U.P.B. Sci. Bull., Series A, Vol. 80, Iss. 2, 2018 ISSN 1223-7027

THE WORK "L'ÉTUDE DE LA COURBE DYNAMIQUE D'AIMANTATION D'UN FERRITE MIXTE DE MANGANÈSE ET ZINC, DE HAUTE PERMÉAB ILITÉ", BUL. INST. POLITEH. BUCUREŞTI 29(2) 25-41(1967), REVISITED

Dan A. IORDACHE[1, 2]

As it is known, the assignment of the defects and impurities embedded in the crystalline lattice of the Charge Coupled Devices (CCDs), used as particle detectors is achieved starting from the values of some physical parameters, mainly of the: a) difference $|E_t - E_i|$ between the energies corresponding to the traps and to the intrinsic Fermi level, respectively, b) the polarization degree of the capture cross-sections of free electrons and holes, respectively, c) the pre-exponential factor Dep of the depletion dark current.

In the frame of the classical gradient method, the values of these physical parameters are found by means of the attraction centers (attractors) of the iterative procedure. For this reason, the present work aims to study the main features of the attraction centers (and of some related numerical phenomena) intervening in the evaluation of the main physical parameters of (the temperature dependence of the dark current in) CCDs by means of the classical gradient method.

Keywords: dynamic magnetization curves, hyteresis loops and parameters, power laws, phase transitions, numerical phenomena.

1. Introduction

1.1. Preliminary considerations

As it is well known, the scientists' opinion about the time endurance of the scientific works is usually very pessimist. E.g., the information specialist Dr. Werner Gitt appreciated [1], p. 162: "Most of the scientific publications become outdated after ten years". Given being the work indicated by this paper title is 50 years old, we consider as being of interest to find if there remain still valid some elements of this work. Taking into account that there is a huge number of soft magnetic materials of high technical interest[2], each of them involving several categories corresponding to the: (i) composition, (ii) manufacturing technology,

[1] Physics Department, University POLITEHNICA of Bucharest, 313 Splaiul Independentei, 060042 Bucharest, Romania, daniordache62@yahoo.com and the Academy of Romanian Scientists, Bucharest

[2] E.g., only the table 13.4 of S. V. Vonsovski treatise [2] involves not less than 18 main types of soft magnetic materials: a) the technical Fe, b) pure Fe, c) Fe-Si, d) textured Fe-Si, e) hypernik, f) permalloy 45, g) permalloy 78, h) permalloy Mn, i) permalloy Co, j) mumetal, k) alloy 1040, l) supermalloy, m) permendur, n) permendur V, o) perminvar, p) alsifer, q) Ni-Zn ferrite, r) Mg-Zn ferrite, and … s) Mn-Zn ferrite, omitted in the Vonsovski's list!

(iii) frequency used field (static, low frequency, radio-frequency[3], microwave frequencies):

a) it is not at all surprising that the work indicated in this paper title (corresponding to very strict and narrow parameters intervals) was never cited outside the circle of author's collaborators,

b) the practical action of the international beneficiaries consisted in the elaboration of one-page synthesis of the specific properties of the studied material. This task was very well fulfilled by the analysis of M. Ben Elieser for the Physics Abstracts and Chemical Abstracts reviews [3].

Taking into account that according the findings of Emeritus Psychology Professor Dean Keith Simonton (California University at Davis): "Most articles published in the sciences are never cited by anybody …, but the main predictive factor of the impact is the productivity" (last third of the paper "What makes a genius", National Geographic, no. 169, May 2017), we have to find in following the author's (and of his research group) productivity in this scientific field.

Given being the basic documentation of a work is an essential parameter for its time resistance, we have to examine briefly also this aspect for the studied work.

