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in space and time, and suboptimal communication between very different communities can be a waste of everyone's energy and time.

The Barcelona workshop, crystallized around the question of linkages between polar and lower-latitude climate phenomena, addressed all those questions and represented, in that regard, a major milestone for the community. It was also an opportunity for me to realize that scientists spend a good share of their time disagreeing with each other, particularly about topics for which new theories are needed. I understood that science is not about simply crafting theories—any theory is necessarily incomplete—but about crafting theories that cannot be disproved. To date, no one has proposed a robust and simple theory that can explain how our poles affect our climate, but we now agree on the ways to make progress with the research. That agreement is perhaps what keeps our scientific community moving forward.

Reference

1. For the official Barcelona workshop report, see T. Jung et al., *Bull. Am. Meteorol. Soc.* (in press), doi:10.1175/BAMS-D-15-00121.1.

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Letters

The future of ITER

Fusion has long been an interest of mine, and I have followed closely the progress of ITER, the international prototype fusion reactor project. I found David Kramer's story (PHYSICS TODAY, May 2015, page 21) particularly revealing.

I began my career as a program manager and had the good fortune to serve under a group of managers who worked together on the Apollo program, where many of the tools for program management were developed. Coincidentally, the programs I took part in were primarily fusion related, including the Large Coil Project intended to develop prototype toroidal field coils for tokamaks.

The current state of ITER is easy to understand. None of the basic tenets of program management—well-defined specifications and budgets, effective change control, clear lines of authority, and a manager with the ability to promptly make key decisions—have been applied to it. The optimism apparently associated with the recent appointment of Bernard Bigot as director general is laughable. Until the participants are committed to converting ITER from a technopolitical hodgepodge into a real project, the US is completely justified in its skepticism. ITER has no chance of success under the current conditions.

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A data archive for storing precision measurements

Precision measurements are essential to our understanding of the fundamental laws and symmetries of nature.

Traditionally, fundamental symmetry tests focused on effects that are either time independent or subject to periodic modulation due to Earth's rotation about its axis or its revolution around the Sun. In recent years, however, attention has been drawn to time-varying effects, starting with the searches for a possible temporal variation of fundamental "constants." Even more recently, researchers are looking for transient effects[1] and oscillating effects[2] due to ultralight bosonic particles that could be components of dark matter or dark energy.

To search for nonuniform dark energy or dark matter, researchers have proposed networks of atomic magnetometers and clocks.[1] The readings of remotely located network sensors are synchronized—for example, using the timing provided by GPS—and analyzed for specific transient features. Also being discussed are hybrid networks consisting of different types of sensors that would be sensitive to different possible interactions with the dark sector (see http://www.nature.com/nphys/journal/v10/n12/extref/nphys3137-s1.pdf).

A compelling example of time-stamped and stored datasets is the orbit and clock estimates of the Global Navigation Satellite Systems (GNSS) available through the International GNSS Service (http://igscb.jpl.nasa.gov). This service is the backbone of modern precision geodesy. The available multiyear archival data can be used to search for transient variations of fundamental constants associated with the galactic motion through the dark-matter halo (see http://www.dereviankogroup.com/gps-dm/).

The field of precision measurement appears to be undergoing a paradigm shift, with new theoretical and experimental ideas sprouting almost daily. For instance, reanalysis of data from using atomic dysprosium to look for the variation of the fine-structure constant and to test Lorentz invariance has set new limits on the scalar dark matter.[3,4] That has been made possible by the existence of well-documented, accessible data sets stored electronically.

An example of a new experimental idea is using precise beam-position monitors in particle accelerators to test for specific types of Lorentz-invariance violations.[5]

Inspired by all those exciting developments, we propose that data streams from any ongoing precision measurements be time-stamped and stored for possible future analysis. We are convinced that the cost of data storage and GPS timing is relatively small and that the data storage will be straightforward to implement technically, though, of course, the price and complexity crucially depend on the precision of the time stamp and the data rate. Conversely, failing to time-stamp and store the data is likely to be an enormous waste. The search for transient effects of the dark sector is already a good motivation to create a data archive, and additional ideas of how to use such data are likely to emerge in the future.

