Self-organization of Matter

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Abstract

The traditional characterization of forms or states of matter which can be easily distinguished (solid, liquid and gaseous) is focused on differences rather than on common principles of organization of matter in general. The attempt to describe continuous changes in the organization of particulate matter leads to the possibility of using the angle of internal friction as a parameter, allowing, together with other parameters, a unified description of existential forms of matter and conditions of their existence. The self-organization of matter observed from this point of view can explain, for example, the origin of landforms created both by natural forces and human activity. It can contribute to the solution of technical problems in the field of particulate matter and help in the explanation of phenomena in both inorganic and organic nature.

Introduction

Quia pulvis es et in pulverem reverteris
Dust you are, to dust you shall return.
(Genesis 3:19)

It appears that the existential form of matter follows the preference of nature to create, purposefully, a certain form of matter more frequently than other forms, whereas the laws have the nature of a self-organization of matter leading to the preferred existential forms.

Traditional theories of the development of existential forms of matter (based on the existence of isolated, independent states) do not have the potential to accept ever-deepening findings and connections between seemingly independent laws of the physical world. The existence of independent states (forms) of matter, characterized by certain unique, specific properties — e.g. solid, liquid and gas — cannot answer questions about the general structure of matter. In the classical matter structure model, the individual existential forms of matter change from one state to another by transitions through a sequence of state temperatures (thawing, condensation, evaporation, etc.). However, this traditional approach cannot explain the shared principles of all existential forms of matter in a uniform way and thus cannot lead to new research directions for finding a unified principle for all existential forms of matter and their properties. A new perspective would provide an answer to a range of system questions directed at changes of matter states, and offer new ways of searching for further connections in the structure of the material world.

The article indicates selected identification factors of existential forms of matter preferred in nature, with respect to particle morphology, the angle of internal friction, compactness of matter and, in the case of a mixture of particles, also with respect to the representation of grain-size fractions. An explanation of the process of continuous changes via the self-organization of the structure of matter allows the determination of initial conditions for the evolutionary theory of the structure of matter, where the role of the controlling parameter, determining the existential form of matter, is the generalized angle of internal friction, characterizing the matter state. As a consequence, this allows a unified description of all existential forms of matter by unified laws.

The proposed facts hitherto unknown of the evolutionary development of matter shows the possible searching directions for as yet undescribed forms of matter. Many generalized experiences linked to life on earth are not in agreement with facts we see in the universe, which means that not all we believe in generally corresponds to the real situation. Instead, it often formulates our opinion rather than the reality.

The presented self-organization effect in the structure of matter during its evolutionary development allows the explanation and probability evaluation of the occurrence of forms of matter in the universe, and the probability of the origin of living matter in various forms. The theory of self-organization applied to the structure of matter allows the explanation of its internal arrangement, and a proposal of measurable various properties. This rule respects currently known,

Fig. 1 Self-organization of matter in space in the form of spiral nebula. Painting by M. Gelnar

Rys. 1 Samoorganizacja materii w przestrzeni w postaci spiralnej mgławicy. Obraz M. Gelnara

time-tested laws, and provides good prospects for the description of not fully explored areas of 'very thin' and 'very dense' matter. Interesting results of application of the theory of self-organization in the structure of matter were obtained during the description of the behaviour of particulate matter.

Particulate matter

We are surrounded by various existential forms of matter we call 'states' or 'forms'. The basic existential forms of matter are generally considered to be solids, liquids and gases. According to our experience-based knowledge, individual states have fundamentally different properties, which have led to the formation of isolated scientific disciplines investigating individual existential forms of matter. After being subject to the current educational processes, rarely do we doubt the simultaneous existence of independent existential forms of matter. This article presents experimentally documented facts that prove that there is a unified basis of the forms of matter, which only changes one into another in the evolutionary development of the self-organizing structure of matter. Individual forms of matter have a different probability of occurrence in the studied system. The sources, which directly or indirectly inspired this work, have apparent variety, but the principle of the evolution of the structure of matter is based on comparative, interdisciplinary processes, which seem to be independent, but are mutually parallel and affect each other harmoniously.