1.2. Study of the documentation of the examined paper concerning the previous works on the magnetic materials

The study of the references (from the pages 40-41) of the examined paper, about the previous works in this field point out that there were known: a) the most important (for the studied field) old papers [4], b) the intermediate studies, up to the establishment of the ferrimagnetic materials theory, as [5], c) the discovery by the French scientist Louis Néel (awarded in 1970 with the Physics Nobel prize[4]) of the ferrimagnetic state and of the corresponding materials [6], d) the main works of the French school of magnetism [7], especially those referring to the ferrimagnetic materials [7c]-[7g], and even to the Mn-Zn mixed ferrite [7f], e) the principal works of the American school of magnetism [8], f) some of the main works of the German magnetism school [9], g) the principal works of the Japanese school of magnetism [10], h) as well as other studies printed in the frame of some Romanian publications [11]. Other important studies on soft magnetic materials [12] became known for us later, being involved as additional references in our subsequent works (see sections 3.3 and 3.4 in following).

---

[3] The studied magnetic material by this work presents a special interest in Electronics, but the most investigated materials are those used in Electrical Engineering.

[4] The Physics Nobel prize was awarded in 1970 to Louis Eugène Félix Néel (1904-2000) for "his fundamental work and discoveries concerning anti-ferromagnetism and ferrimagnetism, which have led to important applications in solid state Physics".

We have to mention also the direct author's cooperation (prior to the examined paper elaboration) with some of the best Romanian experts in the fields of: (i) technology of the magnetic materials manufacturing as: Jeanine Neuberger (b. 1926, Bucharest, d. 2011, Darmstadt, Germany), Rodica Cătuneanu (b. 1932), Ioana Voinea-Stanciu (main collaborator and provider of the most magnetic materials studied by our works), (ii) electronics measurements, as the electrical engineer V. Tanach (between 1962-1965), and – immediately after the examined work printing with engineer (later professor dr. eng. and corresponding member of the Romanian Academy) Adrian Rusu (since 1967), prof. dr. Alexandru Lupaşcu (since 1978), (iii) hard magnetic materials and corresponding devices for the electrical engineering, mainly PhD Eng Marlene Marinescu and her husband – Phys PhD Nicolae Marinescu (between 1961-1965), and: (iv) Laser radiation interaction with some magnetic materials (between 1979 and 1981). Additionally, the author has to underline that his whole activity in the field of magnetic and dielectric materials was accomplished in the frame of a strong cooperation with some other specialists in this field, mainly the professors Aurelia Stepanescu-Sansoè (from Dipartimento di Fisica of Politecnico di Torino and Istituto "Galileo Ferraris" from Turin), the PhD advisers in the fields of magnetic materials – prof. dr. eng. Horia Gavrilă, and of the dielectric and magnetic materials – prof. dr. Doina Gavrilă, and others.

1.3. Subsequent (author's and of his research group) studies in the field of the soft magnetic materials

The study from Bul. IPB **29**(2) 25-41(1967) was followed by other 38 published works in the same scientific field, with the cooperation of 24 Romanian specialists (academic professors, PhDs and engineers).

a. Works communicated (and published by the corresponding Proceedings) in the frame of some International specialty Conferences

A first group of 17 works was communicated (and published) in the frame of some International specialty Conferences, as those of the: (i) first (1997) and second (1999) French-Canadian-Romanian Workshop on Materials of Electrical Engineering, 3rd (2001), 4th (2004), 5th (2006) and 6th (2008) International Conferences on Magnetic and Dielectric Materials (MmdE), (ii) the 2 Conferences of the Balkan Physical Union from Thessaloniki – Greece (1991) and Istanbul (1992), (iii) the 3 international Conferences on the applied (for us in Magnetism) Computational Physics, from Prague (1992), Bratislava (1995) and Brno (1998), etc.

b. Works published in some ISI reviews of the Romanian Academy

A second group of 3 works was developed with the cooperation of 8 other Romanian specialists (PhD advisers, inclusively) and published in the scientific reviews of the Romanian Academy: *Review Roumaine de Physique* (1980), *Mém. Sci. Sections of the Romanian Academy* (1981) and *Romanian Journal of Physics* (2005).

