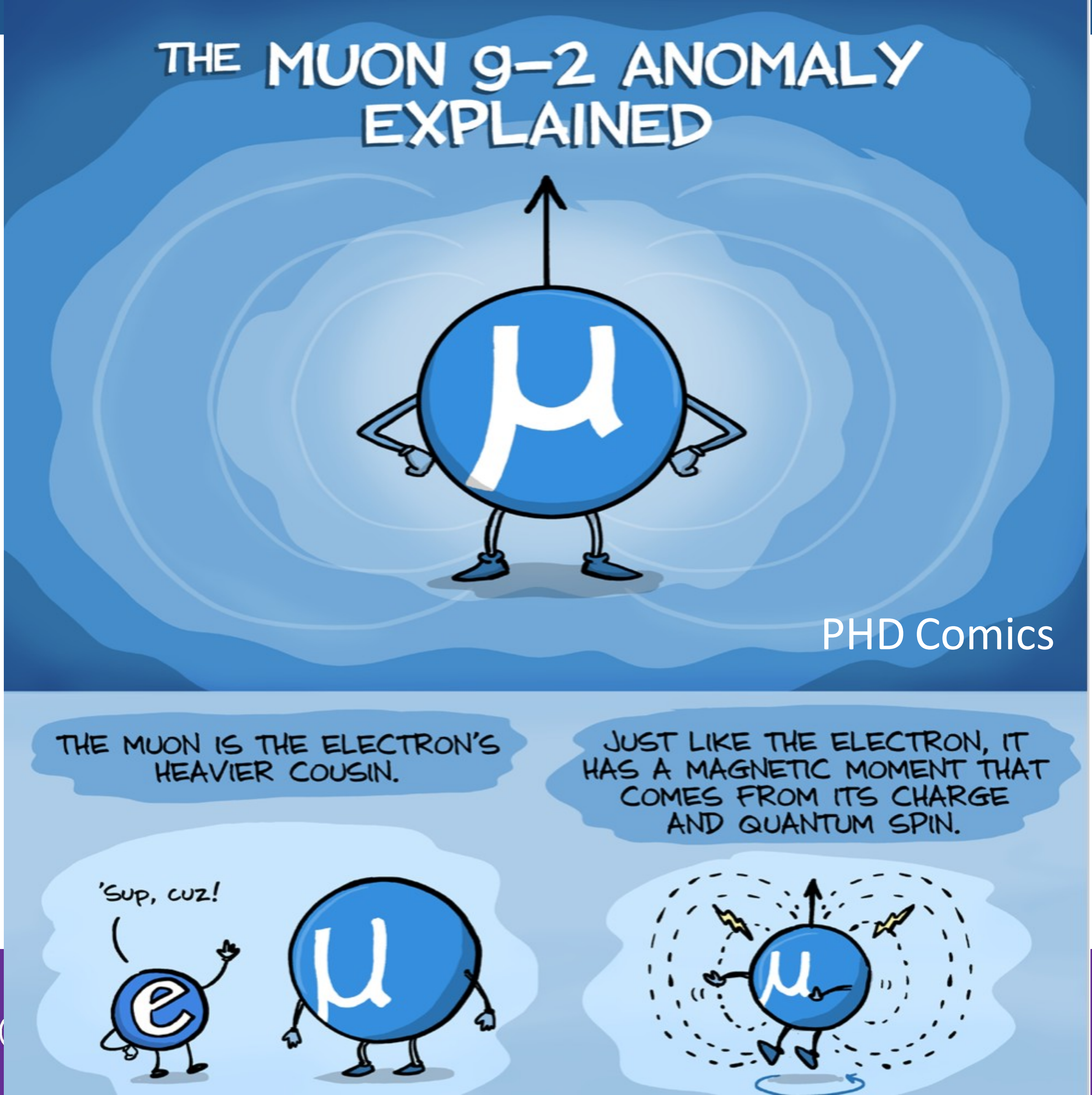
A black hole may carry "soft hair," low-energy quantum excitations that release information when the black hole evaporates.

by Gary T. Horowitz*



Four decades ago, Stephen Hawking proposed that black holes could destroy information—a conclusion that is incompatible with standard laws of quantum physics. This idea started a controversy known as the "black hole information problem" that even now has not been resolved. A new study by Hawking himself and Malcom Perry, both at the University of Cambridge, and by Andrew Strominger at Harvard University shows that some of the assumptions that led to the information problem might be wrong [1]. Their results do not completely solve the problem, but point to a promising research direction that might lead to its long-awaited solution.

According to Einstein's general theory of relativity, stationary black holes are completely determined by just three observable parameters: their mass, charge, and angular momentum. Almost none of the information about what fell into the black hole is visible from the outside. Physicist John


THE MUON g-2 ANOMALY EXPLAINED
μ
THE MUON IS THE ELECTRON'S HEAVIER COUSIN.
'SUP, CUZ!
e
μ
JUST LIKE THE ELECTRON, IT HAS A MAGNETIC MOMENT THAT COMES FROM ITS CHARGE AND QUANTUM SPIN.
μ

PHD Comics

1. Find the best science
2. Communicate it

Finding the best science

MOTIVATION Why this research?

OPEN QUESTIONS What are the specific research needs?

KEY RESULT What is really new?

IMPACT What are the implications of the result?

Editing 100s of Scientists

Some (uncommon) resistance

"…you are simplifying too much. They'll think I am stupid…"

"…if a scientist does not know what a Lyapunov exponent is, he (and you) should just go back to school. I am not going to waste time explaining it…"

"…you have massacred my text…once again…there is no way to explain this without Hamiltonian equations"

Challenges

- Talking to your supervisors/competitors/colleagues
  - talking to someone who already knows, jargon
  - talking to impress, to be evaluated
  - communicating the "how"
- The curse of knowledge
- Not relating to the audience

Overcome these challenges

- Write with the reader in mind
- Practice

  Clear, effective writing/communication can be learned!
- Read, read, read!

