Evolution of Self-Organized Photon Waves

Jiří Stávek
Laboratory of Diffusion Processes
Bazovského 1228, 163 00 Prague, Czech Republic
e-mail: stavek@volny.cz

Experimental observation of the evolution of chemical waves can guide us how to re-interpret experimental data found for the case of self-organized photon waves. During the first rapid stage – *h-tuning stage* – the product m u λ reaches the Planck value h. During the second stage – *h-self-organization stage* – three kinds of the self-organizing mechanisms are now known. Doppler-Voigt-Einstein self-organization transmits information about the relative velocity. Hubble-Nernst self-organization transmits information about the distance. Schmidt-quasar-redshift self-organization brings not yet decoded information. In the final stage – "Zwicky"'s tired light" – *h-decay stage* – self-organized photons loose the ability to tune the Planck constant h. The product m u λ shows the tendency to reach a critical value h_{crit}. Behind this value photons are not able to self-organize waves and become a part of the ZPE (zero point energy).

Keywords: diffusion action, spontaneous formation, self-organized structures, h-tuning, h-self-organization, h-decay, ZPE. Submitted on October 6 2005

Diffusion action of chemical waves

Self-organization is a process of evolution where the development of new complex structures takes place primarily in and through the system itself [1,2,3,4,5]. The essence of self-organization is that system structure (at least in part) appears without explicit pressure or constraints from outside the system. The organization can evolve in time or space, can maintain a stable form or can show *transient phenomena*. There is a strong tendency for systems far from equilibrium to create spontaneously self-organized dissipative structures. They can be seen not only within the biological systems but also in physical and chemical world of inorganic substances [6].

In order to start with the quantitative analysis of some complicated and rapidly self-organized systems, it is necessary to collect and evaluate experimental evidences found during intensive studies of chemical waves. Experimental observation of the evolution of chemical waves is relatively easy and could be done in any chemical laboratory. The starting composition of chemical compounds for those studies together with the needed glassware (thin tubes or Petri dishes) represents rather low costs.

Colloidal chemists have frequently observed macroscopic spatial patterns during the past one hundred years. Liesegang [7] observed the 2D formation of patterns of inorganic substances in the presence of gelatin termed as Liesegang rings (LR). The discovery of the Belousov-Zhabotinsky (BZ) oscillation reaction catalyzed intensive research of these oscillation reactions [8].

It was found that during the evolution of successive waves the product of instantaneous propagation speed u and the wavelength λ converge to a constant value [9,10,11]. This product $u\,\lambda$ depends on the type and the concentration of the polymer used in the case of Liesegang rings. The first stage of self-organization – *h-tuning stage* –

was observed for the case of the Liesegang rings in the years 1934 and 1935. Researchers in the field of Belousov-Zhabotinsky waves found this effect in the decades 1970 – 1990. These experimental data were collected by Ševčíková and Marek [12].

There is a tendency to characterize the diffusing front by a characteristic particle mass m that is needed for the estimation of the *diffusion action* of chemical waves. The product of the characteristic mass m, propagation speed u and the wavelength λ was termed as the *diffusion action* [13,14,15]. This approach for the characterization of the LR formation was used repeatedly several times since 1934 [16].

On the other hand, several theoretical physicists contributed to this topic [17,18,19,20,21,22], too. Reinhold Fürth introduced the concept of the self-organized Brownian particles in the year 1933.

Several decades long experimental and theoretical research can be condensed into the following equation:

$$K\kappa m\lambda u = h \tag{1}$$

where K is the diffusivity factor, κ is the tortuosity factor, m is the particle mass, λ is the wavelength, u is the propagation speed, h is a characteristic constant of the diffusion action. The parameter K – diffusivity factor - describes the geometrical arrangement of the experiment. For one-dimensional space (thin glass tubes) K = 1, for two-dimensional space (thin layer in a Petri dish) K = 2, in case of the three-dimensional experiment the value K depends on the space angle available for the diffusion of Brownian particles from their source. If the whole space is available for the propagation of the chemical waves, then K = 4π. Many studies of the dispersion relations were performed in gels, membranes, resin beads, glasses in order to prevent hydrodynamic disturbances from the reacting media. These media help to localize the propagating bands; on the other hand they modify the diffusion path of ions. The diffusion field in these restricted environments changes by a tortuosity factor κ that characterizes the diffusivity in porous media.

