

Synergetics and the Images of Future

Helena Knyazeva

Institute of Philosophy, Russian Academy of Sciences,
Volkhonka St.14, 119 842 Moscow, Russia*

Stuttgart, August 12, 1998

Abstract

The hope of finding new methods of predicting the course of historical processes, could be connected with the recent developments of the theory of self-organization, called also synergetics. It provides us with knowledge of constructive principles of coevolution of the complex social systems, coevolution of countries and geopolitical regions being at different stages of development, integration of the East and the West, the North and the South. Due to the growth of population on the Earth in blow-up regime, the general and local instability of development is increasing. The social world seems to go towards a unity, a sustainable commonwealth through the pulsations rather than monotonously. It goes via alternation of disintegration, even if partial, and getting more powerful integrations of structures. There is a path of multiple reduction of temporal and material expenses, path of a resonant excitation of desirable and - that is not less important - feasible in a given social system structures. In the case of right topology of integration of geopolitical structures an arising whole organization can accelerate its tempo of evolution.

*Current address: Institute for Theoretical Physics and Synergetics, University of Stuttgart, Pfaffenwaldring 57/4, D-70550 Stuttgart, Germany; e-mail: helena@theo.physik.uni-stuttgart.de

Synergetics as a new methodology of futures studies

In order to develop further the methods of scenario building and to facilitate the paths towards desirable and sustainable futures, we cannot do without a nonlinear evolutionary thinking. The theory of self-organization of complex systems, or synergetics, might be a scientific basis for such a thinking. The main principles of nonlinear evolutionary thinking might be drawn from the theory.

Synergetics is a new interdisciplinary movement in modern science signifying a process of becoming of a new outlook of a human on the world as well as on himself in the world. Synergetics is a new dialogue of a human with nature, a new synthesis of human knowledge and wisdom. The new theory develops a new approach to cognition of evolutionary crises, instabilities and chaos and to mastering the methods of nonlinear management of complex systems being in the states of instability. This theory leads to understanding of some principal limits of predictability in ecology, sociology, economics, geopolitics.

Being a modern post-Darwinian paradigm of evolution, the theory of complexity and self-organization is being now under rapid development in different countries by various scientific schools: H. Haken¹, I. Prigogine², S.P. Kurdyumov³, E. Laszlo⁴, K. Mainzer⁵, B. Mandelbrot⁶, E. Morin⁷, F. Varela⁸.

Synergetics is oriented to reveal general patterns of evolution and self-organization of the complex systems regardless of the concrete nature of their elements or subsystems. It has a hard core (mathematical models and computer simulation of behavior of complex systems) as well as a ramified net of application of the developed models. The nonlinear synergetic models as interdisciplinary ones are applicable to the human activities and to management of the complex social systems.

One may speak about a futuristic dimension of synergetics. The methodology of nonlinear synthesis based on the scientific principles of self-organization and coevo-

lution of the complex structures of the world might be used as methodological basis for projecting various paths of mankind into the future.

The methodological consequences presented in the paper are based on the analysis of the results of mathematical modeling and computational experiments with evolutionary processes in open nonlinear media (or systems) carried out by the Moscow Synergetic School at the Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences. A number of these results have been obtained and proven in form of mathematical theorems. The new methodological notions under discussion have a solid foundation of the mathematical developments. The details of the mathematical models and nonlinear analysis can be found in recent publications of S.P. Kurdyumov and his collaborators⁹.

As it was noted at the Nordic Regional WFSF Symposium in Reykjavik (20 to 22 March, 1997), futures studies has a methodological vacuum at the present (W. Bell). Being a promising interdisciplinary research program, synergetics is a source of new fresh ideas for futures studies as well. It can provide us with a new methodology of constructing the soft lines of the future.

Spectra of evolutionary paths into the future

Future is open and varied. There is a spectrum of possibilities of future development. Future is not 'l'avenir' (what will be tomorrow), but 'les futuribles' (one of the possible future states). Synergetics gives a new scientific background for this modern view.