c. Works published in the frame of some Romanian ISI academic reviews

A third group of 9 scientific works (including the paper indicated in the title of this paper) was published by the different series (Mathematics and Physics, Chemistry, Electrical series) of the Scientific Bulletin of the "Politehnica" University of Bucharest, in the years: 1977, 1978 (1 work yearly), 1979 (2 works), 1982, 1990, 1994 and 2003 (1 work per year), with the cooperation of other 7 Romanian specialists (outstanding PhD advisers, inclusively, as Professors Ion M. Popescu and Constantin Cristescu).

d. Works communicated (and published by the corresponding Proceedings) in the frame of some Romanian specialty Conferences

A fourth group of 8 scientific studies were communicated in the frame of some Romanian specialty Conferences, namely:

a) 3 works at the First National Symposium on Magnetic Materials, organized in 1979 by the Research Institute for Electrical Engineering. (ICPE), Bucharest, and published in this Conference Proceedings, at pages 76-82 and 83-93, respectively (first volume), 442-450 (3rd volume),

b) Other 3 works communicated at the 3rd National Magnetism Conference, organized by the State Council for Nuclear Energy (CSEN) - Central Physics Institute (ICEFIZ) - Technical Physics Center, Iaşi, 1983, and published in the Conference Proceedings at the pages 150-55, 156-161 and 162-165, resp.

c) one work presented in the frame of the 3rd National Conference on Electronics, Telecommunications and Computers, Polytechnic Inst. Bucharest, November 1986, published at pages 108-112 in Proceedings,

d) another work communicated at the First Scientific Session of the Romanian Society of Magnetism and Magnetic Materials, Res. Inst. for Electrical Engineering. (ICPE), Bucharest, 1990, published at pages 65-76 in Proceedings.

e. Published didactic works in the Magnetism field

A fifth (and last) group involves:

a) the "Guide for the use of the device intended to the dynamic magnetic measurements JF-01" developed by our research group, published in 1978 by our Polytechnic Institute of Bucharest, as a booklet of 19 pages (this device was sold to different Romanian education and research units, in 500 samples) [13a],

b) the chapter 6 (pp. 129-154) "Magnetic Properties of solids", in "Lectures of condensed Matter Physics", 4th edition, 2003, Printech Publishing House, Bucharest,

c) the didactic movie "Earth’s Magnetism", Central Office for Education Tools of the Romanian Education Ministry, 1980 (approx. 15 minutes).

2. Studied Methods and Devices for the Dynamic Magnetic Measurements

We have to find again that the devices of magnetic measurements represent a very scarce category in the frame of the electrical (and magnetic) measurements devices (e.g. they are not present by any device in the collections of more than 200 didactic and scientific instruments manufactured by the international specialty firm PASCO (from Roseville, California, USA) [27]. As it concerns the dynamic magnetic measurements, they have to be divided in measurements at: a) low (audio), b) radio, c) microwave frequencies. In following, we have to distinguish between the measurements at: (i) weak, and (ii) medium magnetic field strengths.

In the frame of the studied paper, the measurements at weak magnetic fields were accomplished by means of a low frequencies impedance bridge (see fig. 1 and pages 26, 27), while those at medium magnetic fields use an amplifier-integrator set up (installation) of the type presented by fig. 8 at page 37 of the work [7]. The principles of the dynamic magnetization measurements at weak and medium magnetic field strengths reported by the studied work were confirmed and presented in detail by our work [8], referring to the device JF (low frequency) - 01 developed by us. The electronic scheme of our magnetic measurements device JF-01 (JF = low frequency) is presented by fig. 1 below, while the image of itself this device is shown in fig. 2.