In the recent summary of this topic [23] the evolution of the diffusion actions of Liesegang rings formation, Belousov-Zhabotinsky waves and the cAMP (cyclic adenosine 3”,5”-monophosphate) waves were analyzed. The main trend for all three types of chemical waves is similar. During the evolution of successive chemical waves there is a strong tendency to self-organize their diffusion fields in such a way that the diffusion actions converge to a constant value of about $6.6 * 10^{-34}$ Js (stage 1 – *h-tuning stage*). Diffusion actions of next waves fluctuate around this quantity of action for a long time in dependence on the capacity of the system (stage 2). This second stage could be termed as the *h-self-organization stage* while the system keeps the well organized formation of patterns via the small fluctuations of diffusion action around the value of the Planck constant *h*. This *h-self-organization stage* could be realized by the change in the mass of particles, the change of wavelength between patterns, and the change in the propagation speed.

When the stage 2 is over, the successive waves irreversibly decay towards chemical equilibrium (stage 3) where the creation of waves stops. In this third stage – *h-decay stage* – the system is not able to keep longer the constant value of its diffusion action *h*. When the diffusion action reaches a certain critical value of the diffusion action h_{crit}, the system stops to continue in the next formation of waves. The individual molecules remain in the system and the ability to self-organize waves is lost.

The observed stretching of chemical waves is evaluated as the self-organization of chemical waves in the constant space. In this concept the space is not expanding or compressing but all effects are caused by the modification in the geometrical arrangements of individual molecules creating the waves in the constant space.

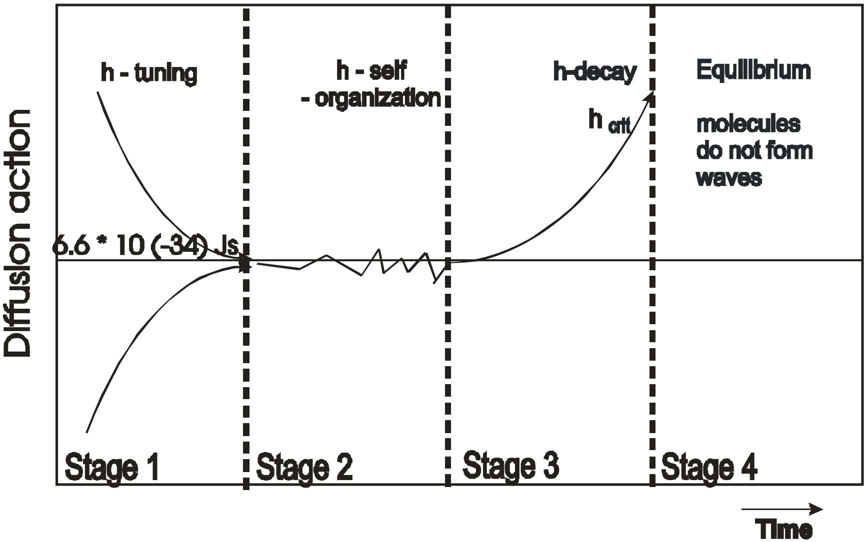

Figure 1 Evolution of diffusion actions of chemical waves

The property of vast collections of Brownian particles to diffuse into their surroundings as local osmotic waves reveals that these waves have a strong tendency to self-organize their diffusion fields. This self-organization of the diffusion field can be done via the characteristic mass m, propagation speed u or the wavelength λ in such a way that their diffusion action tend to fluctuate around the characteristic value $6.6 * 10^{-34}$ Js. This behavior of chemical waves is schematically shown in Figure 1.

Emergence of the self-organization: h-tuning stage of photon waves

The analogy between chemical and photon waves can guide us how to re-interpret the experimental data we could find in the scientific literature. These experimental data might support this concept or to disprove it as the failed concept. In this contribution it will be assumed that the photon with its mass m is able to self-organize its surroundings (zero point energy - ZPE – is represented here by photons that lost the ability to self-organize its surroundings) with the wavelength λ and the propagation speed u.

For the first stage when the self-organization emerges spontaneously from its parts the experimental data should reveal the *h-tuning stage* in the very begin of the evolution of these photon waves. In this stage we should discover *h-tuning* via the mass of photon particles, the wavelength adjustment or the propagation speed adjustment:

$$m \lambda u \to h \qquad (2)$$

Mugnai, Ranfagni and Ruggeri [24,25] experimentally observed the *c-tuning effect* for the case of microwaves (λ was 3.5 cm) over distances of tens of wavelengths in the year 2000. They observed that the light speed of these microwaves at the distance 30 cm from the source was about 5 to 7% higher than the value c. The light speed at the longer distance from the source slowly approached to the value c. The value c was reached at the distance 130 cm from the source.

