ISSN : 0974 - 7435 Volume 10 Issue 19

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(19), 2014 [10954-10959]

Applications of polymer condensed matter physics paradigm

Yajun Wang

Equipment Department, Xinxiang University, Xinxiang, 453000, (CHINA)

ABSTRACT

The importance of macromolecular condensed matter physics is obvious. The study of macromolecular condensed matter physics has been highly focused and supported by our nation and the national natural science foundation committee has set the Major Project of the research of condensed matter physics and the Great Project of consistency in multi-demission of condensed matter polymer separately since 1998 and 2004. There are also serious of related great projects gave and endorsed annually. The existence of so many sorts of macromolecule materials in daily life has improved and enriched our lives to a great extent in many aspects. This research dissected the condensed matter physics paradigm and the macromolecular condensed matter physics paradigm using the method of summarizing, analyzing, literature, and probed into the application of macromolecular condensed matter physics. The result of this research showed that the establishing of the macromolecular condensed matter physics paradigm has promoted the development of this science and make this science develop to the deeper aspects of the important branch of the macromolecular condensed matter.

KEYWORDS

Macromolecular condensed matter physics; Paradigm; Scaling theory; Entropic deduced phase transformation; Lytropic condensation.

INTRODUCTION

It is scholar Yande SHENG, Renyuan QIAN and Qihua WU that made the major contribution to the research of application of macromolecular condensed matter physics paradigm. SHENGdid a deep probe to the condensed matter of macromolecule single chain, the interwist of condensed matter macromolecular chain, the high orientation of amorphous high polymer chain and the random orientation of partial chain, the dynamic concentration of touching, the texture of the liquid crystalline macromolecule. SHENG made a great contribution to the forming of the macromolecular condensed matter physics paradigm[1]. Scholar FENG and JIN summarized the basic conceptions and definitions in the condensed matter physics and discussed the range of the condensed matter physics, revealing the macromolecular condensed matter physics paradigm. WU concluded the theory framework of macromolecular condensed matter physics, he introduced the main character, research method of the condensing of macromolecule in details. The research method including the scaling method, the regular of macromolecular condensed matter phase transformation. Especially he made some state of phase transformation caused by entropy, high connected system, soft condensed matter physics and the scaling method theory. Wu built the macromolecular condensed matter physics paradigm on the base of confirmed theory paradigm and range of research. Besides, scholar Dayong CHENG, Rushan HAN and Zhaojia CHEN also analyzed the macromolecular condensed matter physics and condensed matter physics from different views. This research mainly discussed the application and building of the macromolecular condensed matter physics paradigm.

THE MEANING OF PARADIGM

The discussing of a science's paradigm of a science is to show the framework model of the development in every progress of the science. It take concrete theory for instance to explain the basic method of one of the progress of science development. For example, the physics paradigm of aristoteles,the astronomy paradigm of Ptolemy, the dynamic paradigm of Galileo, the relative theory paradigm of Einstein etc are all being this. Then the conception of paradigm sprawled to every school to embody its inner structure, basic theory framework and researching range. For instance, Landau and Anderson put forward the condensed matter physics paradigm, which emphasizes the multi-body effect and symmetry breaking and advocates to research with the mean field approximation method. This paradigm then gave state and introduction in depth to elementary excitation, generalized stiffness, topological defect, and formed the basic theory framework of condensed physics.

And by then, the condensed physics has been growing to a flawless science. So the making and confirming of a science paradigm will effectively promote the development of this science.

THE LIMITATIONS OF THE CONDENSED MATTER PHYSICS PARADIGM

The condensed matter physics paradigm

After the introducing of the major of the condensed matter physics paradigm above, we are going to make a state in details. Landau and Anderson, who put forward the condensed matter physics, emphasized the multi-body effect and the symmetry breaking (common symmetry in physics, TABLE 1).

TABLE 1 : The common symmetry in physics

conversion	unobservable	conservation law and selection rule
spatial translation	position of absolute space	momentum
Translation of time	absolute time	energy
rotation	the absolute orientation in space	angular momentum
Space Inversion	absolute left or right	parity
Time inversion	absolute symbol of electric charge	charge conjugation
particle replacement	distinguishable nature of identical particles	bose or fermi statistics
gauge transformation	the relative phase among different charge states	conservation of charge

Landau stated the breaking as: relate to special state of matter, an symmetry element exists in ordered or unordered pattern, and this means the appearing of ordered phase, the order parameter value is the mean of values of high temperature and low temperature phases, and the critical temperature marks the beginning of second order phase transition.