A whole system of concepts, notions and ideas connected with nonlinearity and "aims" of evolution, i.e. signifying the construction of a kind of evolutionary teleology, is in the process of development now. First of all, these are the notions of localization processes in open dissipative media (the structure formation in them), spectra of structure-attractors as stable formations which evolutionary processes

in such systems go to, the ways of resonant excitation of evolutionary structure-attractors, types of fast, avalanche-like development, blow-up regimes (modes with peaking)¹⁰.

In relatively simple mathematical and computational models, a result of fundamental importance has been obtained: a continuous nonlinear medium potentially contains in itself different kinds of localization processes (different kinds of structures). Medium is a united source that acts as a carrier of different forms of future organization and as a field of different evolutionary paths. In other words, there are discrete sets of evolutionary paths of complex systems in the world.

The same notion follows from the original synergetic model of order parameters and slaving principle elaborated by H. Haken. There is a principle of circular causality which describes the relationship between the order parameters and the parts that are enslaved by the former: the individual parts of a system generate the order parameters that in turn determine the behavior of the individual parts. It can also be expressed in quite another form, namely: the order parameters represent a consensus finding among the individual parts of a system, to draw an anthropomorphic picture. Thus, the few order parameters and the few possibilities they have in accepting their individual states reflect the fact that in complex systems only few definite structures that so-to-speak are self-consistent with respect to the elements are possible. Or to put it differently, even if some configurations are generated artificially from the outside only few of them are really viable¹¹.

The notion of discrete spectra of evolutionary paths of complex systems, a field of developmental paths constitutes a basis of the synergetic methodology. The notion entails a number of important consequences: the plurality of the future, the availability of the moments of instability connected with the choice of a path of further development, the specific role of a man in nonlinear situations of branching the evolutionary paths and choosing a desirable and favorable path of development.

In a general case, namely if a mathematical description is admissible, the spec-

tra of possible, "allowed" structures correspond to sets of eigenfunctions of some nonlinear equations presenting the evolutionary processes in the complex system. The sets of eigenfunctions of the corresponding nonlinear equations are mathematical representations of spectra of evolutionary structure-attractors. The spectra of evolutionary structure-attractors are determined exclusively by the own properties of a given complex system (open nonlinear medium). They are its inner potentials, so to speak, "a tacit knowledge" of the system itself.

It's important to understand that social systems as well as any complicated systems usually have several alternative paths of development. There are many developmental paths. An exit to the future is not unique. We must take into account multiple futures. The developmental paths are determined by spectra of structure-attractors of social systems as a kind of complex nonlinear systems. Besides, some eventual changes of inner properties of social systems can lead to a transformation of spectra of evolutionary structure-attractors, sets of possible paths into the future.

In his article in "Futures" I. Prigogine developed a whole philosophy of instability. Whereas nature was considered as entirely controllable in the framework of the deterministic worldview, nowadays we begin to understand that nature contains instability as an essential element which we have to respect, because we cannot predict what will happen¹². The synergetic models used here allow us to develop the view. The future states of complex social systems are not simply open and unpredictable: there are spectra of possible forms of future organization. Although there can be a lot of evolutionary paths, their number is not infinite. Spectrum of structure-attractors is not continuous. It is not any arbitrary evolutionary path that can be feasible in the given social system.

The future forms of social organization are open in form of a fan of pre-determined possibilities. The exits to the future are narrow. There are certain "corridors" of evolution. Therefore, we have to solve a problem of a controlled openness of the social development: how we can facilitate a sustainable and self-maintaining ways

of development? How it is possible to choose a harmonic developmental path into the future?

Synergetic rules of nonlinear management

The theory of evolution and self-organization reveals some principles of nonlinear management of complex systems. The theory teaches us the art of soft management.