With respect to the structure of matter, the initial state selected was the state of particulate matter, owing to the fact that it lies between the solid and gas states and because it is relatively unexplored, and thus there is a large chance of discovering principal effects. Increasingly, studies have been published documenting new effects and findings of completely new properties of particulate matter. Luding, [1] in his work, shows the possibility of information transfer through particulate matter. Brown [2,3] earlier opened the question of information, entropy and the state of particulate matter, in a theoretical and subsequent experimental study. He not only explained theoretically, but also studied the state of particulate matter experimentally, with respect to particle structure and entropy. The conclusions and experiences led to an indirect proof of a unified foundation, and general relations for all existential forms of matter. Einstein [4] stated his opinion indirectly on the occurrence of existential forms of matter with the same probability. Cugliandolo and Kuchan [5] stated the possibility of the different probability of occurrence of partial existential forms of matter in an evolutionary system, which becomes more important in relation to the self-organization of the structure of matter. The traditional approach and methodological instructions do not provide a way of understanding and interpreting the common base of the forms of matter. Today, nobody doubts the need to search for the common foundations and processes behind the formation of existential forms of matter. Jaeger, Nagel and Behringer [6,7] described the surprising properties of granular matter, which can change its coexistence from 'pseudo-liquids' to 'pseudo-solids'.

The authors in these studies document the differences, as well as the unifying tendencies in the description of partial existential forms of matter, with a focus on particulate matter and its transition between 'pseudo-liquids' and 'pseudo-solids'. For instance, Jaeger [7] contains a presentation of the behaviour of mustard seeds on a slope, where the static angle of the slope is 30° and the dynamic angle is lower. The outputs correspond to the result of measurements and simulations by a number of other authors. The authors [7] propose a model for ideal particulate matter as a new model of matter, which lies between the limit values of the internal friction angle of 0° (ideal fluid) and 90° (ideal solid), and includes more than 70% of all existential forms of matter on this axis. This means that particulate matter is the most frequently occurring form of matter.

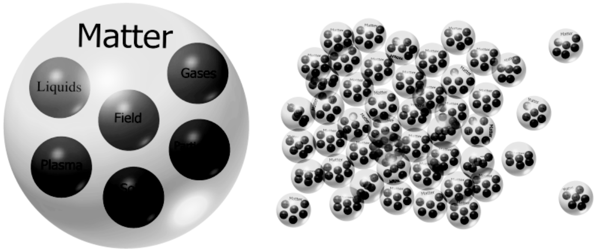

Fig. 2 Representation of the evolutionary development of a system and subsystems made of all existential forms of matter and energy

Rys. 2 Reprezentacja podejścia ewolucyjnego systemu i podsystemów stworzonych ze wszystkich istniejących form materii i energii

m=1/n weight of the subsystem - m.n=1 weight of the complete system
n (non-dimensional size) - number of observed subsystems
m (kg) - weight of the subsystem
1(kg) - the weight of the whole is one

m=1/n waga podsystemu - m.n=1 waga całego systemu
n (wielkość bezwymiarowa) – ilość obserwowanych podsystemów
m (kg) – waga podsysytemu
1(kg) – waga całości wynosi 1

In addition, Zegzulka8 proposes the definition of an initial geometric, physical and mathematical standard for particulate matter using a characteristic slope angle of 30°. Some studies present very important processes in an understandable form. Buchanan [9] generalizes and draws attention to the well-known effects of the description of processes of particulate matter. He describes fundamental, generally known and visible changes in the properties of sand, when adding a very small amount of water to sand significantly changes its coexistence. For instance, children in sandboxes change the angle of the internal friction of sand by changing the amount of free water, obtaining very large variations in the internal friction angle. The internal structure of particles and the strength of bonds between sand particles fundamentally affect their form of existence, as a pseudo-liquid or pseudo-solid. The author of the study shows that a relatively small amount of water radically changes the angle of internal friction (and thus the properties) of sand.

