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SOCIAL EQUIVALENT OF FREE ENERGY

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SUMMARY

Characterisation of unbounded resources of a social system within the sociological interpretation has resulted in a large number of different notions, which are relevant in different situations. From the view point of statistical mechanics, these notions resemble free energy. In this paper the concept of social free energy is introduced and first steps toward its development presented. The social free energy is a function equal to physical free energy appropriately determined for the social system, with intrinsically sociological interpretation as a measure of social action obtainable in a given social system without changes in its structure. Its construction is a consequence of response of a social system to recognised parts of environment dynamics. It is argued that development of a social system response resembles exciting the normal modes of a general, physical system.

KEY WORDS

social systems, social free energy, adaptation, organisation, dispersion relation

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INTRODUCTION

Social systems are complex systems. Prevalently, they have been verbally described. Deeper understanding of their dynamics benefits from their quantitatively based description. Recently, in a number of independently conducted researches, the role of the isostructural social action was emphasised, its interpretation tested and evolution simulated [1 – 8]. Social action is collection of all resources of a social system which are not bound to regular dynamics. It measures parts of material and immaterial, individual and collective collections of elements the corresponding types of which are observed in social dynamics. Resources falling within social action, therefore, are included in dynamics irregularly, for neutralisation of unwanted environment influence, i.e. for improving adaptation of a system in a stochastic environment. Environment is stochastic, otherwise unspecified, thus includes, e.g. other social systems. Ideally, neutralisation is performed without significant changes in social system structure, thus corresponding social action is termed isostructural social action. Following recently argued claim, it will be referred to as a social free energy because of its resemblance of physical free energy [7, 8].

The importance of social free energy is that it is the quantity which individuals and groups unwittingly evaluate in order to use it as a basis for interpretation of past, present, or predicted future social system states.

Formulated parts of concept of social free energy are given elsewhere. They include working out of some aspects of social free energy, its meaning in different situations and formulation of indicator about the reached level of social system adaptation. Up to now, analysis implied on the one hand given social system structure and on the other hand fixed understanding of environment dynamics. The explicit taking into account of their time dependency adds to understanding of the intrinsic dynamics of social free energy, e.g., its formation and redistribution. The corresponding inclusion is by no means straightforward, as the full time dynamics of these, mutually highly related processes extremely complex and presently intractable.

In this paper the interplay between the change in understanding of environment dynamics and in social system structure is analysed. A general environment influence is assumed, and is followed with the discussion of its consequences bringing about better adaptation of a corresponding social system. Generically, consequences include redistribution of resources from social free energy into bounded part of resources. That preliminary analysis of redistribution process reveals several characteristics of bounded resources: (i) they are structured, (ii) the possibility of their structuring depends primary on characteristics of the social system, while (iii) their quantity depends primary on interpretation of environment. In particular, and connected with point (i), the structuring of bounded resources is analysed here.

The outline of the paper is as follows. In the second section social free energy and related quantities are described in more detail. In the third section the observable, yet infinitesimal change in environment influence is assumed and its average consequences described. It is followed in the fourth section with more abstracted description of bounding of part of social free energy. Discussion of other, presently unrelated yet manifestly similar collective forms exploiting social free energy is contained in the fifth section, while conclusions and lines of future development are given in the sixth section.

SOCIALLY INTERPRETED PHYSICAL QUANTITIES

Among physical quantities, the thermodynamic ones are particularly appealing for use in social system dynamics description aiming to reach quantitative level. The thermodynamics is about aggregated description of systems, originally physical. Considered in a broader sense, it effectively optimises simplicity of description (as the usual number of quantities introduced is relatively small) and extent to which it describes states of systems close to equilibrium. Thus thermodynamics collects system indicators, representations of an intense reduction of information existing within the system. These properties have been recognised by several authors, as seen in their applications of thermodynamic quantities onto human and other biological systems description.

In particular, social free energy was recognised as profit [1], common benefit [2], availability [3], free value of canonical portfolio [4], balanced average cost [5], or general quantity utilized in description of economic processes [6], or as a general quantity describing overall system-environment interaction [7, 8]. While seemingly different, it was argued that these notions refer to the same, referent quantity on which the interpretation of different system states is based. Other thermodynamic quantities, e.g. entropy, temperature [9] and extropy [10] were also applied in human systems. Temperature is prevalently interpreted as a measure of manifest dynamics. Extropy is found useful in describing complex systems as it measures deviation from arbitrarily chosen referent state. By that, one overcomes the problem of linking the current state with the equilibrium state, which itself is rather problematic for characterisation.

ENVIRONMENTALLY INDUCED PROCESSES

Further in the text the following scheme of system-environment interaction is assumed: (i) some element of environment dynamics occurs constantly, but not necessarily regularly, (ii) that element influences social system dynamics, (iii) both the element and its influence are recognised by the social system, (iv) intra-system processes are started aiming at better adapting the system to environment. The listed sequence occurs constantly, simultaneously for different elements of environment dynamics. The short-term and long-term processes are qualitatively different.