1) The future is open and unpredictable, but not arbitrary. There are spectra of possible future states, certain discrete sets of structures-attractors of complex evolutionary processes.

Initial conditions do not determine the vector of human activity; the initial conditions will be forgotten when one of structures-attractors has been initiated. The latent and revealed attitudes determine the present activities. The present state of affairs is constructed by and from the future.

The soft lines of the future presuppose ways of special, soft management.

2) Soft management is management by "clever" and appropriate influences. Weak, but proper, i.e resonant, efforts are of great efficiency. They have to correspond with the inner trends of development of a complex behavioral system.

Correct resonant actions can lead to revelation of tremendous inner forces and possibilities of a human being or a social (cultural, scientific) community. Thus, synergetics rediscovers the well-known philosophical principle: small events cause large results.

3) The art of soft management consists in the ways of self-management and of self-control of complex systems. How to manage a complex system without rough management is the main problem. How can we push a system in a favorable evolutionary path with a small, resonant influence? How can we provide a system with a self-maintaining and sustainable development?

As a matter of fact, the synergetic notions are in accordance with the behavioral

rules of Eastern people, first of all, with the principle of non-violence. "The Taoist school held that the rulers should go with natural law (the 'Tao'), governing as little as possible"¹³.

4) Some human actions are doomed to be unsuccessful. They fail because they were not in line with the inner trends of the complex system development. If they are not proper, they will surely be actions in vain. These are, so to say, evolutionary prohibition rules which are imposed on some kind of human actions.

Taking into account the general synergetic consideration, we can explain quite naturally the historical (the past and eventual future) failures of voluntaristic management of scientific technical and social progress. The unsuccessful and tragic social experiment to build socialism in Russia as well as in the whole geopolitical space of the former USSR can be mentioned here. A management is ineffective, if it attempts to construct those structures which are not adequate to the inner trends of the evolving system, figuratively speaking, which 'violate' reality. Man has either to look for ways of changing the own features of the given open nonlinear system or to give up the attempts 'to force' the system to develop in an inappropriate way.

5) Some possible changes of inner properties of complex systems can lead to a transformation of spectra of evolutionary structure-attractors, sets of possible paths into the future.

6) There must be a certain topology of action. It turns out that the managing influence must not be energetic, but rightly topologically organized. Its topological configuration, symmetric 'architecture' is important, not the intensity of an influence. The resonant action is a spatially distributed action. It's a kind of prick at the right places and at the right time.

Synergetics defines how it is possible to multiply reduce time and required efforts to generate, by a resonant influence, desirable and, what is no less important, feasible structures in a complex system. The weak defeats the strong, the soft defeats the hard, the low defeats the loud, as taoists put it. The new science of complexity

allows to reveal a synergetic sense in the ancient notion.

Constructive principles of the complex systems coevolution

Super-rapid development of social processes.

One of the fundamental facts which force us to revise the former worldview is the law of population growth. The fact has been investigated by the Russian scholar S.P.Kapitza¹⁴ as well as by the team of S.P. Kurdyumov¹⁵. It was shown that the growth of population on the Earth obeys not exponential law, but hyperbolic law, i.e. occurs in blow-up regime.

According to the models, we are living already in the period of peaking: the blow-up point is approximately in the year 2025. The size of population on the Earth will not certainly reach infinity that year. It will pass a pronounced maximum and stabilize at its highest point¹⁶. But the main and huge period of the history of mankind taken in all available demographic and anthropological data is described quite precisely by the models.

The phenomenon determines the modern picture of civilizational development. Due to the growth of population on the Earth in the blow-up regime, the general and local instability of development increases, the threat of catastrophes appears. The problem of evolutionary crises concerns the whole world, not only some geopolitical regions being temporary under the reconstruction, such as the space of former USSR or former Yugoslavia.

The evolutionary crises are to some extent inevitable, because the blow-up regimes lead to instability, to a threat of probabilistic decay of a complex structure near a blow-up moment.

