Soft-particle multi-Yukawa fluid at an interface: field theory treatment

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Model fluids of particles interacting with a multi-Yukawa potential have been extensively used in the investigation of a large variety of liquids and soft matter materials. In this report we propose a field theoretical approach for the description of neutral, charged and anisotropic soft-particle fluids under confinement. In the considered formalism the effective Hamiltonian is a functional of field and consists of the interaction term and the entropy term directly connected with the Jacobian of transformation from the usual coordinate space to the field variables. In the vicinity of a simple interface, that is a surface the only effect of which is to confine the fluid, we have found a general depletion phenomenon of the density profiles. These effects are described in very cases where no effects are predicted at the mean field level. The density profiles predicted verify the density contact theorem as well as a new charge contact theorem in the case of ionic fluids and a new order parameter contact theorem in the case of anisotropic fluids. The developed approach shows that such effects are due to fluctuations via entropic coupling. We show that these contributions do not depend on the sign of interactions and they always correspond to a depletion effect. These depletion phenomena can explain some unexpected phenomena like the loss of orientational ordering of anisotropic fluids at a confining interface. For the case of fluids with competing interactions, confinement can lead to the formation of disordered spherical clusters in the surface region, while in the bulk the fluid still remains uniform.