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# Atmosphere of Venus: Problems in perception

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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.

Although Lomonosov may have assumed that Venus has an atmosphere, then set out to prove it by making direct observations during the transit, and then calculated the atmosphere's thickness based on its potential refracting effects, we remain unconvinced that he truly observed any of the actual phenomena—such as the aureole—on which the proof that Venus has an atmosphere now securely rests.

## References


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■ **The Quick Study** regarding Mikhail Lomonosov's viewing of the 1761 transit of Venus is disturbing for a number of reasons. The authors claim that an achromat objective "focus[es] all colors to the same point," which is well known to be false. Achromats, whether their two lenses are cemented together or separated by air, bring two wavelengths—typically blue and red light—to a common focus while leaving other wavelengths significantly uncorrected for axial chromatic aberration. But more serious is the authors' use of smoked glass as the solar filter. Viewing the Sun through smoked glass can damage an eye in several ways. The 1/1700 attenuation cited by the authors for their actual solar filter is dangerously weak. Moreover, placing their smoked glass at the eyepiece rather than at the objective lens makes it even more apt to produce eye damage because of the higher concentration of solar energy at the eyepiece—which therefore needs additional attenuation—coupled with the increased risk that the concentrated heat will cause the filter to crack.

The author's own statement in the article makes the case: "Solar viewing was barely tolerable" with their smoked glass. Naive readers attempting to replicate solar viewing in this fashion risk damaging their eyes. Those readers would probably have no method of verifying the attenuation level of a piece of smoked glass across the UV-visible-IR spectrum, so the experiment would be for them a trial-and-error process. Error in this case could cost one his or her eyesight.


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# Electrostatic effects in living cells

The classical Brownian motion theory used so imaginatively in the article by Eli Barkai, Yuval Garini, and Ralf Metzler (PHYSICS TODAY, August 2012, page 29) ignores fluctuations in the electric field. The theory allows fluctuation in number density, or concentration, of solutes in biological systems. But those solutes are almost always charged, whether they are the "bioions" $Na^+$, $K^+$, $Cl^-$ nearly always present in the mixtures inside and outside cells or whether they are divalents, like $Ca^{2+}$ or $Mg^{2+}$; nucleic acids, like DNA and RNA; the organic acids and bases of cell metabolism; or proteins, like ion channels and enzymes.

Fluctuations in the concentration of charged species must produce fluctuations in the electric field. Although such fluctuations are not present in the classical theory of Brownian motion, fluctuations are large and unshielded on the time scales used in simulations of molecular or Brownian dynamics. And not only will the fluctuations in electric field be different in different places, they are likely to have widely variable, highly nonlinear effects.

The diffusion produced by the fluctuations is an important determinant in numerous biological functions, such as resting and action potentials, cell motility, and enzyme activity. But diffusion and thermal motion contribute very differently to various functions because cellular function involves such a broad range of structures and molecules in which electric charge moves in different ways.

The thermal motion of coupled, charged systems, which include nearly everything inside a biological cell, is likely to be anomalous when interpreted in terms of the classical Brownian motion theory of uncharged particles. Classical theory should not be used to describe the random motion or macro-