Investigation of linear and ring polymer chains in confined geometries: the massive field theory approach

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Taking into account the well known polymer - magnet analogy developed by de Gennes [1] between the field theoretical ϕ^4 $O(n)$ - vector model in the limit $n- > 0$ and the behaviour of long - flexible polymer chains with the excluded volume interaction in a good solvent the investigation of a dilute polymer solution of linear and ring polymer chains in confined geometry like slit of two parallel walls with different boundary conditions such as: Dirichlet-Dirichlet, Neumann-Neumann and Dirichlet-Neumann which corresponds to the situation of two repulsive walls, two inert walls and for the mixed case of one repulsive and the other one inert wall were performed. The correspondent dimensionless depletion interaction potentials and the depletion forces were obtained with use of the massive field theory approach in fixed space dimensions d=3 up to one loop order [2-4]. Besides, taking into account the Derjaguin approximation the investigation of a dilute solution of linear and ring polymer chains inserted in a solution of mesoscopic spherical colloidal particles of one sort or two different sorts were performed and the correspondent depletion interaction potentials were calculated [2,4,5]. The obtained results indicate about the interesting and nontrivial behaviour of linear and ring polymer chains in confined geometries and give possibility better to understand the complexity of physical effects arising from confinement and chain topology which plays a significant role in the shaping of individual chromosomes and in the process of their segregation, especially in the case of elongated bacterial cells. The obtained results are in good qualitative agreement with the scaling predictions [1], the previous theoretical investigations and with the numerical results obtained by Monte Carlo simulations for linear [6] and ring polymer chains [7] and can find practical application in production of new types of nano- and micro-electromechanical devices.

References

[1] P.G. de Gennes, Scaling Concepts in Polymer Physics (Cornell University Press, Ithaca, NY, 1979).

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

[3] Z. Usatenko, J. Halun, J. Stat. Mech.: Theory and Experiment P 013303 (2017).

[4] Z. Usatenko, P. Kuterba, H.Chamati, D. Romeis, Eur. Phys. J.: Special Topics 226, 651 (2017).

[5] Z.Usatenko, J.Halun, P.Kuterba, Ring polymers in confined geometries, Condensed Matter Physics 19, 43602 (2016).

[6] H.-P. Hsu and P. Grasberger, J. Chem. Phys. 120, 2034 (2004).

[7] R. Matthews, A.A. Louis, J.M. Yeomans, Confinement of knotted polymers in a slit, Molecular Physics, 109, 1289 (2011).