Charge Correlations in a Near-critical Plasma: Simulations challenge theory

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In a classical plasma (or an electrolyte solution) the charge-charge structure factor obeys $S_{ZZ}(k;T,\rho) = 0 + \xi_{Z,1}^2 k^2 - \xi_{Z,2}^4 k^4 + \cdots$, where $\xi_{Z,1}$ and $\xi_{Z,2}$ are the second- and fourth-moment charge-charge correlation lengths depending on T and the overall ionic density ρ. The vanishing of the leading term, the first Stillinger-Lovett (SL) sum rule [1], simply reflects bulk electroneutrality. The second SL rule [1], or *second-moment condition*, dictates that $\xi_{Z,1} = \xi_D$, where the Debye screening length ξ_D varies as $(k_B T / q_0^2 \rho)^{1/2}$, q_0 being the elementary charge.

Recent grandcanonical Monte Carlo simulations [2] of a fully *size* and *charge symmetric* 1:1 (finely discretized) hard-sphere plasma or *restricted primitive model* [3], impose electroneutrality and so satisfy SL1 automatically. However, careful finite-size scaling analyses of extensive histogram-reweighted data indicates that the second-moment condition is *violated at* criticality by approximately 10%, $\xi_{Z,1}^c$ exceeding ξ_D^c. It is also found that $\xi_{Z,2}^4$ *diverges* to $+\infty$ as $T \to T_c$ in a manner that seems to mirror $S_{NN}(0)$, the density-density fluctuation.

These findings contradict Generalized Debye-Hückel theory [4] and also the exactly soluble *charge-symmetric* spherical models [5] both of which support SL2 *at* criticality *and* the finiteness of the fourth-moment. Nevertheless, the observed behavior is strikingly similar to that of the *charge-asymmetric* spherical models [5] where SL2 fails *at* criticality while $\xi_{Z,2}^4$ diverges as $S_{NN}(0)$.

[1] F.H. Stillinger and R. Lovett, J. Chem. Phys. **48**, 3858 (1968).
[2] Work with S.K. Das and Y.C. Kim (to be published).
[3] See, e.g., Y.C. Kim and M.E. Fisher, Phys. Rev. Lett. **92**, 185703 (2004).
[4] B.P. Lee and M.E. Fisher, Europhys. Lett. **39**, 611 (1997).
[5] J.-N Aqua and M.E. Fisher, Phys. Rev. Lett. **92**, 135702 (2004).

Visual aids: please see over:

Visual aids needed:

(a) Two large side-by-side screens (visible to all in audience);
(b) Two (powerful) overhead projectors for transparencies, one operating on each screen;
(c) One table (3' x 2' or larger) for notes, etc., close to the projectors;
(d) One long rigid (say, wooden) pointer to reach the screens (a laser or light pointer not being acceptable);
(e) if practicable (but not essential), a small blackboard or some blackboard space.

NOTE: If the arrangements above are not standard, it will probably be necessary to set aside 10 to 15 minutes before the talk begins to check and adjust the set-up, house lights, etc.