Constructive role of chaos in social evolution.

It's worthwhile to understand a constructive, or creative, role of chaos in social evolution. A market could be considered as an analogy of chaos in social domain.

It's a market in general sense, market of material products as well as services, "market of ideas", exchanges of scientific information. This generalized market is a self-regulator of social processes. It is a generator of new information, social and cultural innovations.

Chaos plays a constructive role in the moments of choosing a further evolutionary path as well as in constructing a complex evolutionary whole. Chaotic, scattering, dissipative processes serve as a way of connection of elements of a complex structure. They are basis for the establishment of coherent behavior of elements or subsystems of the world. Figuratively speaking, chaos can serve as a "glue" which binds parts into a united whole. If a connection of the elements within a structure is too weak, a decay of the structure can take place.

Nevertheless, an initial chaotic basis, "switching on" the free market mechanisms is not a guarantee for an exit to self-organizing structures of in a social medium. The path of chaos, the thermodynamic branch remains as one of possible evolutionary paths in complex nonlinear systems, too.

Laws of nonlinear synthesis.

The rationality and even necessity of integration of different cultural, social and geopolitical structures are rather obvious in modern time. Though the process of such integration presents a general civilizational trend, it occurs actually with enormous losses, historical deviations and delays. It's worthwhile to comprehend some ways of common life, coevolution, convergence of heterogeneous elements of the world with simultaneous conservation of cultural and historical peculiarities, tempo of development, the quality of life etc.

Synergetics allows us to discover laws of coevolution of complex structures "of different ages", i.e. structures being at different stages of evolution and having different rates (tempos) of evolution, as well as laws of "including", building a simple structure into a more complex one. The knowledge of the evolutionary laws provides a possibility to understand ways of integration of countries, regions, geopolitical

structures evolving with different speed and being at different stage of evolution.

There are various, but not arbitrary, ways of integration of rather simple structures into a more complex one. There is a restricted set of integration ways, ways of construction of a complex evolutionary whole. Besides, a certain degree of overlapping of simple structures is very important when a process of integration is taking place. There must be certain topology, "architecture" of overlapping. There must be a positive "feeling of measure".

New principles of nonlinear superposition describe how a complex evolutionary whole is being assembled from the integrated parts. Integration of structures is not merely their putting together: the regions of structures localization are overlapping with energy defect taking place. In this case, a whole is not equal to sum of its parts. Generally speaking, it is neither more nor less than the sum of parts. It is qualitatively different. It is an evolutionary whole, because it unites structures of "different ages", the structures being at different stages of evolution.

The integration of different structures occurs according to their "architecture", topology of organization as well as their speed of the development. The main law of integration of parts into a complex whole can be formulated as follows: synthesis of relatively simple evolving structures into a more complex one occurs due to the establishment of a common tempo of their evolution.

The intensity of processes in various fragments of complex structure (for example, for social systems - the level of economic development, quality of life etc. in various countries) can be diverse. The fact of integration signifies that structures becoming parts of a whole acquire a common tempo of the social development. Structures fall into one tempo-world, begin to develop with the same speed. One can speak about a co-existence of "different aged" structures in the same tempo-world.

A path of acceleration of evolution.

Synergetics discovers principles of management, economy and acceleration of evolution. There is a way of shortening of a long zigzag evolutionary path and of multiple

reduction of temporal and material expenses. There is a way of *a resonant excitation* of a desirable and - that is not less important - feasible in a given social system structure, one of a spectrum of possible structure-attractors. The latter way is an analogy of biological processes of morphogenesis and re-duplication of DNA.

In the case of *right topology of integration* (in the case of a certain degree of interaction of structures and a certain symmetry of architecture of a building unified structure) an arising whole organization can accelerate its tempo of evolution.