One problem of a unified description of all existential forms of matter is the choice of a characteristic parameter, which would be accepted by all disciplines specializing in various forms of matter. The descriptive characteristics of partial forms of matter were only developed separately for different forms of matter (gas, liquid, solid), and partial existential forms of matter have only been described by independent values (Young's module, dynamic viscosity, kinematic viscosity, angle of internal friction), using various methods of measurement based on the size of loss dissipation work in the specific state. The logic and reasoning behind this process is, among others, based on the large differences between the sizes of dissipation work in individual states, and the historically separated physical and technical development of scientific disciplines investigating only a single form of matter.

The description of the mechanism of friction generally depends on the size of particles and on the properties of intra-particle bonds; friction always represents an accompanying phenomenon of movement. In the mechanics of granular matter, static as well as dynamic friction is taken into account. This is usually determined by a function of the particle size, the size and shape of particles leading to types of contact bonds, which then forms a general characteristic of the properties of matter described with respect to friction by Tomas [10].

Goldenberg and Goldhirsch [11] describe a mechanism for increasing elasticity in substances made of particulate matter. The influence of the particle size on selected aspects of dynamic behaviour of particulate matter was described by Ngoc-Son Nguyen [12]. The effect creates bonds between individual particles depending on their size. The shape of particles and agglomerates of particles also have a significant impact on the total friction parameter, as described by Kozicki [13].

The characterization of the 'angle of internal friction', from the point of view of the current state of science and technology, is based on the conventional interpretations and measurements of Schulze [14]. The transformation effects, kinetic energy ↔ potential energy ↔ pressure energy ↔ dissipation work, and other connections are studied by a number of research teams (such as EFCE, the Working Party on Mechanics of Particulate Solids [15]), which allow a number of views on measurement and interpretation of measured values in the form of internal friction angles [16]. This value is used to describe the processes related to particular matter or within particular matter regardless of scientific field.

The presented article applies the value of the generalized internal friction angle in the form of an individual parameter for the description of the self-orga-

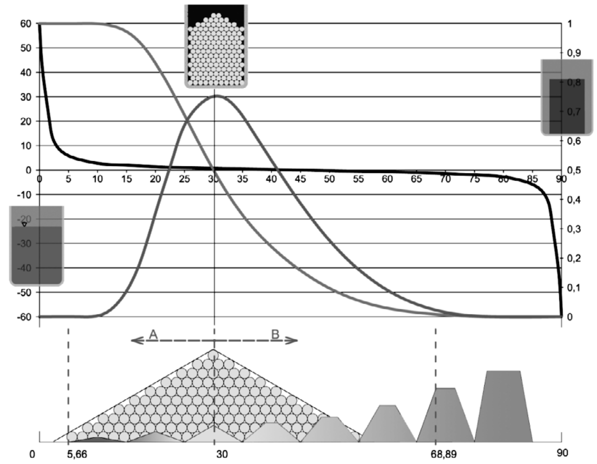

Fig. 3 Self-organization of the structure of matter in the process of evolutionary changes

Rys. 3 Samoorganizacja struktury materii w procesie zmian ewolucyjnych

nization and evolution of matter. The dependent value is the probability of occurrence of a specific form of existence of matter in the evolution system.

We perceive the actual differences between piles of sand composed of particles of micrometre, millimetre, decimetre and metre sizes in comparison to our own physical size. A pile formed by metre-large particles is considered almost a mountain. But the differences between these sets of particles are not actually studied. We focus on well-known models of matter, searching for actions of force between particles, and expecting to obtain answers by combining already known laws. However, perhaps the answer is elsewhere and actions of force are not the dominant factor. Instead, the ancient laws of evolutionary development of systems that include our world are determining, and we only see a very small slice of the evolution of the world, which we unjustifiably consider dominant.

As early as in 1882, Luegers, [17] in a chapter on the structure of material, presented a relatively good understanding of the size of particles, which subsequently form larger groups that can then be considered again as a single particle.

In 1895, Jansen [18] derived an equation for the development of pressures in particulate matter, which has become the basis of all studies on the process of pressure in granular matter, and has gradually been made more precise and complete.