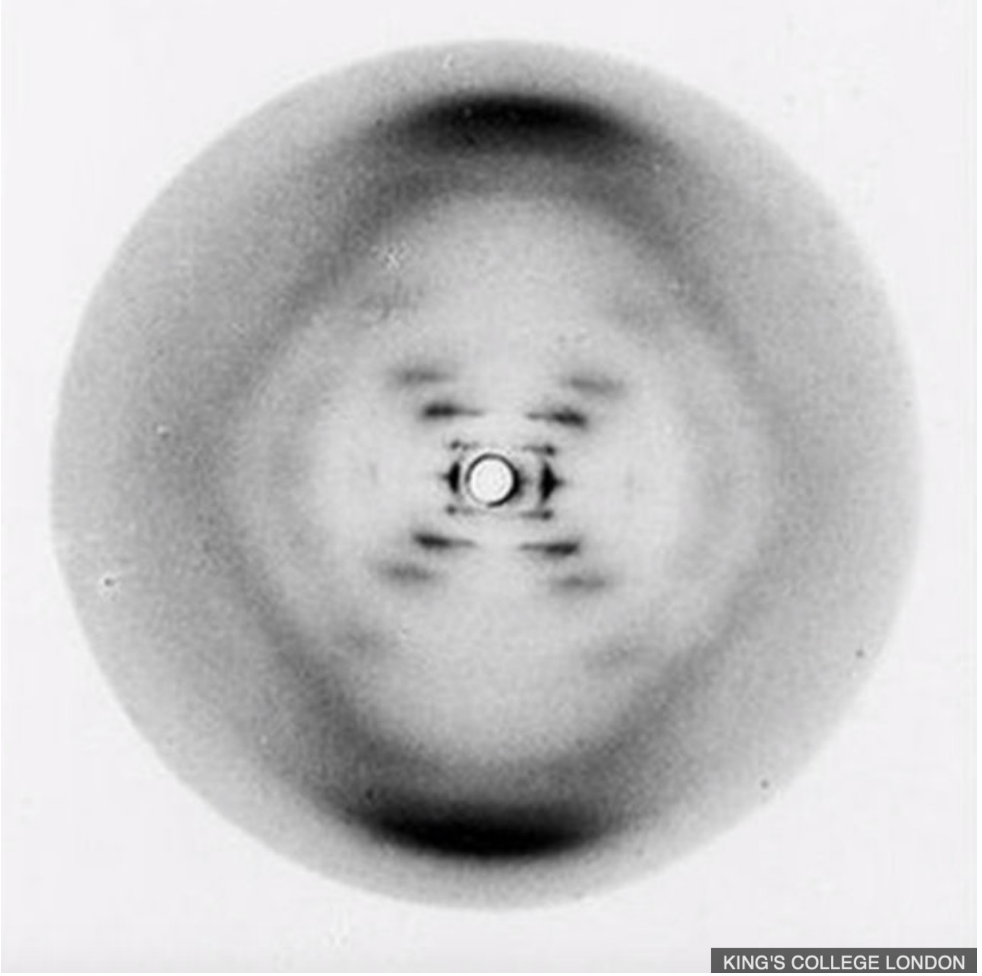
There is little correlation between English proficiency and writing skills

Stages of writing

1. **Find your story**
2. Build a story structure
3. Find the best language for the story:

   Apply effective writing strategies

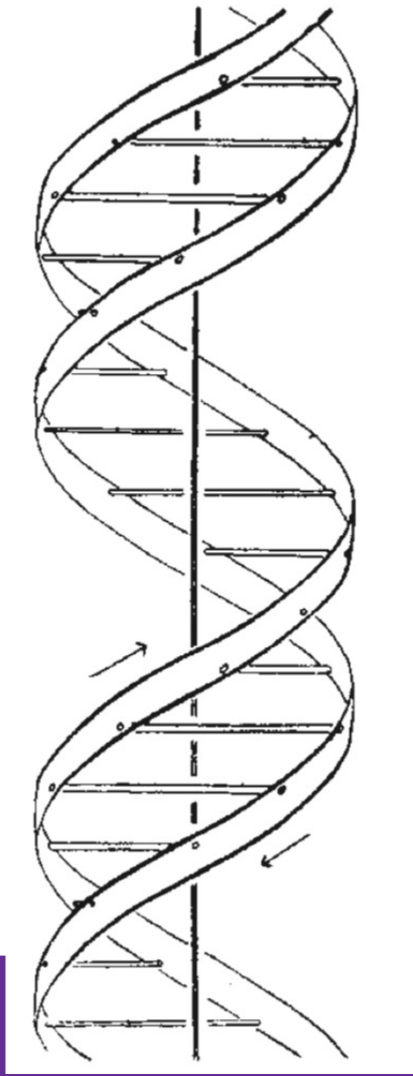
Data vs Story: DNA



R. E. Franklin and R. G. Gosling, "Molecular Configuration in Sodium Thymonucleate,"
Nature 171 (1953): 740–41.

"Sodium thymonucleate fibres give two distinct types of X-ray diagram."

Data vs Story: DNA



J. D. Watson and F. H. C. Crick, "Molecular Structure of Nucleic Acids — A Structure for Deoxyribose Nucleic Acid," Nature 171 (1953): 737–38.

"We wish to suggest a structure for the salt deoxyribose nucleic acid (DNA). The structure has novel features which are of considerable biological interest."