When structures of different ages are being integrated into a complex structure, we have, according to the laws of nonlinear synthesis, a defect of power (or a defect of energy), i.e. we can save energy and other expenditures. To put it in other words, the topologically proper organization of structures in a whole leads to an approaching of a peaking (blow-up) point. The whole is developing faster than its integral parts. It becomes more profitable to develop together, because it allows saving the material (in particular, energetic), spiritual and other resources.

Every new way of a topologically right integration of structures, i.e. an appearance of every next layer (with bigger exponent of nonlinearity) of hierarchical organization, accelerates a tempo of development of a whole as well as of its integral parts.

Pulsative rhythm of an ascent to the sustainable commonwealth.

According to the theory of self-organization, any open systems with strong non-linearity are very likely to pulsate. They are subjected to natural oscillations of development: the differentiation of parts is replaced by their integration, the running apart - by the drawing together, the slackening of ties - by their strengthening. The world seems to go towards a unity through some pulsations rather than monotonously. It goes via alternation of disintegration, even if partial, and the getting more powerful integrations of structures.

Aside from a hope that the disintegration of a complex system does not exclude in the future a possibility of its integration, the synergetic worldview offers something

more constructive.

First of all, we can reach the desired structure-attractors in a shorter time avoiding numerous absurd and unnecessary tries, infernos, evils. This is the above mentioned idea of speeding up the evolution by means of the resonant influence.

Second, considering the prospects of integration synergetics argues that there are laws for the architecturally perfect synthesis of differently aged structures (i.e. the structures being at the different evolutionary stages) into a harmonic whole. There is an optimum of the integration, a certain measure of connection of parts in the frames of the whole.

Thus, basing on the understanding of mechanisms of switching over the opposite complementary regimes, the regimes of disintegration and integration, we may assume that a renewal of broken ties will occur using some former channels. "The spread over the old traces" will appear to take place.

The initial stage of formation of a complex structure would seem to slacken the processes running in a corresponding open nonlinear system. However, if structures are being integrated in a topologically proper way, an arising whole structure begins to develop faster. A new higher rate of development is setting up throughout a whole united domain.

Concerning problems under discussion we may draw a conclusion that a unified, rightly organized market accelerates development of the participating sovereign states. Therefore, a path of formation of a new federation in Russia, and in a more general case, a path of growing integration of the sovereign states into the world commonwealth, is to a certain extent pre-determined.

Synergetics as an optimistic view of the future

To summarize, new elements of methodology of futures studies derived from synergetics could be formulated as follows.

Synergetics builds new notion of discrete spectra of evolutionary paths. Proceeding from this view, it is possible to construct the images is desirable and attainable future.

Synergetics develops a new evolutionary holism, i.e. explains how a complex evolutionary whole can be assembled from different parts. It gives us knowledge of constructive principles of coevolution and sustainability of the complex social systems, coevolution of countries and regions being at different stages of development. Synergetics reveals evolutionary laws of nonlinear synthesis, namely:

1) availability of various, but not arbitrary, ways of integration of structures into a whole complex one,

2) importance of a right topology, "configuration" of integration of simple structures into complex ones,

3) integration of structures as different tempo-worlds,

4) possibility - in the case of right, "resonant" topology of integration - of significant economy of material and spiritual expenses and acceleration of tempo of the system development.

Generally speaking, synergetics is closely connected with optimism. That is an optimistic attempt to understand the constructive principles of evolution and coevolution of the complex systems, to reveal causes of evolutionary crisis, instability and chaos, to realize the limits of control and interference in the social systems development and to master the methods of nonlinear management of complex systems. This is an attempt to find ways of facilitating of self-maintaining and sustainable development of the world.

This field of possibilities can transform, reconstruct itself, if the inner properties of the social system are changing. If we manage to model the spectra of developmental structure-attractors of the complex social systems, we can get an opportunity to avoid the critical states and undesirable developmental paths and to choose the most favorable, acceptable for us - and at the same time feasible in a given system

- path of development. This demonstrates the special role and responsibility of a human subject in the nonlinear situations of bifurcation and choice.