These previous authors modelled the structure of particles using simple models formed by pellets, and searched for the interactions between individual pellets and their groups. The diameter of particles or the size of groups is never mentioned. Actions of force are emphasized (Van der Waals forces, electrostatic and electrodynamics forces, chemical bonds and mechanical bonds are neglected). Since there is a vast number of types and forms of particulate matter, these models show regular properties rather than specific properties valid only for a single form of particulate matter.

An unconventional approach is necessary: a single grain of sand is easy to define, but a large number of grains can together behave as a solid or fluid. Nedderman and Tüzün [19] elaborated a purely kinematic model, including only a single experimental constant for the description of the velocity field of granular material flowing from a container. Experimental measurements were carried out by measuring the velocity field of a 'two-dimensional' hopper that corresponded perfectly to the model.

In this unclear quantity of locally completely dominant laws, which are investigated to this day in the hope of finding a generalization, it is necessary to search for solutions elsewhere, in untraditional areas. In the literature [20,21] authors search for relationships between the angle of internal friction, the size and shape of flow images, the pressure processes, and flow dynamics with respect to their own pulses. A separate section is dedicated to the creation of pressure spikes, owing to the movement of particles at the beginning of motion, and another section is dedicated to the fall of static and dynamic vaults (cavities above the outflow opening) [22]. The dual ability of granular matter to act as a liquid and a solid signals the capabilities and interesting relationships of continual transitions from state to state, in curves without points of discontinuity.

The application of synergetic methods in modelling granular matter processes has not led to an expected solution of long-term deficits of more general models [23,24].

Hope for a more general solution may be seen in ideas based on modern thermodynamics by Prigogine, [25,26] where it is valid that if a system lies on the nu-

