Impressionism, Realism, and the aging of Ashcroft and Mermin

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Citation: Physics Today **66**, 7, 8 (2013); doi: 10.1063/PT.3.2025
View online: https://doi.org/10.1063/PT.3.2025
View Table of Contents: https://physicstoday.scitation.org/toc/pto/66/7
Published by the American Institute of Physics

A Norman Ramsey cover story

The January 2013 issue of PHYSICS TODAY contained informative and enjoyable articles on Norman Ramsey's separated oscillatory field method and its continuing impact on precision spectroscopy research (pages 25, 27, and 36). However, a photo on the cover may be misleading. The molecular-beam apparatus labeled as "1949" was actually constructed by Tom Gallagher (now at the University of Virginia) and me as part of our thesis projects done under Norman's guidance at Harvard University in 1969–70.

Although originally designed for high-precision measurements of hyperfine structure in molecules, the apparatus was later used for a search for *P*- and *T*-violating effects in molecules.[1] After Norman closed down his Harvard laboratory in the 1980s, the apparatus was transported to St. Olaf College in Minnesota, where Jim Cederberg, another Ramsey graduate student, used it for undergraduate research projects for more than 25 years. During that time, according to Jim's website, more than 70 students worked with the apparatus to study the hyperfine structure of polar molecules; that work resulted in 16 published papers. A few years after Jim retired from St. Olaf, the apparatus was moved to Georgia's Southern Polytechnic State University; under the direction of Lu Kang, it will, I hope, inspire another generation of students in the joys of atomic and molecular spectroscopy.

Not only does Norman's intellectual legacy live on, but at least in this case, the physical apparatus itself continues to be productive after more than 40 years of active use.

Reference

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Impressionism, Realism, and the aging of Ashcroft and Mermin

For many years I have been eagerly awaiting the second edition of Neil Ashcroft and David Mermin's *Solid State Physics* (Holt, Rinehart, and Winston, 1976). It is undoubtedly one of the best physics books ever written, but it is not aging well: An insensitive community keeps advancing the field with little respect for its prophets. However, after learning in PHYSICS TODAY (July 2012, page 8, and Mermin's response to letters, December 2012, page 12) that Mermin has become a QBist, I am afraid the sharp explanations in the first edition might become as blurred as Marcel Duchamp's *Nude Descending a Staircase (No. 2)*. How are we supposed to understand statements such as "Filled Bands Are Inert," one of the book's subheadings, from a QBist perspective? What is the Bayesian account of an exciton? And how about effective masses? Are they the second derivative of a belief?

My only hope is that Neil Ashcroft remains, if not a full-blown Realist, at least an Impressionist whose motifs can be clearly identified by our aging eyes.

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■ **Mermin replies:** I am a realist. But my model of reality necessarily rests on what I have experienced, either directly, or indirectly through the reports of others. For all practical purposes (FAPP, John Bell's famous adverbial acronym), it doesn't matter if, like most physicists, I confer reality on such theoretical abstractions as quantum states or energy levels that enable me to calculate the likelihood of my subsequent experience. But for resolving obstinate conceptual conundrums (FROCC), such as "the quantum measurement problem" or "quantum nonlocality," it is crucial not to reify our intellectual tools. "Filled bands are inert" means FROCC that "if the electronic state I assign to a crystal is an antisymmetrized product of Bloch levels, then, in calculating the odds on what I am likely to experience when I subject the crystal to a sufficiently weak intervention, I can ignore levels from bands entirely below the Fermi energy." I leave the FROCC view of electrons, crystals, Bloch levels, bands, Fermi energies, excitons, and effective masses as exercises for the reader.

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■ **Ashcroft replies:** Realist, and calibrated as full-blown? Given the subtleties of the notion of reality, I somehow doubt it. Impressionist? I delight in freely recorded broad-brush renditions of the observable physical world. But Marcel Duchamp's painting comes across more as a superimposition of rather sharp images. They seem to reflect quite lucidly a progression in time of a more developed form.

Over the years many readers have remarked that the initial edition of our book should "not be touched"; it is just right in its treatments of the fundamentals. But by all means augment it with a sequel, encompassing the many advances in condensed-matter physics that have occurred over the past 38 years. The view that it should not be touched seems to have been shared by those who translated our 1976 text into French, German, and Portuguese just within the past decade.