Experimental data describing the *c-tuning stage* (and therefore *h-tuning stage*) during the first 30 waves of microwave photons support the analogy between the chemical wave self-organization and photon wave self-organization. Figure 2 depicts that behavior.

Transmission of information: h-self-organization stage of photon waves

After the rapid and short first stage (*c-tuning stage* and more generally *h-tuning stage*) the photons with their surroundings are ready to transmit several kinds of information. Table I summarizes events that could be observed during this *h-self-organization stage*.

Table I Transmission of information during the h-self-organization stage

Process	Type of information	Experimental evidence
Doppler-Voigt-Einstein self-organization	Relative velocity	Stretching of waves in the constant space, redshift, blueshift
Hubble-Nernst self-organization ($v_{rel} = 0$)	Distance	Redshift quantization, secondary photon particles, Hubble-Nernst photon decay constant
Schmidt-quasar-redshifted self-organization ($v_{rel} = 0$)	Not yet decoded	Redshift quantization, secondary photon particles, photon decay constant
Blueshifted self-organization ($v_{rel} = 0$)	Not yet known	Inhibition of decay rate of photons in supersaturated ZPE, objects at the same distance have different redshifts

The transmitted information about the relative velocity in this *h-self-organization stage* was found in several steps. Christian Doppler [26] presented his famous contribution in Prague in 1842. Woldemar Voigt (in 1887) [27,28] postulated the universal speed of light and presented suitable equations for that behavior (stretching of photon waves in the constant space). This interpretation was followed by several original contributions. G.F. FitzGerald (in 1889) and H.A. Lorentz (in 1892) proposed the “stretching of arms” of the used instrument. Albert Einstein [29] (in 1905) published the original contribution to this field based on the “stretching of space”. This concept has played the unique role in the physics in the period 1905 – 2005.

On the other hand, there were published many attempts how to interpret this behavior using a different approach. One possible mechanism of the “*c-tuning*” based on the “*h-self-organization*” was published in Apeiron [30]. The future experimental data taken for the case of a moving source with microwaves might reveal the “c-tuning” effect (Mugnai, Ranfagni and Ruggeri experiment).

The second important information that should be transmitted is the knowledge about the distance of the observed object. This information could be coded by the decay properties of photons. Brownian particles can grow or decay (dissolve, evaporate) if their surroundings is super-saturated or under-saturated by other growth materials. Stávek and Ulrich [31] interpreted the growth and dissolution of particles and crystals by Mandelbrot”s concept of fractal geometry. For the characteristic fractal dimension $D_R = 3.0$ the specific dissolution rate H (kg kg^{-1} s^{-1}) is the same for all particles of that system.

Hubble (in 1929) interpreted his famous redshift data as the “apparent velocity” and derived the Hubble constant with the dimension km Mpc^{-1} s^{-1}. Nernst [32] (in 1935) interpreted the Hubble constant as the “decay rate of photons”. Stávek [33,34] calculated the Hubble – Nernst photon decay constant from the intensity of the microwave background radiation (secondary photons) and the solar irradiance (primary photons) as $H = 2.395 \pm 0.03 \times 10^{-18}$ kg kg^{-1} s^{-1} = 73.90 ± 0.8 km Mpc^{-1} s^{-1}. The second experimental evidence of decaying primary photons is the redshift quantization observed in their spectra. This redshift quantization was described by Willim G. Tifft and Halton Arp in their numerous contributions.

Maarten Schmidt identified some radio sources with apparent stars in 1963. Halton Arp [35] studied in details the behavior of these quasars and proved that their high value of redshifts cannot be associated with the “apparent velocity”. It seems that quasar redshifts bring to us a new kind of information (neither relative velocity, nor distance). This kind of information was not decoded yet. Photons emanating from quasars decay with higher specific decaying rate in compare with the natural decay rate described by the Hubble - Nernst photon decay constant. The ratio of the intensity of radio wave photons emanating from quasars to the intensity of primary photons might be helpful in the determination of the decay rate of those primary photons.

The analogy between chemical waves and photon waves lead us to postulate a new type of information transmitted by self-organized photon waves– the blueshifted self-organization. In this case the relative velocity between the observed object and the observer is zero. The blueshifted effect is caused by the inhibition of the decay rate of primary photons or the growth of primary photons with the characteristic fractal dimension D_R = 3.0. These effects might be caused by the supersaturated ZPE (zero point energy = photons that lost ability to create waves).