Let us use two examples to illustrate the sequence listed: firemen service and agriculture. Firemen service does not exist in less structured societies. It is a specific structure realised as a consequence of environment influence (fire). For organisations above some level of development, firemen service becomes prerequisite of further persistence and development of the system. Firemen service is not tended to contradict the otherwise determined dynamics of the system, but to enable its further dynamics. The level of development of fully developed firemen service is aligned with the level of development of other services, as they all share same technological, legislative and other bases. It is a fact that fire as an environmental influence is possible constantly, what is prolonged onto the duration of the firemen service as a collective form.

In case of agriculture, the same two elements are seen; environment influence and system response. Influence is realised as existence of a finite quantity of bread grains, fruits and vegetables the humans could use for living. The response is realised as food-production which follows characteristic dynamics of purposefully prepared plants. Improvement in agriculture includes structuring of legislative, educational, scientific and other types of collectives contributing in turn to stability of reached level of understanding along with its further development.

Several processes are covered within the notion of response to environment influence. As a rule they include transfer of resources which were bounded within the system, and which becomes linked to a particular structure, itself developed as part of the response. Newly formed structure in general does not influence intensity of dynamics of the rest of dynamics, but changes the set of roles in the system value set.

A recognition of an element of environment dynamics means that the value set of corresponding social system is broadened with interpretation of that element. It figures as elementary environment excitation, the term described in detail elsewhere.

The response of the system on environment influence is alignment with the fact that a part of environment complexity is recognised, and with the tendency to optimise consequences thereby caused. Response is individual and collective. Further in the text the emphasis is put on the collective response. There are several attributes of collective response: duration, extent and role. Duration is expressed through characteristic time unit equal to value of time interval between properly defined start and end of the response. Extent is characteristic distance of space region in which the response is significant. Finally, role is expressed in value set underlying total dynamics of social system, thus its response included. Value is a settled measure of response to both the environment dynamics and the human dynamics.

The environment dynamics then enables one to understand better the intrinsic character of social systems – the structuring during response means realisation of previously potential mode of dynamics; structuring is connected with transfer of resources. Such a transfer was possible before it actually occurred within the response. However, without external influence there was no need for corresponding resource transfer and generally there was no spontaneous structuring.

Once formed, each structure is involved in complex dynamics, e.g., in structure-structure dynamics. Overall, that dynamics determines in turn the previously stated characteristics of the structure, which generally significantly differs and varies. However, it is argued further in the text that the structures share universal framework, combining their duration, extent and role.

DYNAMICS OF SOCIAL FREE ENERGY

Structuring which accompanies the system response generally includes, as illustrated in the previous section, resource transfer from social free energy into regular dynamics, as covered by social temperature. The transfer is naturally accompanied with the human actions. The diversity of these actions and overall resource transfers is divided into four categories depending on whether the human response is collective or individual, and whether it is short-term or long-term response. The long-term response usually in interpreted as restructuring of the system, while the short-term response is isostructural. Out of the four combinations of responses in this article the short-term collective response is analysed in more detail.

Application of the social free energy along with the social entropy onto description of social systems brings about intuitive macro-level results. In particular, the analysis of two hypothetical systems which are extremal regarding their adaptivity and level of living illustrates that point. Let in the system A the social free energy attains its minimal value and that all resource augmentation is transformed into enlargening of the social entropy. The corresponding development is characterised with the maximal number of different behaviours. However, at the same time the stability is minimal. The other system, system B, is characterised with the lowest possible value of social entropy and that all the resources transferred from the environment become part of the social free energy. That system is maximally adapted to its environment. However, its internal tension is maximal, as there exist for relativelly long time significant discrepancy between possible and understandable level of living on the one hand, and the realised level of living on the other hand. These illustrations point to the fact that generally the longest duration achieve systems which simultaneously optimise their social free energy and social entropy, i.e. which optimise the adaptivity and goal attainment.

If one would like to express changes in thermodynamically based quantities, then meta-theoretically the appropriate starting point is the Gibbs differential

$$dF = -S\mathrm{d}T, \qquad (1)$$

strictly valid for equilibrium processes without changes of boundaries. Qualitatively, it expresses the fact that resources belonging to the social free energy influences level of living, in particular intensity of actions in known ways of living. The equilibrium character here points to relativelly durable processes. In order to overcome that restriction and obtain the form for changes of social free energy valid for short-term collective processes, the explicit taking into account of human collectives is needed.

COLLECTIVE EXCITATIONS IN SOCIAL SYSTEMS

Overall, the longer the duration, the more precisely the role is determined. The relation between the role and extent is not so straightforward, as the role is presumably set within the verbal context of value set. The conjecture posed is that the extent and role are linked. The underlying relation is designated *dispersion relation*. In order to reveal the link the role should be suitably quantified, from the point of view of the corresponding value set, ideally independently of the extent. Quantification is performed firstly by linking the role with observable time characteristics of dynamics, and subsequently by linking the later with the extent.

Let us consider several examples in order to illustrate the use of dispersion relation in characterising collective excitations: spectators at a stadium [11] and firms.