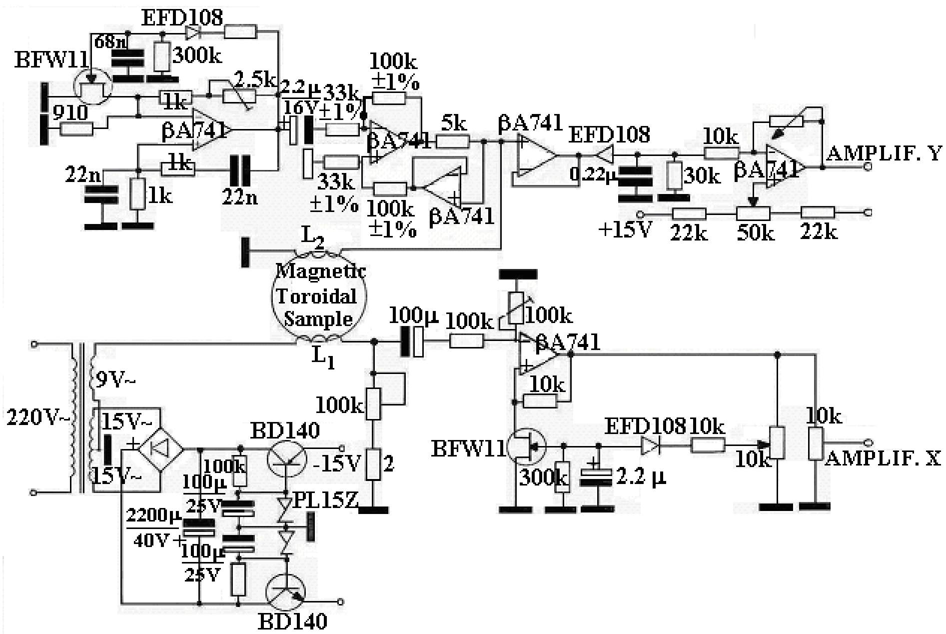

Fig. 1. Electronic scheme of the magnetic measurements device JF-01

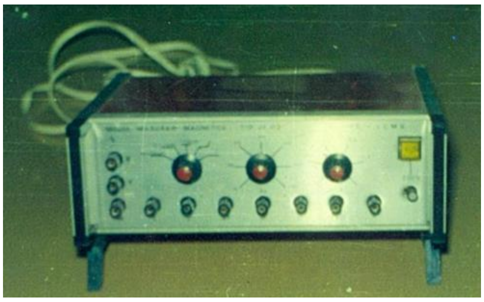

Fig. 2. Image of the device of magnetic measurements at low frequencies JF-01

Given being this device corresponded to an actual need of our education system and even of some research activities (as those from the field of the magnetic materials necessary to electronics industry), our device was introduced in manufacturing activities by the leadership of the Polytechnic Institute of Bucharest (at the beginning of the years 1980), being manufactured in more than 500 copies, each one evaluated at about $200, at the Romanian currency from the years 1980.

Our main subsequent published papers on these topics were:

a) The detailed study of the principles of low-frequency magnetic measurements, accomplished by the work [9],

b) The rigorous processing of the experimental data obtained by means of the studied methods, done by the work [10],

c) Study of the main experimental methods and of their corresponding data processing procedures, both for the fields of low frequencies and of the medium frequencies (100 kHz – 100 MHz) [11],

d) Description of the new device LFR-01 intended to the evaluation of the reversible magnetic permeability and to more accurate data processing [12].

The studies concerning the experimental methods intended to the measurement of the dynamic low frequency parameters of the soft ferrimagnetic materials were completed by the elaboration of the device LFR-01 [12], presented in the frame of the 3rd Romanian Saloon of Inventions, Technologies and New Products [13], the front panel of this device being presented in fig. 3.

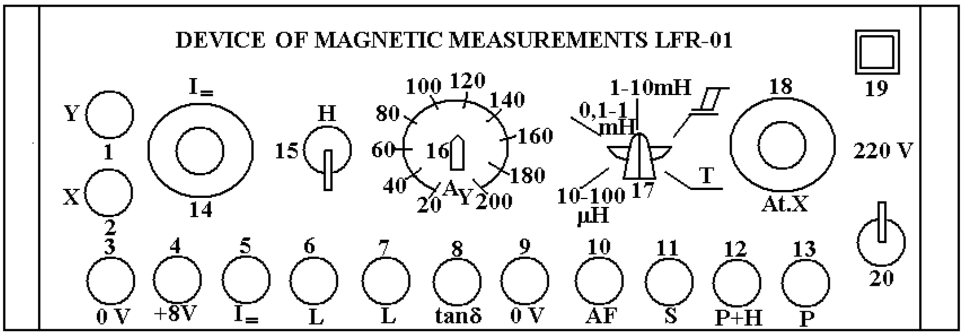

Fig. 3. The front panel of the device LFR-01.

