

Investigation of a dilute solution of ring polymer chains in a slit geometry of two parallel walls with mixed boundary conditions

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Investigation of a dilute solution of ring polymer chains with the excluded volume interaction in a good solvent immersed in a confined geometry of two parallel walls with mixed boundary conditions was performed. The mixed boundary conditions assumes that we have one wall at the Dirichlet boundary condition and the other one at the Neumann boundary condition what corresponds to the situation that one surface is repulsive for polymer chains and the other one is at the adsorption threshold. We consider a dilute solution of ring polymers with the excluded volume interaction immersed in a slit geometry of two parallel walls and allow the exchange of polymer coils between the slit and the reservoir. Thus a polymer solution in a slit is in equilibrium contact with an equivalent solution in the reservoir outside the slit. We follow the thermodynamic description of the problem as it was given in [1,2]. Taking into account the well known polymer - magnet analogy developed by de Gennes we calculated in the framework of the field theoretical ϕ^4 $O(n)$ -vector model in the limit $n \rightarrow 0$ the dimensionless scaling function of the depletion interaction potential and the dimensionless scaling function of the depletion force for the above mentioned case using the massive field theory approach at fixed space dimensions $d=3$ up to one-loop order. The obtained results for a dilute solution of ring polymer chains with the excluded volume interaction in a good solvent indicate that the depletion force in the case of mixed boundary conditions becomes repulsive in contrast to the case of linear polymer chains (see [2]) and give some additional insight in comparison to Gaussian model of phantom ideal ring polymer chains in such solutions (see [3]). This result for the dimensionless scaling function of the depletion force is in agreement with the scaling predictions proposed by de Gennes some time ago [4]. Besides, it should be mentioned that the presented results give possibility better to understand the complexity of physical effects arising from confinement and chain topology and can find practical application in new types of micro- and nano-electromechanical devices.

[1] F. Schlesener, et al., Phys. Rev. E **63**, 041803 (2001).

[2] D. Romeis, Z. Usatenko, Phys. Rev. E **80**, 041802 (2009).

[3] Z. Usatenko, J. Halun, J. Stat. Mech. **2017**, 013303 (2017).

[4] P.G. de Gennes, Macromolecules **15**, 492 (1982).