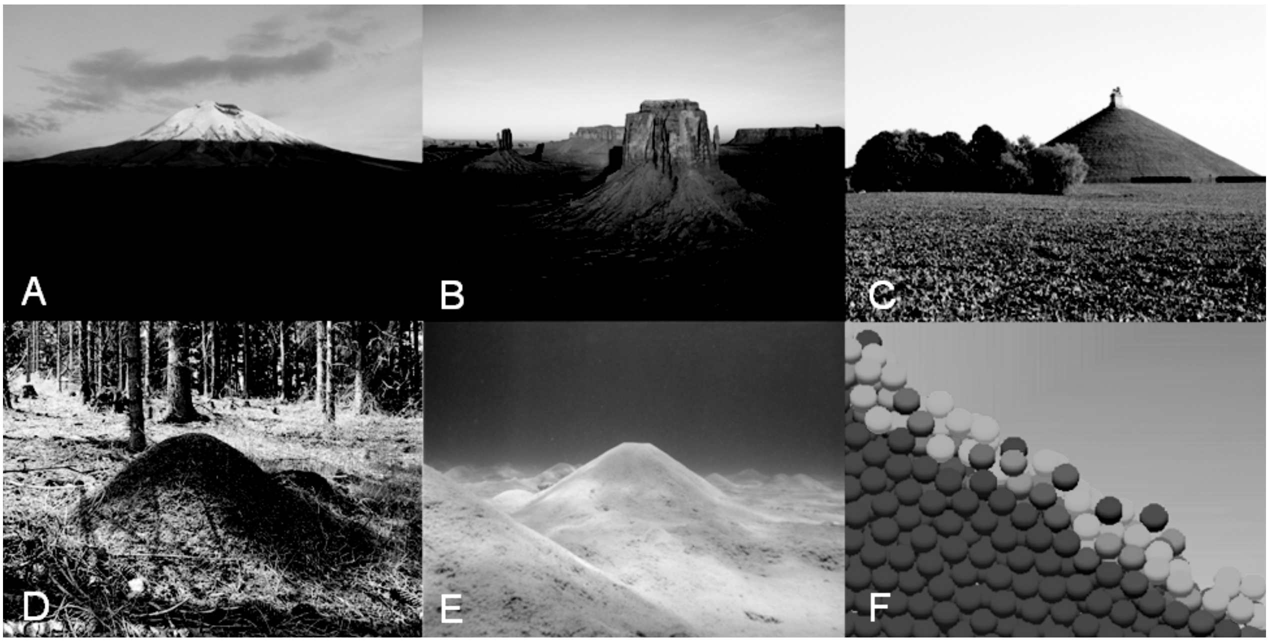

Fig. 4 Terrain forms of various scales: (A) Cotopaxi volcano, Ecuador, 5,897 m a.s.l. (Photo: R. Cada); (B) Grand Canyon, Arizona, circa 500 m; (C) Lion's Mound, Waterloo, Belgium, 100 m (Photo: L. Pazdera); (D) Anthill on sand in a forest, Ludgerovice, Czech Republic,;(E) Egyptian coast, Marsa Alam, Egypt, 30 cm (Photo: R. Brazda); (F) Simulation of a slope in DEM, scope-free simulation, Laboratory of Bulk Materials, Technical University of Ostrava (Photo: J. Rozbroj, D. Gelnar, J. Necas)

Rys. 4 Formy terenu o różnych skalach A) wulkan Cotopaxi, Ekwador, 5,897 m a.s.l. (fot.: R. Cada); (B) Wielki Kanion, Arizona, około 500 m; (C) Kopiec Lwa, Waterloo, Belgia, 100 m (fot.: L. Pazdera); (D) Mrowisko na piasku w lesie, Ludgerovice, Czechy,;(E) Wybrzeże egipskie, Marsa Alam, Egipt, 30 cm (fot.: R. Brazda); (F) Symulacja zbocza w DEM, symulacja bez zakresu, Laboratorium of Materiałów Sypkich, Technical University of Ostrava (fot.: J. Rozbroj, D. Gelnar, J. Necas)

merical axis far from an equilibrium point, the number of possibilities for its potential existential forms grows rapidly. Such systems effectively dissipate heat and are also capable of creating new types of particle arrangements and bonds, depending on the existential form of the non-equilibrium state. To differentiate such structures from equilibrium ones, Prigogine named them 'dissipative'.

It is a major task for physics to define the limit conditions and search for equilibrium states between forms of matter, while these platforms may then be used to indicate non-equilibrium states. In compliance with Prigogine, we can rightfully expect that dissipation causes new forms of matter, and this article uses these findings to specify the possible occurrence of unknown forms or states of matter. Some authors even conclude from the principle of self-organization that the property of self-organization of nature is valid for all space-time scales.

Therefore, forms will need to be considered as not a physical state, but rather as various distributions of matter in space and distributions of energy within it, and from this viewpoint, granular matter is only another form of matter lying on the numerical axis of the structure of matter between φ Є (0°, 90°).

Owing to the fact that synergetic expression of the status has the potential to reach a level of abstraction sufficient to synthesize many fields, certain terminological problems may arise. The same terms have different meaning in various fields, and the same processes have been interpreted differently and with different criteria in various fields. Additionally, certain fields have created their own descriptive characteristics of material forms, as a result of their isolated development.

The application of the model of self-organization of matter structure is becoming a promising means of providing a description of synergetic relationships, when determining a unified description of the structure of matter in the whole range of its existential forms, based on a generalized angle of internal friction. This is the universal parameter applied to all existential forms of matter, for fluids, solids and granular matter, as well as yet-undiscovered forms of matter. For the evolutionary model of matter depending on the self-organization of processes, a description of evolutionary systems was chosen, using a set of Lotka-Volterra equations for cooperative phenomena, [27] modified by A. Danek on the numerical axis of defined and predicted matter structure [21].

Synergetic Expression of State Changes: A Mathematical Model

The description of a partial sample of real matter is characterized by its composition from many partial states of matter. Granular matter is commonly present, together with liquids and gases, in an electrostatic or magnetic field, or in relation to various forms of existence of matter, as shown in Figure 2.

