Attraction Between Like-Charged Interfaces

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We study the interactions between two negatively uniformly charged rigid surfaces confining their own positive counterions. The pressure at the mean-field level is simply the density of counterions at the mid-plane between the plates and no attraction is found. To account for the correlations between the microions omitted in the mean-field theories, we introduce a density-functional theory similar to the one often employed in studies of simple liquids. This approach introduces a grand-potential free energy, Ω [ρ(r)] which is a functional of the non-uniform density of counterions ρ(r). The equilibrium properties of the system are obtained through the minimization of the total free energy. The excess of free energy responsible for the correlations is derived in the framework of the Debye-Hückel-Hole theory of the one-component plasma, with the homogeneous density replaced by a weighted density. The minimization of the total free energy yields the density profile of the microions. The pressure is calculated and we find that the interaction between the two plates becomes attractive when their separation distance is sufficiently small and the surface charge density is larger than a threshold value.