This blueshifted self-organization can contribute to the explanation why some objects at the same distance and the same relative velocity to the observer show different redshifts. The photons from those objects diffuse through zones with different concentrations with ZPE (zero-point energy). The higher concentration of ZPE can inhibit or even stop the natural decay rate of photons. In some cases the high concentration of ZPE can cause the growth of primary photons.

The combination and interplay of the above described self-organization effects of photon waves can confuse an observer whose interpretation of experimental data is based only on the Doppler principle.

Zwicky's tired light: h-decay stage of photon waves

During the second stage of the evolution of photon waves both the diffusion action h (Planck constant) and the propagation speed c are kept constant. However, recent experimental data revealed that after a certain time the third period of the evolution of photon wave occur. The photon wave slowly looses its ability to keep constant value h: *h-decay stage* of photon wave. This evolution stage will be termed here as the "Zwicky"'s tired light". Zwicky (in 1929) proposed to interpret the Hubble data by an unknown tired light mechanism. Zwicky had in mind the second evolution stage of the photon wave: *h-self-organization stage*. The more correct application of the "tired light" phrase is to reserve its use for the description of photon waves that looses their ability to tune Planck constant h.

The analogy with chemical waves can help us to forecast the behavior of photon waves in this stage. The value of diffusion action h will be steadily changed till the critical value h_{crit}. If the critical value h_{crit} is exceeded photons loose the ability to create waves:

$$m \lambda u \rightarrow h_{crit} \tag{3}$$

There are two groups of experimental data in the recent astronomical literature that could be used for the description of processes in the *h-decay stage*. The last ten years have seen truly exciting progress in observational cosmology.

The new data for the distant Type Ia Supernovae revealed that at large look-back times and distances the validity of the Hubble"s law breaks down. Two independent groups of researchers found that result: The Supernova Cosmology Project headed by Saul Perlmutter and The High-Z Supernova Search headed by Brian Schmidt. These two groups independently announced in 1998 that redshifts of those standard candles are smaller in compare with the prediction of the Hubble law [36]. This evidence can be interpreted in the traditional way: "slower expansion in past, higher expansion at present → universe accelerates its expansion".

The analogy between the evolution of chemical and photon waves offers a different interpretation of those data. The "tired photon waves" loose the ability to tune the Planck constant and the *h-decay* effect is observed. The wavelengths of those "tired" photons are shorter and if the propagation speed *c* is constant, the diffusion action decreases its value (provided that the mass of the photon is constant). This effect can be more pronounced if the value of the propagation speed decreases, too. This situation is depicted in Figure 2.

However, the system can counter-balance the shorter wavelength by higher propagation speed in order to tune the Planck constant. Adam Riess et al. [37] examined the most distance Type Ia Supernova yet discovered. It was at a redshift of $z = 1.7$ and was not fainter, but brighter than expected. This effect was confirmed for ten more distant supernovae found in the year 2003. All of them were brighter than expected. The traditional interpretation leads to the conclusion: "in the redshift range $0.5 < z < 1.0$ the expansion of the Universe should have been accelerating, at $z > 1.0$ the expansion of the Universe should have been decelerating".

The future research will reveal the exact shape of that relationship: the dependence of diffusion action (mass of photon, the propagation speed and the wavelength) on the time. This proposed concept expects the photon wave modification of individual photons instead of the Universe space manipulation.

The new valuable experimental data have been collected by the group of John Webb, Victor Flambaum and their co-workers [38] since 1998. This group analyzed the spectra of quasars with the high redshifts in order to evaluate the evolution of the fine structure constant alpha (alpha = e^2/hc where *e* is the charge of an electron, *h* is Planck"s constant and *c* is the speed of light). They have found that the value of the fine structure constant is smaller for quasars with higher value of redshift. Several interpretations of those data are possible (see papers related to this topic).

The interpretation based on the analogy with the evolution of chemical waves guides us to the conclusion that the value of the diffusion constant increases its value towards the critical value h_{crit}. This *h-decay* effect could be caused by the increase of *m*, λ or *c* or by their combination. The future research is needed in order to clarify the individual contributions of these parameters.

Zero-point energy: physical vacuum filled with photons that cannot create waves

The analogy of the evolution of chemical waves with the evolution of photon waves brings the additional important information. Once the critical value of the diffusion action h_{crit} is exceeded, the molecules stop to self-organize waves and move randomly in that system.