SPECTATORS AT A STADIUM

Spectators usually come with rather large devotion to the match, or sport event watched, so that their equivalent social temperature is rather high. Therefore, the external stimulus to behaviour of spectators – the dynamics of sport watched, triggers rather easily different collective modes. A sideways consequence is that many of the modes are mixed or damped. Several differentiated modes are:

1. intense fan support triggered by impressive action on the ground,
2. constant support of group of fans and
3. Mexican wave.

It is assumed presently that these three modes are ordered in the sequence of larger wave vector (thus smaller extent), and in the sequence of larger value, i.e., the intensity of the spectators needed. The sketch of the dispersion relation thereby implied is in Fig. 1. The duration of all these modes require several considerations. It is estimated that in the same order the modes are listed their duration raises. This seems paradoxical in comparison with the constancy (i.e., throughout the match or the event) of the fan support. However, the fan support is considered a highly damped mode which is constantly excited by the large energy content of the fans involved.

To the same group of collective excitations as spectators at a stadium the participants at a concert, intelligent mobs and similar groups of people belong.

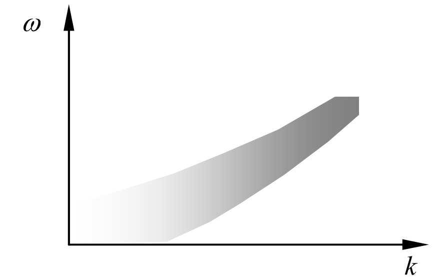

Fig. 1. Sketch of the dispersion relation of spectators at a stadium. The brighter grey level points to the larger dissipation, i.e., shorter duration of an elementary mode.

FIRMS

Firms are collectives which are rather durable in comparison with the groups of spectators, concert participants etc. Their extent and value vary considerably. Generally, the distribution of the extent of firms points to a large number of localised firms and relatively small number of delocalised firms. However, some trend in duration is not extractable from the well-known, intuitive facts.

The basic evolution of processes in terms of their dispersion relation at the present level is the following one: initially, the collective excitations are non-realised, known prevalently as ideas, with similar probability of realisation throughout the region containing social systems with similar techno-cultural level reached. That gives a finite initial average repetition rate, value and practically infinite extent. In time, people develop ideas, apply them and develop their realisations, all in constantly interfering way. Because of the work conducted, on the one hand the average value of the excitation raises. On the other hand, it becomes more aligned to humans, hence in its extent the differences on the scales smaller than the characteristic scale of the system(s) appear. Because of the enhancing interest the people find in the excitation, its dissipation enlarges. The sketch of the described evolution of excitations, i.e. the accompanied dispersion relation, is shown in Fig. 2.

Such a shape implies one measurable consequence – the existence of a well-defined initial energy ω_0, representing the energy each human needs to adopt the idea of the excitation.

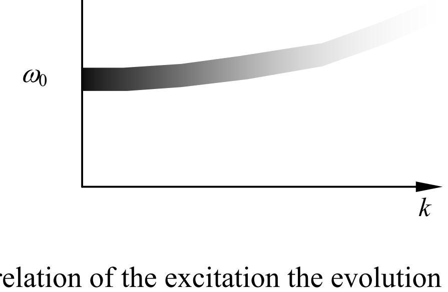

Fig. 2. Sketched dispersion relation of the excitation the evolution of which is described in the text. Presently the only general characteristic is $d\omega/dk > 0$. The change in line intensity points to the assumed change in excitation intensity, i.e., the level it influences people.

CONCLUSIONS AND LINES OF FUTURE DEVELOPMENT

The conjecture argued about in this article is that the existing structure of social systems is a consequence of the tendency for better adaptation to environment dynamics. On the one hand, therefore, a lot of structures could serve as collective excitations the analysis of which reveals some underlying regularity of collectives, e.g., their dispersion relations. On the one hand, however, not all collectives are suitable for initial analysis, because their dynamics could bring about the ceasing of the initial impetus attributed to them in the form of the relativelly strong localisation or dissipation, overall their ubiquitouty and indistinguishability. Overall, as the optimal collectives for further development of the concept the relativelly new structures are extracted and in subsequent work the quantitatively based analysis will be performed.

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SOCIJALNI EKVIVALENT SLOBODNE ENERGIJE

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SAŽETAK

Karakterizacija nevezanih resursa socijalnog sustava u okviru sociološke interpretacije rezultirala je različitim interpretacijama, značajnim u različitim situacijama. Sa stajališta statističke mehanike te interpretacije odgovaraju slobodnoj energiji. U ovom radu je koncept socijalne slobodne energije uveden i upotpunjen s prvim koracima u njegovoj razradi. Socijalna slobodna energija je funkcija iznosa jednakog slobodnoj energiji određenoj za socijalni sustav, intrinsično sociološke interpretacije u obliku mjere socijalnog djelovanja ostvarivog u određenom socijalnom sustavu bez promjene njegove strukture. Njeno oblikovanje posljedica je odziva socijalnog sustava na raspoznate dijelove dinamike okoline. Raspravljano je o tome da razvoj odziva socijalnog sustava odgovara pobuđivanju svojstvenih modova općeg, fizikalnog sustava.

KLJUČNE RIJEČI

socijalni sustavi, socijalna slobodna energija, adaptacija, organizacija, disperzijska relacija