Gas has completely translational symmetry and rotation symmetry, but for the difference of symmetry between gas and solid, the translational symmetry and rotation symmetry of solid are broken and merely existing the symmetry of point: the lattice vector translation and the stability dispersed translations. Consequently, there exist a closely link between the broken symmetry and structure transformation. Landau's symmetry breaking theory provided important clues to the research of change of the condensed matter material, and becomes the new indispensible framework of many science theories. So, we have some examples here to show the above point clearly: liquid has a completely translation and rotation symmetry, crystal has an ordered structure, whose symmetry belongs to one of the 230 space groups.

The excited state of low energy is the original roots of many important physical properties. And Landua's conception of the elementary excitation not only developed the Magneto-phonon theory and quasi-electron theory as the important branches of condensed matter physics but also become the main factor to solve the theory of excited state of low energy. So, we can use the conception of elementary excitation to regard the low excited state as a set of quasi-particle, thus, the ideal gas statistics can be applied to deduce physics properties.

Anderson emphasized the connection between breaking and generalized stiffness. Just like the crystal's gaining of stiffness due to the breaking of translation symmetry, other breaking symmetries are the same. For example, the essence of stiffness of superconductor is the phase coherence of electron doublet. Normally, the topological defect will lead to the partial disappearing of generalized stiffness in symmetry broken phase, and this is why the topological defect can affect some physics properties, just like the paradigm of dislocation to crystal, so deeply.

In condensed matter physics paradigm (see Figure 1), symmetry breaking leads to ordered phase, generally, the ground state is fully ordered state. Excited state tend to restore the original symmetry, and a variety of elementary excitation and topological defects are emerged. Ordered and disordered phase are the same in the critical region of T_0.

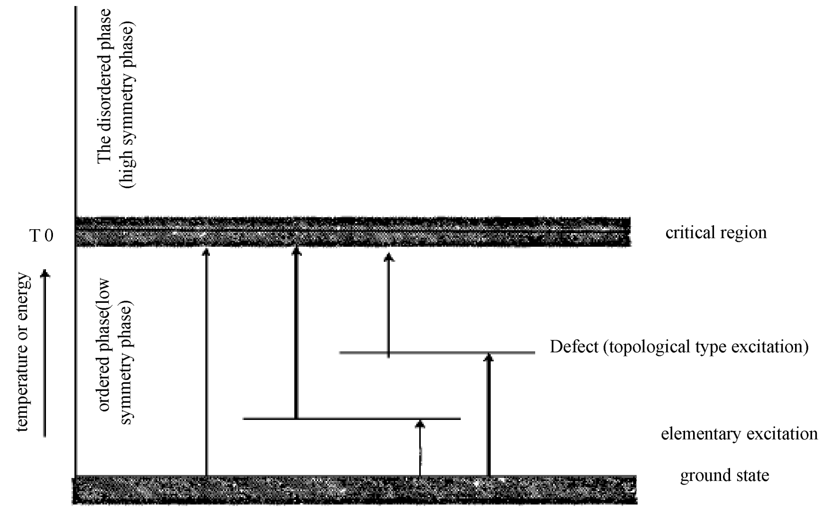

Figure 1 : State diagram of energy state of many particle systems related to the broken symmetry

Typical system broken symmetry shown in condensed matter physics (see TABLE 2), some important phase transformations had no directly relation with broken-symmetry, such as gas/liquid phase translation, shift of mental and non-mental. Ergodicity of the system could be broken caused by compartments of the phase space, such as transformation of liquid, metal and nonmetal respectively had relation with the configuration space traversal broken, relevant in the momentum space traversal breakdown. Although symmetry broken accompanyed traversal broken, but not always in return.

TABLE 2 : Condensed matter systems and symmetry broken phenomenon they shows

phenomenon	broken-symmetry	ordered phase	order parameter	elementary excitation	topological defects
ferroelectricity anti-ferroelectricity	inversion of space	ferroelectricityanti-ferroelectricity	P P_{ij}	optical phonon	domain wall
ferromagnetism anti-ferromagnetism	inversion of time	ferromagnetismanti-ferromagnetism	M M_{ij}	spinwave	domain wall
superconductivity	gauge invariance	superconductivity	$<\Phi>=\rho^{1/2}e^{-i\theta}$	electron	vortex filament
superfluidity ^{4} He superfluidity ^{2} He	gauge invariance gauge invariance	superfluidity superfluidity	$<\Phi>=\rho^{1/2}e^{-i\theta}$ $d_{ij}=<\Phi\Phi>M_i$ M_j	Phonon roton	vortex filament vortex filament disclination
liquid crystal	revolve revolve translation	nematic phase sholesteric Phase smectic phase	n $\rho(Q)$ $\rho(Q)$		disclination disclination dislocation
crystal	translation and revolve translation and revolve	crystal quasicrystal	ρ_G ρ_G '	Phonon Phonon	dislocation Phase wavelet dislocation
electronic crystal	translation	wignercrystal charge density waves spin density wave	ρ_G ρ_G ρ_G '	Ripple son Phase amplitude	discommensuration discommensuration