Every paper tells (not more than) one story

Stages of writing

1. Find your story
2. **Build a story structure**
3. Find the best language for the story:
   Apply effective writing strategies

Classic structure for a scientific paper

1. Context (the broad "why")
2. Research needs (a more specific "why")
3. What we did and found (the "how")
4. Implications (the "so what")

Three-dimensional reconstruction of the giant mimivirus particle with an X-ray free-electron laser

Tomas Ekeberg,[1] Martin Svenda,[1] Chantal Abergel,[2] Filipe R. N. C. Maia,[1,3] Virginie Seltzer,[2] Jean-Michel Claverie,[2] Max Hantke,[1] Olof Jönsson,[1] Carl Nettelblad,[1] Gijs van der Schot,[1] Mengning Liang,[4] Daniel P. De Ponte,[4] Anton Barty,[4] M. Marvin Seibert,[1,5] Bianca Iwan,[1,6] Inger Andersson,[1] N. Duane Loh,[7] Andrew V. Martin,[8] Henry Chapman,[4,9] Christoph Bostedt,[5] John D. Bozek,[5] Ken R. Ferguson,[5] Jacek Krzywinski,[5] Sascha W. Epp,[10] Daniel Rolles,[10] Artem Rudenko,[11] Robert Hartmann,[12] Nils Kimmel,[13,14] and Janos Hajdu[1,15]

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[2] *Génomique & Structurale - IGS - UMR 7256, CNRS, Aix-Marseille Université, Institut de Microbiologie de la Méditerranée, Parc Scientifique de Luminy, Case 934, 13288 Marseille Cedex 9, France*
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[5] *LCLS, SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, CA 94025, USA*
[6] *Attophysics Group, CEA-Saclay, 91191 Gif sur Yvette Cedex, France*
[7] *Centre for BioImaging Sciences, National University of Singapore, 14 Science Drive 4 Blk S1A, Singapore 117546*
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[9] *University of Hamburg, Notkestrasse 85, 22607 Hamburg, Germany*
[10] *Max Planck Advanced Study Group, Center for Free Electron Laser Science, Notkestrasse 85, 22607 Hamburg, Germany*
[11] *J.R. Macdonald Laboratory, Department of Physics, Kansas State University, 116 Cardwell Hall, Manhattan, KS 66506, USA*
[12] *PNSensor GmbH, Römerstr. 28, 80803 München, Germany*
[13] *Max-Planck-Institut Halbleiterlabor, Otto-Hahn-Ring 6, 81739 München*
[14] *Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse, 85741 Garching, Germany*
[15] *European XFEL, Albert-Einstein-Ring 19, 22761, Hamburg, Germany*

We present a proof-of-concept three-dimensional reconstruction of the giant Mimivirus particle from experimentally measured diffraction patterns from an X-ray free-electron laser. Three-dimensional imaging requires the assembly of many two-dimensional patterns into an internally consistent Fourier volume. Since each particle is randomly oriented when exposed to the X-ray pulse, relative orientations have to be retrieved from the diffraction data alone. We achieve this with a modified version of the expand, maximize and compress (EMC) algorithm and validate our result using new methods.

1

INTRODUCTION

...tron lasers provide femtosecond X-ray pulses ...k brilliance ten billion times higher than any ...available X-ray source. Such a large jump ...sical quantity is very rare, and can have far ...plications for several areas of science. It has ...ted that such pulses could outrun key damage processes and allow structure determination without the need for crystallization[1]. In 2006 came the first verification of this "diffraction before destruction" method with the reconstruction of a silicon nitride nanostructure created with a focused ion beam (FIB) and exposed to the FLASH free-electron laser in Hamburg[2].

So far, imaging applications at FELs have mainly been limited to nanocrystallography and to two-dimensional projections of single particles while 3D reconstructions from single particles have remained elusive.

Nanocrystallography[1][3] is an extension to protein crystallography where the high intensity and short pulse duration of a FEL allow for the use of very small crystals. Some proteins only produce small crystals. However, the fundamental problem that some samples are hard or impossible to crystallize is still valid. For this reason, single-particle imaging was a key part of the scientific case for building X-ray free-electron lasers.

2D imaging with FELs such as the imaging of live cells[4][5], organelles[6] and viruses[7] is a promising method for imaging irreproducible samples. A resolutions down to 21 nm have been achieved on Carboxysomes in a recent study[6]. There is also one application where a 2D image from a single-shot FEL experiment was compared to regular X-ray diffraction tomography performed at a synchrotrons[8]. In a recent paper the structure of simple gold nanostructures were recovered in 3D from one single diffraction patterns[9]. This technique is however restricted to structurally simple and strongly scattering structures with a high degree of symmetry.

Several fundamental challenges exist for a general method of 3D single-particle imaging. First, 3D imaging requires the assembly of diffraction patterns from many identical copies of a reproducible object. Many of the applications of 2D imaging so far have been dealing with cells or other particles where each sample is structurally unique. Second, there is no way to directly measure the orientation of the sample when it was hit in the X-ray pulse. Instead the orientation of each sample particle has to be recovered from the noisy signal of the diffraction patterns.

Solving these problems not only gives more information about the sample by presenting the structure in 3D, it is also a necessity for extending signal from weakly scattering samples such as proteins and small viruses. For these samples the scattering from a single particle may be too weak for reconstructing a 2D projection image and increasing the signal to noise ratio (SNR) by merging many patterns could allow for phasing even in this case.

A solution to the orientation problem was proposed by Duane Loh and Veit Elser in 2009 with the expand, maximize and compress (EMC) algorithm [10] which was verified for simulated diffraction patterns in the original publication. Later the algorithm was also tested for an artificial sample although at a resolution that was too low to allow for phase retrieval[11]. This paper presents the first application of the algorithm to a biological sample.

The sample used in this study was the Mimivirus (Acanthamoeba polyphaga mimivirus) particle[12][13][14]. Mimivirus is one of the largest known viruses. The viral capsid is about 450 nanometers in diameter and is covered by a layer of thin fibres. A 3D structure of the viral capsid exist[14] but the 3D structure of the inside is currently unknown.

2

...ERIMENTAL SETUP AND DATA PREPROCESSING

...s particles were aerosolized and then focused ... particle stream using an aerodynamic lens. ...f particles was intersected with the pulse train ...c Coherent Light Source (LCLS). Diffracted ...llected on a detector placed 0.7 m downstream ...action region. At this distance the collected diffraction signal corresponds to the amplitude squared of a slice through the Fourier transform of the electron density of the sample. Mimivirus particles that were not hit by the FEL were shown to remain infectious after the injection process suggesting that they were not harmed by the injection process. A detailed description of the setup can be found in the Supplemental Material. A total of 198 diffraction patterns were selected and preprocessed and a subset fo 25 of these are shown in FIG. 1. The selection preprocessing and selection is explained in supplemental material.