Synergic methods form a part of the new scientific field of synergetics, which studies the processes of the development of creation and the destruction of systems of cooperative phenomena, with the aim of explaining the causes and causality of seemingly unrelated processes in stadia of transfer to new qualities. Generally, this is a cooperative process. These processes are described in synergetics for evolutionary systems, through a set of Lotka-Volterra equations for cooperative phenomena in the sense of self-organizing phenomena:

$$(du_1 / dt) = a_{11} \cdot u_1 + b_{11} \cdot (u_1 \cdot u_2) \qquad (1)$$

$$(du_2 / dt) = a_{21} \cdot u_2 + b_{22} \cdot (u_1 \cdot u_2) \qquad (2)$$

where:
a_{11} – propagator (autocatalytical factor) of the first state u_1,
b_{11}– coefficient of conflict of interest between states u_1 and u_2,
a_{21} – own propagator of state u_2,
b_{22}– coefficient of conflict of interest between states u_2 and u_1.

$$u_1' = a_{11} \cdot u_1 + b_{12} \cdot k \cdot u_1 - b_{12} \cdot u_{12} \qquad (3)$$

Since the sum of the material amounts in an isolated system is constant — i.e. 1 (owing to the law of conservation of mass) — we have:

$$u(t) = u_1(t) + u_2(t) \qquad (4)$$

This situation may be solved if u(t) = const: The law which originates by applying this step is the so-called logistics curve, usually labelled:

$$u(t) = S_0 / (1+ exp(-C \cdot (t - t_0))) \qquad (5)$$

The logistics curve is characterized by two parameters:
S_0 – value of saturation (summary amount of materials – a constant), in point to the curve reaches a value of $S_0/2$,
C – is the growth coefficient, related to the original propagator and the coefficient of conflict of interest by the relations listed further.

With respect to the nature of logistics curve process laws, it is necessary to work with quantiles, since the zero value is reached by the curve in - ∞, which does not help to reach a practical solution, and so a value of e.g. 5% is applied instead.

Logistics quantile calculation:

$$q\alpha = u\alpha / S_0 = 1 / (1+ exp(-C\ \alpha\ (t\alpha - t0))) \qquad (6)$$

Let ($a \cdot t_0 = C$), then:

$$u(t) = S_0 / (1 + exp(-a \cdot t + C)) \qquad (7)$$

In the equations listed above, n is the number of observations (number of pairs t_i , F_i).

What remains is to list the relationships between discovered regressors with the coefficients of the Lotka-Volterra set of equations. The propagator and coefficient of conflict of interest are given as:

$$b1 = a / S_0 \cdot exp(C) \qquad (8)$$

$$a1 = a \cdot (1 - exp (-C)) \qquad (9)$$

The number S_0 is the sum over all existential forms of matter in the original set observed over time. With respect to the fact that the sum material amount (the sum of all phases) is constant, we may set S_0=1 without loss of generality. Instead of variable t, we will use the general variable x. Thus we obtain:

$$u(x) = 1/(1 + exp(-a \cdot x + C)) \qquad (10)$$

Zegzulka describes the relationship between the process of the vertical pressure σ1 and the horizontal pressure σ1 depending on the generalized internal friction angle, which may change in the interval φ ϵ (0° , 90°), the limit values being fluid and solid matter. [21] In this interpretation, the original variable x of the logistics curve is no longer suitable, since it was defined in the interval x ϵ (-∞, +∞). This interval may be displayed as an existential interval of matter structure, depending on the internal friction angle φ ϵ (0° , 90°) via the transformation relation

$$x = -cotg(2\varphi) \qquad (11)$$

This mathematical operation was proposed by A. Danek.

If we search for the first derivation of (1), we obtain:

$$du(x)/dx = (a \cdot exp (-a \cdot x + C))/(1 + exp (-a \cdot x + C))^2 = a \cdot u^2 (x) \cdot exp (-a \cdot x + C) \qquad (12)$$

For the specific assumptions listed above and limit conditions, the resulting solution is:

$$y = 1/(1 + exp (-(3 \cdot x + 3^{(1/2)}) \qquad (13)$$

or, if $u(t) = u_1(t) + u_2(t)$ we may write the second curve as:

$$y = 1 - (1 + exp (-(3 \cdot x + 3^{(1/2)}) \qquad (14)$$

The original variable x is defined in the logistics curve of Lotka-Volterra equations in the interval x ϵ (-∞, +∞). To describe the existential forms of matter (state changes) within the possibilities of occurrence, the internal friction angle is defined in the interval φ ϵ (0° , 90°). Specifically, this is φ ϵ ⟨ 0° , 90°), if we allow the physical reality to also contain the limit values of φ = 0° and φ = 90°, which leads to a range of complications and as-yet-unanswered questions, which would require the definition of an initial set of assumptions for basic physical values; i.e. weight, length and time.