The functions of the main components of the LFR-01 device panel are presented by the following table: 1. Terminal for the signal *B(t)* extraction, 2. Terminal for the signal *H(t)* extraction; 3 and 9 – terminals for the null voltage; 4. Terminal for +8 V supply; 5. Terminal for the connection of the winding, intended to "bring" the studied torus in a certain magnetization state, located on a given hysteresis cycle; 6 and 7 – terminals for the connection of the magnetic torus winding, whose inductance is measured; 8 – terminal for the extraction of the voltage on the pure ohmic resistor of the composed RLC circuit; 9. Point of null voltage; 10. Terminal for the injection of th low (audio-) frequency; 11. Terminal for the connection of the secondary winding (approx. 10 whirls Cu-Em, diameter 0.1 – 0.5 mm); 12 and 13 – terminals for the connection of the primary winding (Cu-Em, diameter 1 mm); 14. Potentiometer intended to the regulation of current intensity $I_=$ for the choice of the magnetization state at the determination of the reversible permeability, 15. Switch $I_=$ direction corresponding to the magnetization state; 16. Switch in steps intended to the regulation of the amplification of the signal *B(t);* 17. Swich for the work regime (3 scales for the determination of the inductance *L*, one scale for the visualisation of the hysteresis cycle and T – to point out the shape of the signal *B(t)*, respectively, 18. Potentiometer intended to the regulation of the signal *H(t)*; 19. Small signal bulks; 20. Electrical network switch.

3. Physical Features of Complexity of the Studied Soft Ferrimagnetic Materials

3.1. Presence of some specific phase transforms

Because for solids the "contact" (interactions) with surroundings produces phase transforms at this matter organization level, both the crystalline lattice structure and the ions (electrons) energy levels structure is essential in order to describe the Complexity features of the technical (solid, usually) materials.

In order to exemplify the implications of these structures, figures 4 and 5 present – for the studied ferri-magnetic spinelic material – the crystalline lattice structure and the corresponding ions energy levels structure, respectively [14b], p. 122.

The transitions from the ions interactions with: (i) nearest neighbors, (ii) ions from another (different) ferri-magnetic sublattice (see fig. 4), (iii) the external magnetic field, determine the phase transforms between the Hopkinson range, the ferri-magnetic phase and the paramagnetic one (see fig. 5).

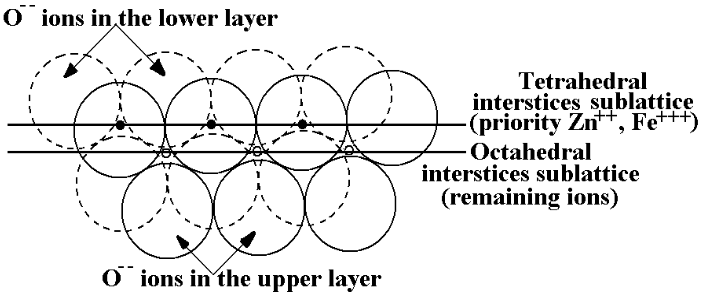

Fig. 4. Structure of the crystalline lattice of soft ferrimagnetic spinelic materials