3

ORIENTATION RECOVERY

...imensional structure determination requires ...bly of many 2D diffraction-patterns into an ...consistent 3D Fourier volume. A diffraction ...presents an Ewald-sphere slice through the 3D Fourier-transform of the electron density. Since each particle is randomly orientated when exposed to the X-ray pulse, the relative orientations of the particles have to be retrieved from the diffraction data alone. This was done using a modified version of the EMC algorithm[10]. This algorithm has been verified for simulated data[10] and has been experimentally tested using artificial "nanorice" particles at a resolution too low to permit phase retrieval[11].

In the EMC algorithm a 3D diffraction space is iteratively updated to comply with the experimental data in the three steps expand, maximize and compress. In the expand step the current diffraction space is expanded into tomograms by taking slices through the diffraction space at a discrete sampling of all rotations. In the maximize step all tomograms are compared to all experimental diffraction patterns by calculating the probability of detecting the experimental pattern while treating the tomograms as expectation values. New tomograms are then created by summing together all diffraction patterns weighted by the respective calculated probability. In the compress step a new 3D diffraction space is assembled from the new tomograms.

For this study we introduce a new similarity function in the maximize step that is based on a Gaussian model:

$$L(K, M) = \prod_i e^{-\frac{(M_i - K_i)^2}{2\sigma_i^2}} \quad (1)$$

where K is the diffraction pattern, M is the slice through the 3D diffraction space, i is the pixel index and σ_i is the standard deviation of the Gaussian. We set $\sigma_i = A\sqrt{M_i}$ where A is a constant. This similarity function balances well the contribution from the few but high-intensity central pixels and the numerous low-intensity outer pixels.

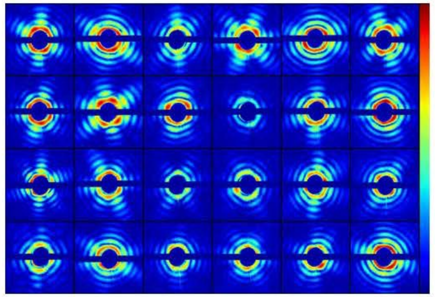

FIG. 1. 24 of the 198 diffraction patterns that were included in the analysis. The central region is missing due to a hole in the detector that lets the beam through. Patterns were selected for having signal to beyond 83 nm^{-1} but not saturating the detector.

Physical
journals.ap

Paragraphs

Make the paragraph the unit of composition.

— Strunk and White, *Elements of Style*

Each paragraph should convey a coherent **"unit of thought,"** which might be summarized in a **"focal sentence"**. Two important options:

Point-first paragraph

Point-last paragraph

Point-First Paragraph

The basic features of GW150914 point to it being produced by the coalescence of two black holes—i.e., their orbital inspiral and merger, and subsequent final black hole ringdown. Over 0.2 s, the signal increases in frequency and amplitude in about 8 cycles from 35 to 150 Hz, where the amplitude reaches a maximum. The most plausible explanation for this evolution is the inspiral of two orbiting masses, m1 and m2, due to gravitational-wave emission. At the lower frequencies, such evolution is characterized by the chirp mass [11]

of wetland complexes, including the Birds of Paradise wetland field complex that is five times larger than earlier remote and ground survey had indicated, and revealed a previously unknown wetland field complex that is even larger. The field systems date mainly to the Maya Late and Terminal Classic (~1,400–1,000 y ago), but with evidence from as early as the Late Preclassic (~1,800 y ago) and as late as the Early Postclassic (~900 y ago). Previous study showed that these were polycultural systems that grew typical ancient Maya crops including maize, arrowroot, squash, avocado, and other fruits and harvested fauna. The wetland fields were active at a time of population expansion, landscape alteration, and droughts and could have been adaptations to all of these major shifts in Maya civilization. These wetland-farming systems add to the evidence for early and extensive human impacts on the global tropics. Broader evidence suggests a wide distribution of wetland agroecosystems across the Maya Lowlands and Americas, and we hypothesize the increase of atmospheric carbon dioxide and methane from burning, preparing, and maintaining these field systems contributed to the Early Anthropocene.

lidar | ancient Maya | wetland agroecosystems

Precolumbian Maya civilization persisted from ~3,000 to 1,000 or 500 calibrated years before present (BP), building vast numbers of cities, farms, roads, and reservoirs. Over the last decade, lidar (light detection and ranging) imagery has greatly expanded our estimate of ancient infrastructure that ground survey had laboriously identified for more than a century (1, 2). This massive

herently difficult to excavate, and widespread recent plowing, draining, and deforestation are destroying many relict field systems (28). Fortunately, tropical forest cover is still extensive in some areas such as Guatemala's Petén, where a recent *Science* article estimated 67 km^2 of seasonally wet, canalized fields based on lidar mapping with some ground validation beneath the forest canopy (1). These Petén field systems and canals will require further extensive validation, excavation, dating, and multiple proxy evidence to confirm their uses, chronologies, and extents over Maya history.