Boundedness of condensed matter physics paradigm

As the rapid development of the classical condensed state physics, it produced polymer condensed matter physics with contemporary polymer science by cross combination, the polymer condensed matter physics not only broken through the theoretical concept and research methods, but also through the traditional statistical theory and mean field method. Thus the condensed state physics were fade aura color gradually by researchers and replaced by condensed polymer physics, it could reflect that the condensed state physics had some limitations and cannot adapt to the study of condensed matter physics of polymer, especially breakthrough of the concept and research method of made polymer condensed matter physics differ from the condensed state physics, thus some new research field gradually came into people's vision, such as single molecular chain condensed state, liquid crystal polymer. Although "many body effects" and "broken symmetry" of classical condensed matter physics paradigm was suitable for polymer condensed matter physics in a certain range, classical condensed matter physics paradigm has not fully cover all phases and phase transitions of polymer condensed state because of its limitations. For example, the macromolecular chain had scale sex because of its self- similar structure and the fractal nature, which studied with the scaling law.

Structure Of Polymer Condensed Matter Physics Paradigm

Urgency of exploring polymer condensed matter physics paradigm

In the course of studies of polymer physics and condensed physics, a series of problems that appeared in the cross combination has plagued study ideas of many researchers. When the concept and research method of macromolecular condensed state physics got a breakthrough, some phenomena appeared to be gradually clear, but for such as concentrated solution and strong solution, linear theory and nonlinear theory of the new fields, the study had no constructing theoretical system and research framework, especially polymer physics research of had close relations with the biopolymer (such as DNA, RNA, proteins and polysaccharides) built their own all of paradigm is an urgent need. Although the National Natural Science Fund Committee has set up major research projects of "condensed polymer physics" and "multi scale polymer condensed state coherence research", but polymer condensed matter physics paradigm based on paradigm has not yet formed, college teaching courses and related field research has not yet great progress. In a word, construction of macromolecular condensed state physics paradigm must be resolved as soon as possible.

Construction of macromolecular condensed state physics paradigm

Two main issues are around in construction of macromolecular condensed state physics paradigm process, one is the condensation process and condensed essence of chain like macromolecules, the other is characteristics and rules of phase transformations of polymer material. the concept of "lyotropic cohesion" could be applied to the first problem, "lyotropic coacervation process" shown in Figure two; for the second problem, study on the basis of emphasizing the soft material characteristics can be improved, and entropy induced phase transition is an important feature of soft condensed matter states, metastable phase far from equilibrium state and intermediate phase emerged in phase transition.

In addition, discovery of the research methods of polymer condensed matter physics, that is, the scaling theory, scaling laws and the critical index theory, is necessary, self similar structure of macromolecular chains and the genera law of revealing should be paid attention. In other word, polymer condensed matter physics paradigm generally includes: features of condensed polymer characteristics including soft matter state, self similarity, complex correlation function, the lyotropic phase transition condensation process; the most typical features are entropy induced phase transformation, transformation of the critical region connectivity, scaling behavior. The main research methods are scaling law. The lyotropic condensation of macromolecular chains is shown as Figure 2.

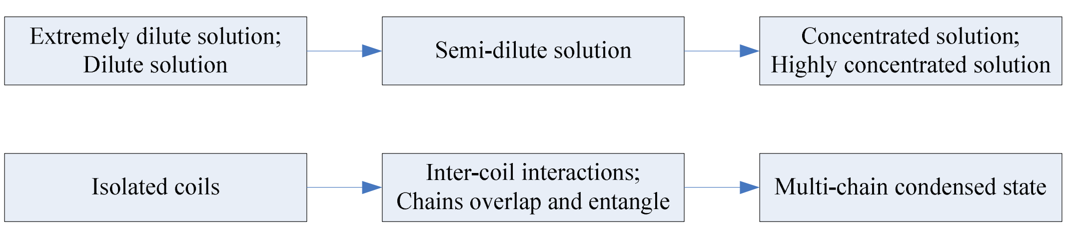

Figure 2 : The lyotropic condensation of macromolecular chains

APPLICATION OF POLYMER PHYSICS CONDENSED MATTERTHEORY PARADIGM

Polymer physics condensed mattertheory paradigm was classified in accordance with the study object and the type of materials division, and materials were made from macromolecule belonged to the soft material category, and had fractal and scaling properties, many functions could be written as a coefficient factor (generally expresses monomeric chemical properties) multiplied by a scaling (generally represents the physical properties chain), such as the root mean square end of the macromolecular chain pitch are $h=b \cdot N^{v}$, power-law of the molecular chain of different chemical structure are the same, with good applicability.