What information should be time-stamped and recorded as a raw data stream? Data from optical and matter interferometers, experiments measuring parity violation and looking for permanent electric dipole moments, precision-measurement ion traps, all precision experiments with antimatter, and, by default, anything measured precisely.

We live in the age of Google and GPS; our thinking about experimental data should be keeping up with the times!

References

1. S. Pustelny et al., *Ann. Phys.* **525**, 659 (2013); A. Derevianko, M. Pospelov, *Nat. Phys.* **10**, 933 (2014).
2. P. W. Graham, S. Rajendran, *Phys. Rev. D* **88**, 035023 (2013); B. M. Roberts et al., *Phys. Rev. D* **90**, 096005 (2014).
3. K. V. Tilburg et al., *Phys. Rev. Lett.* **115**, 011802 (2015).
4. Y. V. Stadnik, V. V. Flambaum, http://arxiv.org/abs/1504.01798.

5. B. Wojtsekhowski, *Europhys. Lett.* **108**, 31001 (2014).

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More on polaron theory history

A recent Readers' Forum section (PHYSICS TODAY, April 2015, page 10) contains a discussion by Mark Dykman and Emmanuel Rashba about my review (October 2014, page 54) of *Polarons* by David Emin and about some aspects of the early days of polaron theory.

The term "polaron" was indeed coined by Solomon Pekar.[1,2] I agree that Pekar's coinage is sometimes overlooked in the literature.

The development of the polaron concept was a gradual process initiated by Lev Landau. Pekar recognizes in his monograph[3] that "in 1933, L. D. Landau proposed an important idea on the auto-localization of an electron in an ideal crystal as a result of a lattice deformation by the field induced by the electron. These local states were assumed to be immobile, and Landau tried to associate them with *F*-centers in colored alkali halide crystals." I think it is fair to state that all successive steps on polaron physics emerged from Landau's first step.

For my book review, I found it unnecessary to write a more detailed introduction, and I limited the historical remarks on the polaron concept to the initial contributions of Landau. He introduced the nascent concept to Herbert Fröhlich,[4] who, in turn, introduced the commonly used basic polaron Hamiltonian for the continuum approximation to Jiro Yamashita, Theodore Holstein, and others, who laid the foundation of small-polaron theory.

Given the context of a short book review, I think not mentioning Pekar's coinage of "polaron" and his important contributions does not constitute a major omission, as Dykman and Rashba suggest. In a different context—in a book or a review article—Pekar's work would be amply cited. For example, reference 5 contains a section devoted to Pekar's polaron.

References

1. S. I. Pekar, *J. Phys. USSR* **10**, 341 (1946).
2. S. I. Pekar, *Zh. Eksp. Teor. Fiz.* **16**, 341 (1946).
3. S. I. Pekar, *Issledovanija po Elektronnoj Teorii Kristallov*, Gostekhizdat (1951); Eng. trans., *Research in Electron Theory of Crystals*, AEC-tr-555, US Atomic Energy Commission (1963).
4. H. Fröhlich, *Adv. Phys.* **3**, 325 (1954).
5. A. S. Alexandrov, J. T. Devreese, *Advances in Polaron Physics*, Springer (2010), p. 12.

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Author clarifies credit for H-bomb calculations

I am pleased by Cameron Reed's excellent and insightful review of my book *Building the H Bomb: A Personal History* (PHYSICS TODAY, July 2015, page 46). Let me add a couple of minor clarifications.

Reed reports that we used "card-fed and plug-board computers" for the thermonuclear calculations. Indeed, we used such computers in 1950 and 1951, but the final calculations that led to the 7-MT predicted yield of the "Mike" device were carried out on the SEAC (Standards Eastern Automatic Computer) at the National Bureau of Standards in Washington, DC. SEAC was a stored-program computer that, in 1952, was probably the best computer in the world, with its 3 kB of memory and its 1-MHz clock speed.

Reed refers, overgenerously, to "Ford's calculations." They were mine only in the sense that I was the person who shepherded the calculations night after night for several months on the graveyard shift. The coupled differential equations that we were solving numerically were devised principally by John Wheeler, with my assistance and that of John Toll and other young theorists at Princeton University's Project Matterhorn and in the theoretical division at Los Alamos. I wrote the code, with Toll's help.

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