We report here the verification of widespread ancient Maya wetland fields in the Rio Bravo watershed of Belize based on lidar data and many excavations with multiple lines of evidence for cultivars, formation, and chronology (Fig. 1). These ancient wetland systems occur in four main areas within the watershed. We focus on the area with the most evidence thus far, the Birds of Paradise (BOP) fields (26, 27), to present a synthesis of formation, use, and chronology based on 42 radiocarbon ages, including 15 from six wetland excavations (Fig. 2 and *SI Appendix*, Table S1; these include all radiocarbon ages amassed for the BOP fields and

Significance

Understanding agricultural subsistence is vital for understanding past complex societies. Lidar data are indicating widespread ancient Maya infrastructure. Wetland agriculture was crucial to ancient cultures, but no previous study coupled lidar with multiproxy evidence to demonstrate the extent and uses of Maya wetland fields. We conducted a lidar survey

Stages of writing

1. Find your story
2. Build a story structure
3. **Find the best language for the story:**
   Apply effective writing strategies

Economy and lightness

- Do not speak in a stuffy manner for a judgmental audience
- Economy

"**The secret of good writing is to strip every sentence to its cleanest components.** Every word that serves no function, every long word that could be a short word, every adverb that carries the same meaning that's already in the verb, every passive construction that leaves the reader unsure of who is doing what—these are the thousand and one adulterants that weaken the strength of a sentence."

William Zinsser in *On Writing Well*, 1976

Quickness & lightness

- **Recognizing and cutting clutter**
  "This work sheds new light on the physics of nuclear fusion…"
- **Adverbs are often useless**
  very, really, quite, basically, generally, significantly, remarkably…
- **Use jargon only when needed**
  The avian species -> Birds?
- **Active vs passive voicing**
  Passive voicing leaves an open question (who did it?)

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  Passive voicing leaves an open question (who did it?)

Quickness and lightness

- **Cut all unnecessary words**

  "This work sheds new light on the physics of nuclear fusion…"
- **Adverbs are often useless**

  very, really, quite, basically, generally, significantly, remarkably…
- **Use jargon only when needed**

  The avian species -> Birds?
- **Active vs passive voicing**

  Passive voicing leaves an open question (who did it?)

Use short sentences!

Techniques for the direct phase modulation of laser diodes, typically based on the control of the applied current or voltage and always associated with a very dramatic amplitude and/or frequency modulation of the emitted light, have been available for decades, while being insufficiently reliable for high-bit-rate communications and quantum key distribution applications.

Use short sentences!

Techniques for modulating the phase of laser diodes have have been available for decades.

They are typically based on the control of the applied current or voltage.

However, because such methods are always associated with a dramatic amplitude and/or frequency modulation, they are unsuitable for high-bit-rate communications and quantum key distribution applications.

Few Examples

Clunky phrase	Equivalent
• A majority of	most
• A number of	many
• Are of the same opinion	agree
• At the present moment	now
• By means of	by
• Less frequently occurring	rare
• small/large in size	small/large

Do we need to depersonalize science?

844 Sitzung der physikalisch-mathematischen Klasse vom 25. November 1915

Die Feldgleichungen der Gravitation.

Von A. Einstein.

In zwei vor kurzem erschienenen Mitteilungen[1] habe ich gezeigt, wie man zu Feldgleichungen der Gravitation gelangen kann, die dem Postulat allgemeiner Relativität entsprechen, d. h. die in ihrer allgemeinen Fassung beliebigen Substitutionen der Raumzeitvariabeln gegenüber kovariant sind.

Der Entwicklungsgang war dabei folgender. Zunächst fand ich Gleichungen, welche die Newtonsche Theorie als Näherung enthalten

BEFORE TITLE: On the breakdown of the Born-Oppenheimer approximation for conical intersections of potential-energy surfaces of the same symmetry

AFTER TITLE: Diabolical Conical Intersections

“I have observed that the Hamiltonian philosophy is like avocado: you either like it or you don’t”

[P.J. Morrison, Rev. Mod. Phys. 70, 467 (1998)].

“Radiative fluxes from 1987A are still changing on time scales short compared to journal publication time scales”

[Virginia Trimble, Rev. Mod Phys. 60, 859 (1988)].

“The difference between the two types of variables can be elucidated by describing two ways of watching fish. In the Eulerian picture one stays at a point and watches whatever fish happen by; in the Lagrangian picture one picks out a particular fish and keeps track of where it goes”

[P. J. Morrison, Rev. Mod. Phys. 70, 467 (1998)].

Visibility

"…a basic human faculty: the power of … thinking in terms of images."
(I. Calvino)

Let the figures tell the story!

"We wish to suggest a structure for the salt deoxyribose nucleic acid (DNA). The structure has novel features which are of

No. 4356 April 25, 1953 NATURE 737

equipment, and to Dr. G. E. R. Deacon and the captain and officers of R.R.S. *Disc* … part in making the observations.

[1] Young, F. B., Gerrard, H., and Jevons, W. … (1920).
[2] Longuet-Higgins, M. S., *Mon. Not. Roy. Astr* … 5, 285 (1949).
[3] Von Arx, W. S., Woods Hole Papers in Phy … (3) (1950).
[4] Ekman, V. W., *Arkiv. Mat. Astron. Fysik.* (St …

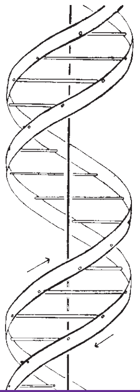
MOLECULAR STRUC… NUCLEIC ACID

A Structure for Deoxyribose …

WE wish to suggest a struct… of deoxyribose nucleic acid … structure has novel features which a… biological interest.

A structure for nucleic acid h… proposed by Pauling and Corey[1]. T… their manuscript available to us… publication. Their model consist… twined chains, with the phosphate… axis, and the bases on the outside… this structure is unsatisfactory f… (1) We believe that the material… X-ray diagrams is the salt, not the f… the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Fur-

is a residue on each chain every 3·4 A. in the z-direc-…

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the con-

Tips:
- Build the paper around figures
- Do figures & captions tell a clear story?

Three-dimensional reconstruction of the giant mimivirus particle with an X-ray free-electron laser

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We present a proof-of-concept three-dimensional reconstruction of the giant Mimivirus particle from experimentally measured diffraction patterns from an X-ray free-electron laser. Three-dimensional imaging requires the assembly of many two-dimensional patterns into an internally consistent Fourier volume. Since each particle is randomly oriented when exposed to the X-ray pulse, relative orientations have to be retrieved from the diffraction data alone. We achieve this with a modified version of the expand, maximize and compress (EMC) algorithm and validate our result using new methods.

