Abstract Submitted
for the MAR14 Meeting of
The American Physical Society

Effect of image charges on double layer structure and forces RUI WANG, ZHEN-GANG WANG, California Institute of Technology — The study of the electrical double layer lies at the heart of colloid and interface sciences. Here, we examine the electrical double layer structure and forces between two neutral or like-charged plates by accounting for the image charge effects under weak-coupling conditions. By treating the fluctuation effect on the ion distribution and free energy self-consistently and nonperturbatively, we show that the image charge interaction appears as part of the self-energy in the Boltzmann factor: there is no limiting condition for which Poisson-Boltzmann (PB) theory is valid, contrary to the general consensus in the community that PB theory is the exact theory in the weak coupling limit. For electrolyte solutions between two neutral plates, we show that depletion of the salt ions by the image charge repulsion results in short-range attractive and long-range repulsive forces. If cations and anions are of different valency, the asymmetric depletion leads to the formation of an induced electrical double layer. In comparison to a 1:1 electrolyte solution, both the attractive and the repulsive parts of the interaction are stronger for the 2:1 electrolyte solution. For two charged plates, the competition between the surface charge and the image charge effect can give rise to like-charge attraction and charge inversion. These results are in stark contrast with predictions from the PB theory.

Rui Wang
California Institute of Technology

Date submitted: 15 Nov 2013 Electronic form version 1.4