Figure 3 depicts the existential interval of granular matter φ ϵ (5.66° ÷ 68.89°), as listed by Zegzulka [28]:

- The black curve depicts the transformation of axis x from the interval x ϵ (-∞, +∞)to the existential interval of matter structure x ϵ (0° , 90°); the transformation was proposed by prof. A. Danek.
- The blue curve displays the logistics curve of matter transfer from fluids (liquid, gas) to solids; i.e. from one state to another.
- The red curve displays the efficiency of changes (flow efficiency). This is, as was shown, the first derivation of the logistics curve; i.e. the curve of transfer from one state to another. The function clearly indicates a single local maximum at 30°, which also confirms the previously mentioned opinion of Kuchan on the possible varying probability of occurrence of partial existential forms of matter in the evolutionary system, since matter with a generalized internal friction angle of 30° has the highest probability of occurrence of 0.75 in the evolutionary, and other existential forms of matter thus have a lower probability of occurrence.

For clarity, we also include containers in the graph, which indicate the location of fluids, granular matter and solids, with respect to the internal friction angle.

On the internal friction angle axis, we read the value of the generalized internal friction angle, and find the existential form of matter and its probability of occurrence in the evolutionary system as the function of the observed internal friction angle.

Self-organization Processes During Landscape Formation

The previous deductions imply that the initial stable formation and, at the same time, the fractal image is an obtuse isosceles yellow triangle with 30° angles at the base, as depicted in Figure 3. The translation and rotation of the default fractal element — i.e. the isosceles triangle — leads to a terrain horizon typography.

Owing to the assumption of application of the default image in the general assessment of terrain creation, independent examples of this invariant element in nature were chosen. Representative examples of these terrain-forming elements, created by animate and inanimate nature, are illustrated in Figure 4. Characteristic terraforming elements of inanimate nature include: volcanic mountain-forming processes, Cotopaxi volcano (A), Mt. Fuji, etc.; and the process of decay of column rocks, Grand Canyon (B). The process of central extrusion of matter (volcanoes) and the process of drop-out of granular particles from columns (decay of column rocks) lead to the initial invariant terraforming fractal triangles. In the area of human terraforming, the Lion's Mound at Waterloo (C) was chosen because it is well-known. This formation was created by moving a large amount of earth and sand to the top of a mound and the creation of an almost ideal initial fractal element. The phenomena created by unconscious processes of animate nature include products of moles (tumps) and ants (anthills). (D) displays a characteristic anthill, where ants could not use foliage and other organic material, and thus used mostly sand particles. (E) depicts the product of fish that create cones made of sand underwater with wall angles close to 30°. This is caused by the round shape of sand particles used to create these mounds. The last (F) depicts a computer simulation of a slope formed by balls in a rotating cylinder; the model was created and validated using the physical model in the Laboratory of Bulk Materials of VSB - Technical University of Ostrava.

Landscape-forming elements created by mutually independent particles may have angles at the horizontal plane ranging between 5.66° and 68.89°, while the basic landscape-forming element is a triangle (cone) with a surface angle of 30°. The presented examples (Figure 4) lead us to believe that the processes of self-organization are not a function of the size of their environment, and do not depend on whether the participants are animate or inanimate.

The terrain typography is formed by the compounding of a base element and its rotation and translation. While the slope angle is 30° the typography remains stabilized. If the slope angle of mountains exceeds 30°, evolution leads to further stabilization by reducing the angle. If it is below 30°, erosion (e.g. wind, liquids, shaking, etc.) has already lowered the angle.