1

INTRODUCTION

...ron lasers provide femtosecond X-ray pulses ... brilliance ten billion times higher than any ... available X-ray source. Such a large jump ... ical quantity is very rare, and can have far ... plications fo... eral areas of science. It has ... ted that such ... processes and allow stru... need for crystallization[1]. In 2006 came the first verification of this "diffraction before destruction" method with the reconstruction of a silicon nitride nanostructure created with a focused ion beam (FIB) and exposed to the FLASH free-electron laser in Hamburg[2].

So far, imaging applications at FELs have mainly been limited to nanocrystallography and to two-dimensional projections of single particles while 3D reconstructions from single particles have remained elusive.

Nanocrystallography[1][3] is an extension to protein crystallography where the high intensity and short pulse duration of a FEL allow for the use of very small crystals.

particle imaging was a key part of the scientific case for building X-ray free-electron lasers.

2D imaging with FELs such as the imaging of live cells[4][5], organelles[6] and viruses[7] is a promising method for imaging irreproducible samples. A resolutions down to 21 nm have been achieved on Carboxysomes in a recent study[6]. There is also one ap... ...ngle-shot FEL ex... ...X-ray diffraction tomography performed at a synchrotron[8]. In a recent paper the structure of simple gold nanostructures were recovered in 3D from one single diffraction patterns[9]. This technique is however restricted to structurally simple and strongly scattering structures with a high degree of symmetry.

Every researcher

2

...ERIMENTAL SETUP AND DATA PREPROCESSING

...s particles were aerosolized and then focused ... particle stream using an aerodynamic lens. ...f particles was intersected with the pulse train ... Coherent Light Source (LCLS). Diffracted ...lected on a detector placed 0.7 m downstream ...action region. At this distance the collected diffraction signal corresponds to the amplitude squared of a slice through the Fourier transform of the electron density of the sample. Mimivirus particles that were not hit by the FEL were shown to remain infectious after the injection process suggestin... by the injection process. ... setup can be found in the ... total of 198 diffraction pat... processed and a subset fo... 1. The selection preprocess... in supplemental material.

ORIENTATIO...

...imensional structure determination requires ...

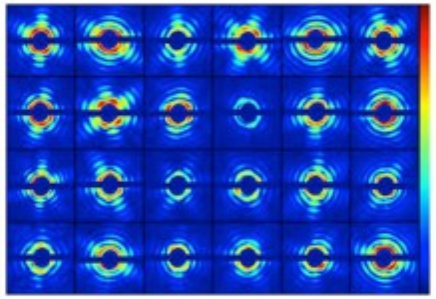

FIG. 1. 24 of the 198 diffraction patterns that were included in the analysis. The central region is missing due to a hole in the detector that lets the beam through. Patterns were selected for having signal to beyond 83 nm^{-1} but not saturating the detector.

Fourier-transform of the electron density. Since each particle is randomly orientated when exposed to the X-ray pulse, the relative orientations of the particles have to be retrieved from the diffraction data alone. This was done using a modified version of the EMC algorithm[10]. This algorithm has been verified for simulated data[10] and has been experimentally tested using artificial "nanorice" particles at a resolution too low to permit phase retrieval[11].

In the EMC algorithm a 3D diffraction space is iteratively updated to comply with the experimental data in the three steps expand, maximize and compress. In the expand step the current diffraction space is expanded into tomograms by taking slices through the diffraction space at a discrete sampling of all rotations. In the maximize step all tomograms are compared to all experimental diffraction patterns by calculating the probability of detecting the experimental pattern while treating the tomograms as expectation values. New tomograms are then created by summing together all diffraction patterns weighted by the respective calculated probability. In the ... ...on space is assembled

Researchers in the field

...ew similarity function ... on a Gaussian model:

... (1)

M is the slice through ... pixel index and σ_i is the standard deviation of the Gaussian. We set $\sigma_i = A\sqrt{M_i}$ where A is a constant. This similarity function