The similar behavior can be found for photons. When the critical value of their diffusion action is exceeded, photons suddenly loose the ability to form waves. Such photons become a part of the zero-point energy (ZPE) – the physical vacuum. The name ZPE was derived from the fact that it is present even when there is no temperature radiation at zero degrees Kelvin.

Some experimental evidences confirmed the presence of the ZPE: the Casimir effect, van der Waals forces, permitivitty, permeability, etc. But until now there is no agreement about the composition of the ZPE that could not be detected by the instruments based on the registration of the electromagnetic radiation.

In modern physics, the concept of the physical vacuum is termed as: space-foam, quantum-foam, Planck particles, quantum wave state, zero-point energy, dark matter/energy, vacuum energy, luminiferous aether, fifth element, quintessence, and many other terms were used. The physical vacuum is "subtler than light" with "invisible" electromagnetic properties.

The analogy with the evolution chemical waves leads us to the conclusion that behind the critical value of the diffusion action h_{crit} the decayed photon particles do not continue in the formation of waves. The mass of the photon particles could be found from the value of critical diffusion action h_{crit} provided that the critical wavelength λ_{crit} and the critical propagation speed u_{crit} will be known.

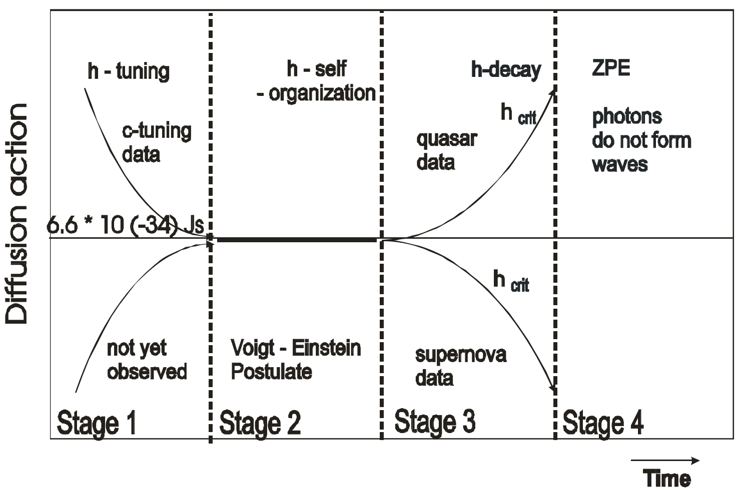

Figure 2 Evolution of photon waves

Conclusions

The analogy between the evolution of chemical waves and photon waves can be verified in the following observations:

1. *h-tuning stage*: during the first 20 – 30 photon waves *h-tuning* and *c-tuning* should be observed,
2. *h-self-organization stage*: four kinds of self-organization mechanisms should be observed. Table I surveys those effects together with experimental observations
3. *h-decay stage*: diffusion action departs from the value *h*, non-linear behavior of λ, modification of the propagation speed *c,* critical value h_{crit} could be found experimentally
4. zero-point energy: physical vacuum is filled with photons that cannot form waves.

References

[1] R. Ashy, *Principles of the Self-Organizing Dynamic System*, *J. General Psychology* **37** (1947) 125.

[2] M.C. Yovits and S. Cameron (Eds.), *Self-Organizing Systems*, Pergamon, New York, 1959.

[3] M.C. Yovits, G. Jakobi and G. Goldstein, *Self-Organizing Systems*, Spartan Books, 1962.

[4] H. von Foerster and G.W. Zopf, *Principles of Self-Organization,* Pergamon, New York, 1962.

[5] R. Paslack, *Urgeschichte der Selbsorganisation*, Vieweg, Braunschweig, 1991.

[6] P. Glansdorf and I. Prigogine, *The theory of structure, stability and fluctuations*, John Wiley & Sons, New York, 1971.

[7] R.E. Liesegang, *Chemische Reaktionen in Gallerten*, Selbstverlag, Dusseldorf, 1898.

[8] A.M. Zhabotinsky, A history of chemical oscillations and waves, *CHAOS*, **1** (1991) 379 – 386.

[9] P. Michalev, V.K. Nikiforov and F.M. Schemyakin, Űber eine neue Gesetzmässigkeit für periodische Rektionen in Gelen, *Kolloid-Z.* **66** (1934) 197-200.

[10] J.A.Christiansen and I. Wolff, Untersuchungen űber das Liesegang-Phänomen *Z. Physik. Chem*. **B26** (1934) 187-194.

[11] G. Ammon and R. Ammon, Diffusion in gelatin and rhythmic precipitation of magnesium hydroxide, *Kolloid-Z*. **73** (1935) 204-219.