Polymer condensed matter belongs to soft substance, and soft substance materials possess biological macromolecules, polymers and colloids characteristics, Structure has properties of macroscopic periodic disorder and partial mesoscopic order, Flexible performance as "weak stimulation, strong response", When the structure or field changed weakly, condensed properties would change very much. Thus, the soft material had two characteristics: for one thing, strong association between the structure and properties were existed, for another thing, performance for field have strong loudness. While the equilibrium of soft matter system was determined by entropy maximum value, and the phase transformation called entropy, entropy was a function of temperature, so it was needed to adopt scaling theory, that is, $y \infty x^a$ of infinity.

Features of Polymer condensed state are as follows: The polymer has obvious supercooled liquid state -- glass state; With special high elastic state; the coexistence of crystalline region and amorphous region; orientation is special; viscosity of the viscous state are high; single chain can form a condensed state. Among them, for a single polymer chain, a polymer chain has tens of thousands of monomer units, interaction among chain units has performance of single chain condensed state (liquid, high elastic state, crystalline state), while the single polymer chain lies in a condensed state is unique feature of polymer. preparation of Single sample concludes extremely dilute solution spray, surface spreading, Frozen extraction and freeze-drying. While the single chain condensed state has no penetration of adjacent chains, stacking of molecular chain usually looser than Multi Chain condensed state, and it has a circle chain morphology;, it has Gaussian chain morphology because of multi chain condensed state being penetrated together.

Single polymer chain condensed state, molecular chain entanglements, amorphous polymer molecular chains of highly oriented local segment random orientation state, dynamic contact concentration, polymer liquid crystalline band texture are usually included in Macromolecular condensed state. Generally speaking, property of solution of single chain polymer measured through laser lighting scattering and size exclusion chromatography; removing solvent and maintaining separate state of clew to prepare polymer single crystals (single crystal morphology as shown in Figure 3) by appropriate experimental method. A physical interpretation of phenomenon of amorphous polymers aging and heat absorption peak and stress peak by cohesional entanglement viewpoint, and the cohesional entanglement is physical crosslink points composed of interactions of local adjacent chains (shown in Figure 4).

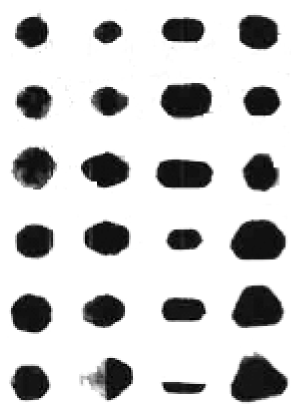

Figure 3 : Typical crystalline morphology of I - PS single-chain crystal (The scale represents 20nm)

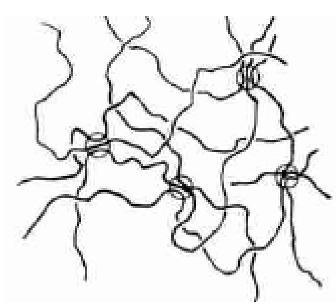

Figure 4 : Schematic diagram of polymer chain entanglements

CONCLUSION

After all, polymer physics condensed mattertheory paradigm had its own theoretical paradigm, which can more clear the development direction of future. Although it should be improved, of course, the application of polymer condensed matter physics paradigm is in its infancy. However, as more attention was paid to macromolecular condensed state physics discipline of the world, the subject must form a mature theoretical model. For this study is limited by many conditions, some applications of macromolecular condensed state physics paradigm just be made preliminary exploration, further study is still remained for other in-depth application.

REFERENCES

[1] Deyan Shen; Research of some basic problems in condensed matter physics of polymer[J], Polymer Bulletin, **(04)**, 69-75 **(2005)**.

[2] Duan Feng, Guojun,Jun; The basic concepts of condensed matter physics [J], Progress in Physics, **(01)**, 1-21 **(2000)**.

[3] Qihua Wu; Discussions on polymer condensed matter physics theory paradigm [J], 2011 National Polymer Academic Report. September, **(2011)**.

[4] Qihua Wu; Reflections on the polymer condensed matter physics paradigm [J], Acta Polymerica Sinica, **(02)**, 149-153 **(2013)**.

[5] Dayong Chen; Polymer condensed finite element analysis through state multi scale [D], Xin Jiang University, **(2006)**.

[6] Rushan Han; The latest progress in ab initio condensed state physics calculation [J], physical, **(11)**, 753-764 **(2010)**.

[7] Zhaojia Chen; From solid state physics to condensed matter physics [J], The teaching of Physics

[8] Qihua Wu; Polymer science frontier development track, Construction of Polymer Physics Courses [J], Polymer Bulletin, **(06)**, 52-55 **(2008)**.