Physics magazine

Give your paper a “hourglass” structure

everyone

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expert

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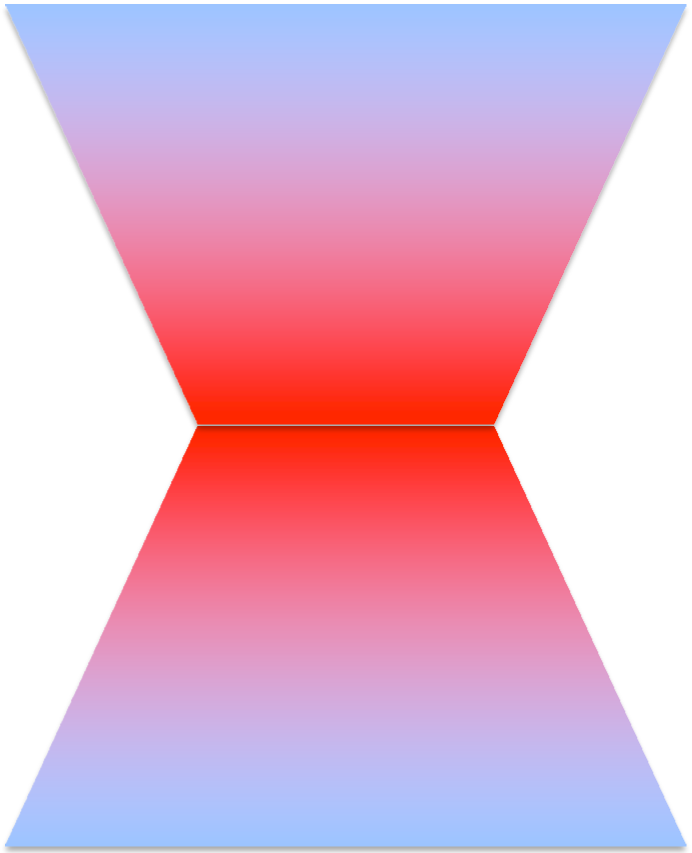
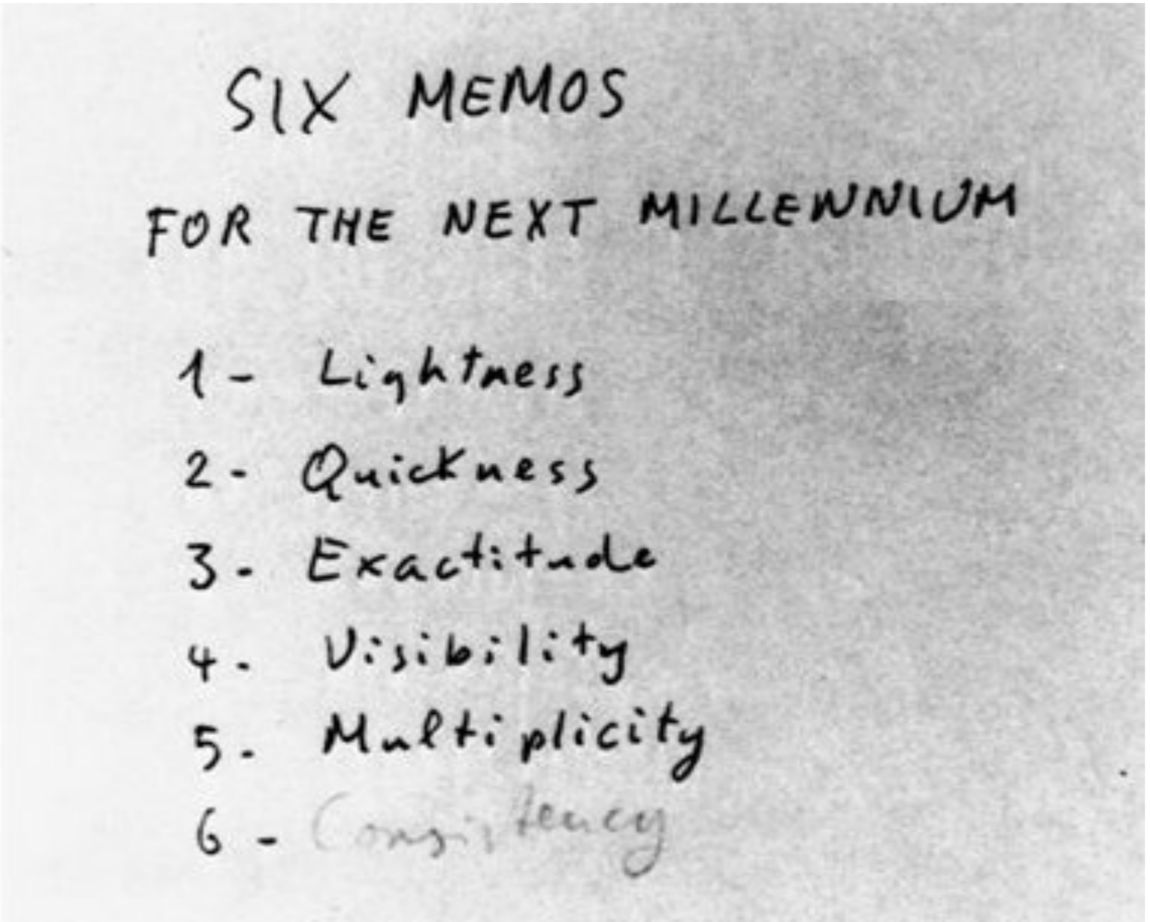
everyone



6 memos for the author of a scientific paper



* Italo Calvino's *Six Memos for the Next Millennium* (Charles Eliot Norton Lectures at Harvard)

Consistency

As a scientist
you are a professional writer

Find your own voice!

Review of Modern Physics: Style guide
APPEDIX A: Writing a better scientific article