Self-organization of matter in the process of evolutionary changes

Lotka-Volterra's equations for cooperative phenomena are used in this article to deduce the resulting equations for the self-organization of matter in the process of evolutionary changes, which are then used in the study of a system comprising various existential forms of matter. These go through evolutionary development and change their existential form with respect to the transition between individual forms of existence of matter (gas, liquid, granular matter, solid matter). The logistics of transition states may be used to determine the probability of existence of all forms of matter in the evolutionary system. From the evolutionary function of the structure of matter it follows that the matter characterized by an internal friction angle of 30° has a special position in the structure of matter; i.e. matter that fulfils the standards of granular matter. The form of this matter has already been subjected to extensive research when searching for possible referential standards of particulate matter. Matter formed by balls is the only existential form of particular matter, where the internal friction angle equals the angle of the slope and, equals approximately the surface angle of a cone created from such matter.

The shape of the evolutionary function indicates a probability curve of matter distribution in an evolutionary system, with respect to internal losses represented by a generalized angle of internal friction. The evolutionary curve may also be used to predict the rates of losses caused by deviations of particles from regular morphological shapes, as a result of bifurcation changes of structures. It also indicates a very probable self-organizational relation between all forms of existence of matter, independent of the scale.

The preferred existential form of matter from the point of view of evolutionary changes is matter with a generalized internal friction angle of 30°. If formed by relatively isolated particles, the dominant particle morphology is ball-shaped, represented by dust and sand.

In the area of the general structure of matters $\varphi \in (0°, 90°)$, the existence of a new standard of matter with a generalized internal friction angle of 30° was predicted, and this was then confirmed by an experiment. The assumption of the evolutionary development of the creation of individual states may lead to the synergetic interpretation of transitions between individual states and phase states, through a continuous function determining, among others, the probability of the occurrence of individual forms of existence of matter in an isolated evolutionary system, which may comprise many partial subsystems.

The shape of the deduced logistics probability function may be used to form an opinion for the occurrence of all forms of matter in the evolutionary system. It includes the probability of occurrence and the properties of matter in areas of hitherto undocumented states of matter; i.e. in areas close to 0° and 90°. These are the area of very small concentrations of matter in unit volume and vice versa; the compression area of very large concentrations of matter in unit volume.

This article presents previously unknown facts in the area of matter structure, and shows the possibility of describing the physical state (form) of matter uniformly in a self-organizing evolutionary system by the generalized angle of internal friction.

A surprising property of the self-organizing function of matter in an evolutionary system is the fact that the probability of space-time is the same as the state with a 0° internal friction angle, and of matter-time as the state with a 90° angle of internal friction. Both limit states of the physical form of matter have the same probability of occurrence in the evolutionary system. Hypothetically, it may be presumed that matter may be formed by the deformation of the space-time, and on the other hand, matter may be destroyed by the deformation of time-space to time-matter.

Acknowledgements

This work was supported by the project CZ.1.05/2.1.00/03.0069 ENET – Energy Units for Utilization of Non-traditional Energy Sources, Ministry of Education of the Czech Republic and the project New creative teams in priorities of scientific research , reg. no. CZ.1.07/2.3.00/30.0055, supported by Operational Programme Education for Competitiveness and co-financed by the European Social Fund and the state budget of the Czech Republic.

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Samoorganizacja materii

Tradycyjny opis form stanu materii, który można łatwo rozróżnić (ciało stałe, ciecz oraz gaz) jest skoncentrowany raczej na różnicach, niż na głównych zasadach organizacji materii w sensie ogólnym. Próba opisu ciągłych zmian w organizacji konkretnej materii prowadzi do możliwości zastosowania kąta wewnętrznego tarcia jako parametru, który pozwoli wraz z innymi parametrami na zunifikowany opis form istnienia materii oraz warunków jej występowania. Samoorganizacja materii widziana z tego punktu widzenia może wyjaśnić, na przykład, pochodzenie formacji terenu utworzonych zarówno przez naturę, jak i działalność człowieka. Może to być zastosowane przy rozwiązywaniu problemów technicznych na polu określonej materii i pomóc w wyjaśnieniu zjawisk zarówno natury organicznej, jak i nieorganicznej.

Słowa kluczowe: ciała stałe, ciecze, gazy, materia nieorganiczna, materia organiczna