Acknowledgments

The use of synergetic evolutionary models and their methodological consequences developed together with Prof. S.P. Kurdyumov (Keldysh Institute of Applied Mathematics of the Russian Academy of Sciences) is greatly acknowledged. The research presented in the paper was supported in 1997-98 by the Alexander von Humboldt Foundation.

Notes and references

1. Haken, H., *Synergetics*, Springer, Berlin, 1978; Haken, H., Can Synergetics Be of Use as Management Theory?, *Self-organization and Management of Social Systems. Insights, Doubts and Questions*, Springer, Berlin, 1984.
2. Prigogine, I., *From Being to Becoming*, Freeman, San Francisco, 1980; Prigogine, I. and Stengers, I. *Order out of Chaos. Man's New Dialogue with Nature*. Bantam Books, New York, 1984.
3. Achromeeva, T.S., Kurdyumov, S.P., Malinetskii, G.G. and Samarskii, A.A., Non-stationary Dissipative Structures and Diffusion-Induced Chaos in Nonlinear Media, *Physical Reports*, 1989, **176**, 186-372.
4. Laszlo, E. *The Interconnected Universe*, World Scientific, New York, 1995.
5. Mainzer, K., *Thinking in Complexity. The Complex Dynamics of Matter, Mind, and Mankind*. Springer, Berlin, 1997.
6. Mandelbrot, B., *The Fractal Geometry of Nature.*, Freeman, San Francisco, 1982.
7. Morin, E., *Method. Towards a Study of Humankind.*, vol.1, *The Nature of Nature*, Peter Lang, New York, 1992.

8. Maturana, H.R. and Varela, F., *The Tree of Knowledge*, New Science Library, Boston, 1988.
9. Achromeeva, T.S., Kurdyumov, S.P., Malinetskii, G.G. and Samarskii, A.A., Non-stationary Dissipative Structures and Diffusion-Induced Chaos in Nonlinear Media, *Physical Reports*, 1989, **176**, 186-372; Kurdyumov, S.P., Evolution and Self-organization Laws in Complex Systems, *International Journal of Modern Physics C.*, 1990, **1**, 299-327; Samarskii, A.A., Galaktionov, V.A., Kurdyumov, S.P. and Mikhailov, A.P. *Blow-up in Problems for Quasilinear Parabolic Equations*, Walter de Gruyter, Berlin, 1995.
10. Knyazeva, E.N. and Kurdyumov, S.P., *Evolution and Self-organization Laws in Complex Systems*. Nauka Publishers, Moscow, 1994. (in Russian); Knyazeva, E.N. and Kurdyumov, S.P., Synergetics in Cultural Context. Contribution to Resolution of Current Civilizational Crisis, *Dialectic, Cosmos, and Society*, 1995, **8**, 3-8.
11. Knyazeva, H. and Haken, H., Perché l'Impossibile è Impossibile, *Pluriverso*, 1997, **2**(4), 62-66.
12. Prigogine, I., The Philosophy of Instability, *Futures*, 1989, **21**(4), 396-400.
13. Jiayin, M., Transformations in the Chinese Cognitive Map, *The Evolution of Cognitive Maps: New Paradigms for the Twenty-first Century*/ Ed. by E.Laszlo, Gordon and Breach Publishers, New York, 1993, 226.
14. Kapitza, S.P., Population: Past and Future. A Mathematical Model of the World Population System, *Science Spectra*, 4, 60-65.
15. Belavin, V.A., Knyazeva, E.N. and Kurdyumov, S.P. Blow-up and Laws of Coevolution of Complex Systems, *Phystech Journal*, 1997, **3**(1), 107-113.
16. Kapitza, S.P., The Phenomenological Theory of World Population Growth, *Physics-Usppekhi* (English version), 1996, **39**(1), 60.