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.

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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 "bio-ions" 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-

scopic diffusion of charged molecules. A theory is needed that includes fluctuating electric forces and that computes those forces from the fluctuating density of all the charges.

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■ **Barkai, Garini, and Metzler reply:** We thank Bob Eisenberg for his comment. Indeed, the role of electrostatic effects in the complex dynamics measured in macromolecularly crowded systems is an open question. Typically, biopolymers, and many artificial crowding agents, do carry surface charges. In physiological salt conditions, counterions screen electrostatic fields over nanometer length scales and are highly mobile, yet one perhaps cannot exclude force mediation between the macromolecules in solution due to electrostatic effects. An immediate consequence should be an increased effective size of biomacromolecules due to coordinated counterion layers.

The data from numerous single-particle tracking experiments in living cells and artificially crowded environments clearly show anomalous diffusion, including observations of weak ergodicity breaking and aging. Our analysis in terms of stochastic processes remains valid, independent of the specific—and likely complex—physical description based on first principles. That validity is due to the probabilistic nature of the stochastic approach: Although it captures the detailed dynamics of a system, it is not limited to specific kinds of interactions. Future studies of the effects of temperature and charges in crowded cells should prove interesting. For example, the influence of charges on the anomalous diffusion exponent α and the anomalous diffusion constant K_α in the mean squared displacement $\langle \mathbf{r}^2(t) \rangle \simeq K_\alpha t^\alpha$ remains an open challenge for both theory and experiment.

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X-ray imaging detectors advance plasma research

Reading Sol Gruner's article on the advancement of x-ray imaging detectors (PHYSICS TODAY, December 2012, page 29) was a pleasure, and I share his excitement for how the new technology is motivating research in multiple fields. A few years ago, I was part of a team of MIT and Princeton Plasma Physics Laboratory scientists and graduate students who used pixel-array detectors when we deployed a new x-ray imaging crystal spectrometer[1] on the Alcator C-Mod tokamak. When doped with small (less than 0.1%) amounts of high-Z atoms like argon, high-temperature plasmas can emit a wealth of information, in the form of x-ray line radiation, that includes flow and temperature data gathered via the Doppler shift and Doppler broadening mechanisms. Since that information is emitted from the plasma volume, tomographic techniques are required to unfold what is happening locally.[2]

The high-resolution images provided by the new detector technology have enabled us to better understand the plasma state and use C-Mod experimental resources more efficiently. What could have taken dozens of repeated discharges when scanning with older instruments can now be done dynamically during a single plasma shot.

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