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Electrostatic effects in living cells FREE

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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.

References

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2. M. L. Reinke et al., *Rev. Sci. Instrum.* **83** 113504 (2012).

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