[12] H. Ševčíková and M. Marek, Comparison of Dispersion Relations for Propagating Waves in the Belousov-Zhabotinsky Reaction, *Physica* **D 39** (1989) 15-21.

[13] J. Stávek, M. Šípek and J. Šesták, The application of the principle of the least action to some self-organized chemical reactions *Thermochimica Acta* **388** (2002) 441-450.

[14] J.J. Mareš, J. Stávek and J. Šesták, Quantum aspects of self-organized periodic chemical reactions, *J. Chem. Phys*. **121** (2004) 1499-1503.

[15] J.J. Mareš et al., Do periodic chemical reactions reveal Fürth"s quantum diffusion limit? *Physica* **E 29** (2005) 145-149.

[16] J. Stávek and M. Šípek, "Interpretation of periodic precipitation pattern formation by the concept of quantum mechanics, *Cryst. Res. Technol*. **30** (1995) 1033 - 1049.

[17] R. Fűrth, "Űber einige Beziehungen zwischen klassischer Statistik und Quantummechanik, *Z. Physik* **81** (1933) 143 - 162.

[18] I. Fényes, "Eine wahrscheinlichkeitstheoretische Begrűndung und Interpretation der Quantenmechanik, *Z.Physik* **132** (1952) 81 - 103.

[19] W. Weizel, "Ableitung der Quantentheorie aus einem klassischen, kausal determinierten Modell, *Z. Physik* **134** (1953) 264 - 285.

[20] D. Kershaw, Theory of Hidden Variables, *Phys. Rev. B* **136** (1964) 1850 - 1856.

[21] E. Nelson, Derivation of the Schrődinger Equation from Newtonian Mechanics, *Phys. Rev*. **150** (1966) 1079 - 1085.

[22] K.L. Chung and Z. Zhao, *From Brownian Motion to Schrődinger Equation,* Springer, Berlin, 1995.

[23] J. Stávek, Diffusion Action of Chemical Waves, *Apeiron*, **10** (2003) 183-193.

[24] D. Mugnai, A. Ranfagni and R. Ruggeri, *Observation of Superluminal Bahaviours in Wave Propagation* Phys. Rev. Lett. **84** (2000) 4830-4833.

[25] A. Ranfagni and D. Mugnai, *Superluminal behavior in the near field of crossing microwave beams* Phys. Lett. **A 322** (2004) 146-149.

[26] Ch. Doppler, *On the coloured light of the double stars and certain other stars of the heavens* Lecture on 25 May 1842 in the Patriotic Hall of the Karolinum building in Prague.

[27] W. Voigt, Über das Dopplersche Prinzip, *Nachrichten von der Königlichen Gesselschaft der Wissenschaften und der Georg-August Universität zu Göttingen* (1887) 41-51.

[28] A. Ernst and J.P. Hsu, First Proposal of the Universal Speed of Light by Voigt in 1887, *Chin. J. Phys*. **39** (2001) 211-230.

[29] A. Einstein, Zur Elektrodynamik bewegter Körper *Ann. Physik* **17** (1905) 891-921.

[30] J. Stávek, Diffusion of Self-Organized Brownian Particles in the Michelson-Morley Experiment *Apeiron* **11** (2004) 373-386.

[31] J. Stávek and J. Ulrich, "Interpretation of Crystal Growth and Dissolution Rates by the Concept of Fractal Geometry *Cryst. Res. Technol*. **30** (1994) 763-772.

[32] Apeiron – special issue "Cosmological Contributions of W. Nernst **2** (1995).

[33] J. Stávek, "Solar Microwave Background Radiation in J. Šesták: *Heat, Thermal Analysis and Society*, Nucleus HK, 2004, pp. 333 – 335.

[34] J. Stávek, "Possible Solar Microwave Background Radiation *Galilean Electrodynamics* **16** (2005) 31-38.

[35] H. Arp, *Seeing Red, Redshifts, Cosmology and Academic Science* Apeiron, Montreal, 1998.

[36] S. Perlmutter and B.P. Schmidt, Measuring Cosmology with Supernovae, xxx.arxiv.org/abs/astro-ph/0303428.

[37] A.G. Riess et al. The Farthest Known Supernova: Support for an Accelerating Universe and a Glimpse of the Epoch of Deceleration xxx.arxiv.org/abs/astro-ph/0104455.

[38] J.K. Webb et al., Further Evidence for Cosmological Evolution of the Fine Structure Constant www.arxiv.org/abs/astro-ph/0112539.