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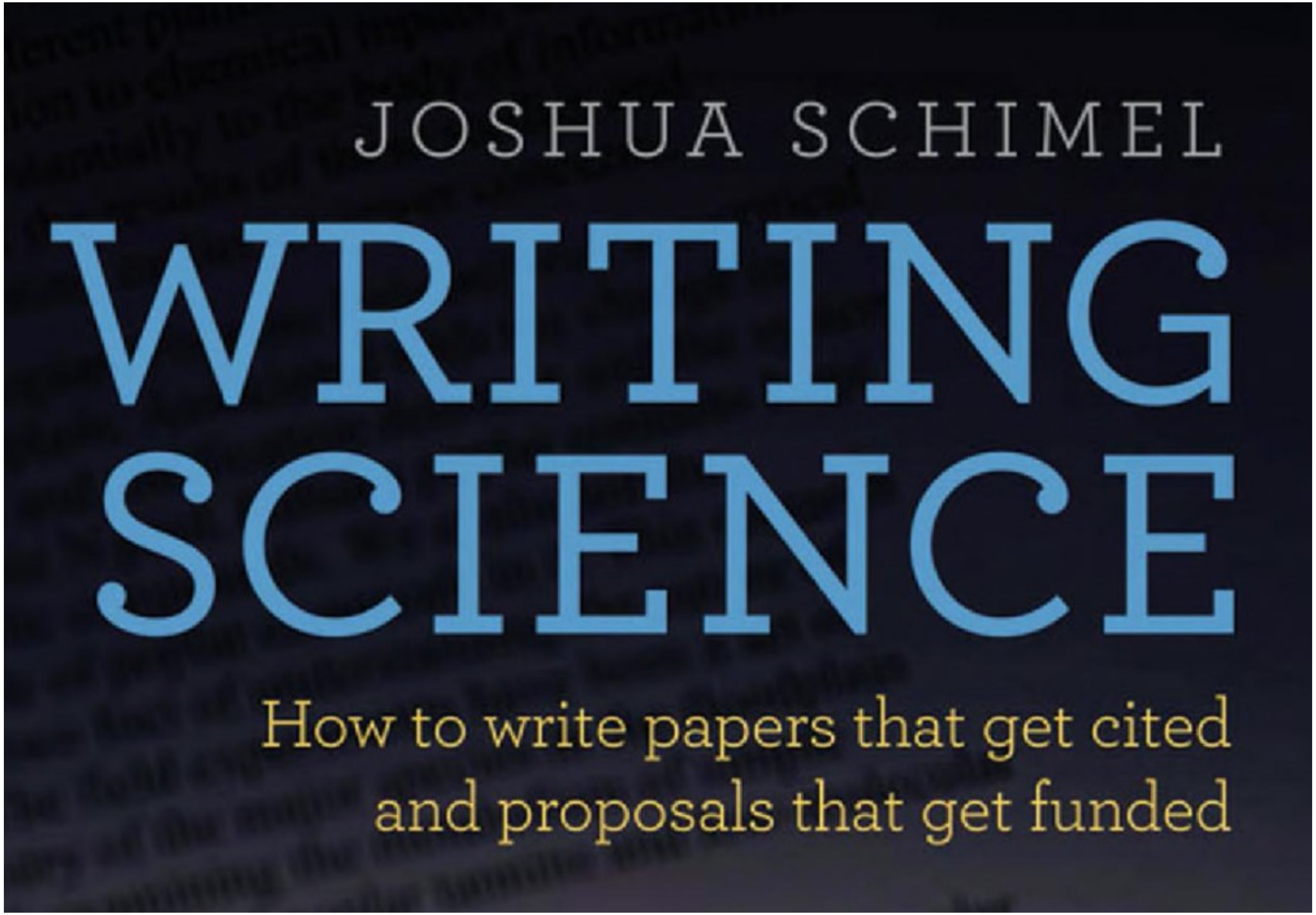
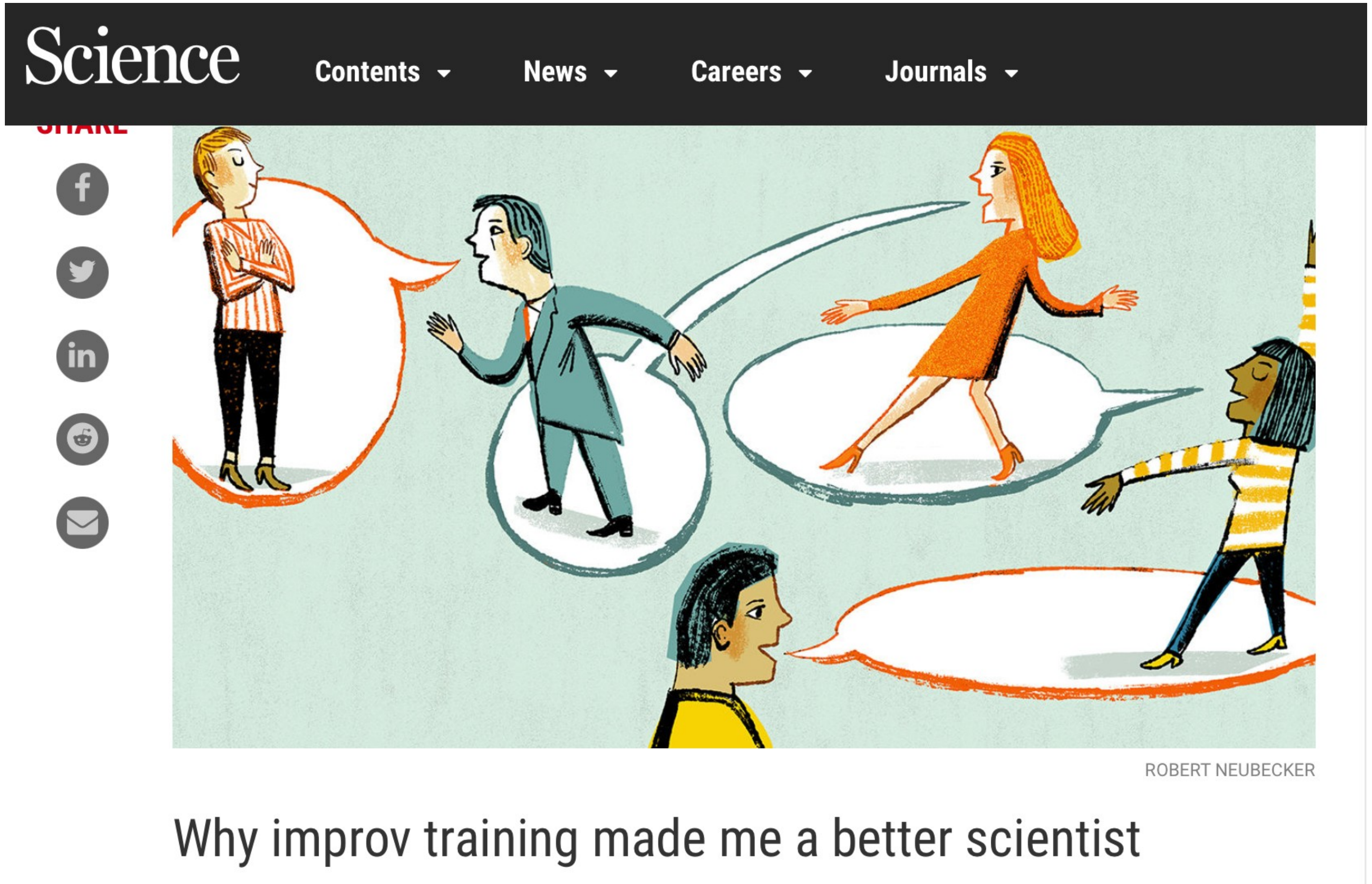

JOSHUA SCHIMEL
WRITING SCIENCE
How to write papers that get cited and proposals that get funded

Improvisation for scientists



https://www.aldacenter.org/alda-method

Thank you!

mrini@aps.org