

# Preface to the Revised Edition

I used the opportunity of this edition to correct some minor mistakes and clarify, wherever it possible, exposition of the theory in comparison with the previous edition of this book (Kluwer, Dordrecht *et cet*, 2000). It provokes enlargement of the book, though I tried to present the modern theory of thermic motion of long macromolecules in compact form. I have tried to accumulate the common heritage and to take into account different approaches in the theory of dynamics of linear polymers, at least, to understand and make clear the importance of various ideas for explanation of relaxation phenomena in linear polymers, to present recent development in the field.

The theory of non-equilibrium phenomena in polymer systems is based on the fundamental principles of statistical physics. However, the peculiarities of the structure and the behaviour of the systems necessitate the implementation of special methods and heuristic models that are different from those for gases and solids, so that polymer dynamics has appeared to be a special branch of physics now. The monograph contains discussions of the main principles of the theory of slow relaxation phenomena in linear polymers, elaborated in the last decades. The basic model of a macromolecule, which allows us a consistent explanation of different relaxation phenomena (diffusion, neutron scattering, viscoelasticity, optical birefringence), remains to be a coarse-grained or bead-spring model, considered in different environments: viscous, to describe the behaviour of dilute solutions, or viscoelastic, to describe the behaviour of both weakly and strongly entangled systems. Besides, extra features of dynamics of a chain in strongly entangled systems, namely the strong resistance to changes of conformation of macromolecule (the internal viscosity resistance due to the entanglements) and local anisotropy of mobility of particles of the chain, which provokes motion of macromolecule along its contour – the reptation motion, have to be taken into account. The dynamic transition point between weakly and strongly entangled systems is calculated as  $M^* \approx 10M_e$ , where  $M_e$  is called conventionally ‘the length of the macromolecule between adjacent entanglements’.

Thus, among the linear polymer systems, three types of systems, according to the ratio of the length of the macromolecule  $M$  to  $M_e$  :  $M < 2M_e$  – non-entangled system,  $2M_e < M < 10M_e$  – weakly entangled systems and  $M > 10M_e$  – strongly entangled systems, have to be considered separately. The laws of the relaxation behaviour of the different systems are different: no reptation relaxation of macromolecules exists in the non-entangled and weakly entangled systems.

The properly formulated phenomenological dynamic equation for a single macromolecule remains to play a role of the central organising principle of the monograph. The model was designed to study systematically deviations from the Rouse dynamics when adding non-Markovian and anisotropic noise. The developed model describes underlying stochastic motion of particles of the chain and provides both the confinement of a macromolecule in a tube and easier (reptation) motion of the macromolecule along its contour – the features, which were envisaged by Edwards and de Gennes for the entangled systems. An intermediate length, which has the meaning of a tube radius and/or the length of a macromolecule between adjacent entanglements, is calculated through parameters of the model. The unified approach appeared to be useful for consistent explanation the relaxation phenomena in entangled linear polymers (polymer solutions and melts), and one can think that a consequent theory of viscoelasticity (so as other phenomena) in mesoscopic approximation can be developed on the base of the unified non-linear dynamics of a macromolecule.

It is my pleasure to acknowledge my gratitude to various people for the comments on the previous edition of the monograph and for advice how to improve it. During the work on the revision of the monograph, in September 2004, due to courtesy of Professor Kurt Kremer, I had a privilege to be a guest at the Max-Planck-Institut für Polymerforschung (Mainz, Germany) and to benefit from its excellent facilities for work. I have learnt and understood much from discussions of the relevant problems with Professor Kremer and members of the Institute, especially, with Burkhard Dünweg, Bernd Ewen, Tadeusz Pakula, Vahktang Rostiashvili and Nico van der Vegt. I thank all of them.

Any comments will be greatly appreciated.

Moscow, RUSSIA

*Vladimir N. Pokrovskii*

<http://www.ecodynamics.narod.ru/>

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Pokrovskii, V.N.

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