Letters and commentary are encouraged and should be sent by email to ptletters@aip.org (using your surname as the Subject line), or by standard mail to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842. Please include your name, work affiliation, mailing address, email address, and daytime phone number on your letter and attachments. You can also contact us online at http://contact.physicstoday.org. We reserve the right to edit submissions.

José Menéndez's laudatory comments about our book are generous in the extreme. David and I are both grateful, and together we hope that the aging process, of ourselves and of our textbook, will not unduly accelerate.

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Atmosphere of Venus: Problems in perception

Vladimir Shiltsev, Igor Nesterenko, and Randall Rosenfeld call Mikhail Lomonosov a great Russian polymath (Quick Study, PHYSICS TODAY, February 2013, page 64), and indeed, he is credited with many important discoveries. In astronomy, however, he is almost exclusively remembered for his putative "discovery" of the atmosphere of Venus at the transit of 1761.

Shiltsev, who is a distinguished physicist and director of the Accelerator Physics Center at Fermilab but not an astronomer, and several colleagues attempted to "experimentally rerun" Lomonosov's discovery at the June 2012 transit. They equipped themselves with 18th-century instruments similar but not identical to the one Lomonosov used (which seems not to have survived) and sought to make out the luminous arc that fringes the silhouette of Venus edging onto the Sun. This arc, or aureole, is produced by refraction of sunlight in the planet's atmosphere. Meanwhile, at the same transit, Rosenfeld and colleagues in Saskatchewan made observations using modern doublet lenses and concluded that the aureole could, in principle, be detected with a 50-mm lens, the type Lomonosov most likely used. Putting all this together, Shiltsev, Nesterenko, and Rosenfeld conclude that Lomonosov must have seen the arc and on that basis correctly deduced the existence of the atmosphere.

We disagree with that conclusion. Such an experimental rerunning of Lomonosov's observations shows only that he *could* have made out the arc, not that he did. And we don't think he did, for the following reasons.

Repeating a historic visual observation with a telescope is not exactly analogous to repeating experiments in physics, such as those of Hans Christian Oersted with electricity and magnetism, say, or Robert Boyle's with an air pump. In those experiments, all the significant experimental conditions can be controlled for and thus duplicated. But in astronomical observations, it is difficult to achieve the same control, since the conditions include not only the aperture and type of the telescope but also atmospheric conditions and subjective factors such as the observer's preconceptions and beliefs.

Lomonosov held, as did many scholars of his day, that all the other planets were inhabited. Accordingly, Venus must have a considerable atmosphere to support its inhabitants. He therefore would have seized on possible blurring or other distortions as evidence of the existence of an atmosphere.

To establish Lomonosov's claim as a discovery and not merely a plausible surmise, it is not enough to show that a modern observer with smallish equipment can see the aureole and that Lomonosov must therefore have done so. One must show, as Rosenfeld stresses,[1] that "careful analysis of observational records"—and that alone—can explain what Lomonosov saw. We took that approach and tried to do this by translating Lomonosov's documents and reviewing his drawings.[2] Importantly, he himself never referred to an "arc," but rather to a "bump" or "blister." Furthermore, he said he saw a "sliver" for one second—another possible atmospheric sighting—but at the recent transit, we could discern the atmosphere for many minutes through small telescopes, one of us (Sheehan) from Flagstaff, Arizona, and the other (Pasachoff) from Haleakala, Hawaii.

A careful analysis of Lomonosov's writings and drawings shows that what he observed, at least as he recorded it, did not resemble the actual aureole as recorded in later ground- and satellite-based observations. Shiltsev's drawing (figure 1c in the Quick Study) shows what appears to be a classical "black drop" bordered by a distorted piece of solar limb, which he identifies with Lomonosov's bump shown in figure 1a. Taken at face value, that analogy suggests that Lomonosov was actually recording a variant of the black-drop effect, which turns out to have nothing to do with Venus's atmosphere.[3,4] The thickish bump is only superficially similar to the hairline arc in figure 1b, Alexandre Koukarine's drawing, which correctly depicts the aureole.