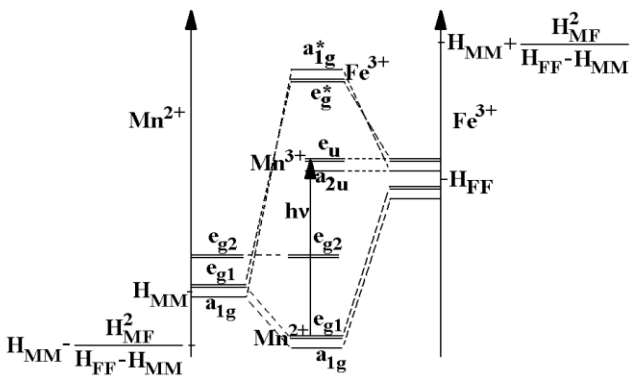

Fig. 5. Structure of the ions energy levels in the soft spinelic ferrimagnetic material $Mn_{0.58}Zn_{0.42}Fe_2O_4$

3.2. Presence of some specific power laws

The first generally recognized work of the Complexity theory in nature sciences belongs [15] to the Physics Nobel prize laureate – prof. Philip Warren Anderson. Its name “More is different” [16] suggests the existence of several organization levels of matter, with specific structures, constitutive equations and laws.

According to the Physics Nobel prize laureate – Kenneth Wilson [17]: “Are complex the states of a system inside whom are concomitantly active strong fluctuations at several organization levels. The same Kenneth Wilson’s works point out also the prevalent role of the *Phase transitions*.

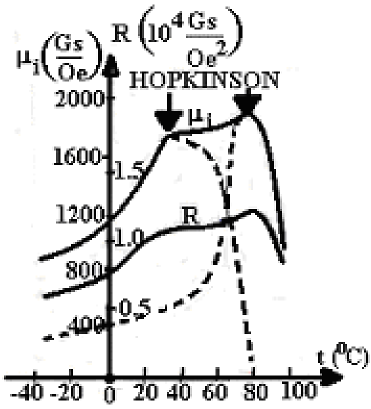

Fig. 6. Temperature dependencies of the initial magnetic permeability μ_I and of the Rayleigh’s coefficient R, for the industrial ferri-magnetic material $Fe_{2.0}Mn_{0.58}Zn_{0.42}O_4$ – R. Dobrescu, D. Iordache “Complexity and Information”, Romanian Academy Printing House, 2010 ([14b], p. 249).

Taking also into account the prediction of Philip Warren Anderson relative to the “explosive” auto-catalytic (exponential) growth following the spontaneous symmetry breaking, one finds that any dimensional parameter p has to be described in complex systems by its logarithm (see also Figs. 7, 8 and 9).

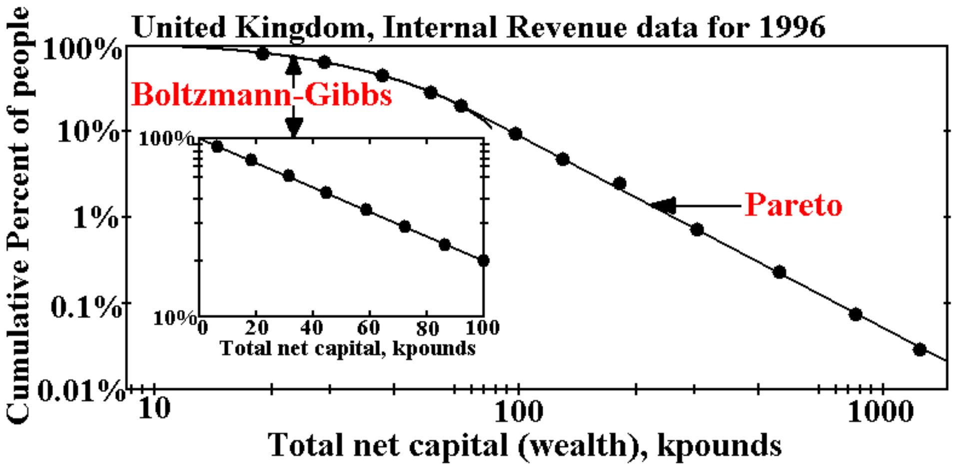

Fig. 7. Cumulative probability distribution of total net capital (wealth) shown in log-log, log-linear (inset) coordinates. Points: the actual data, solid lines: fits to the Boltzmann-Gibbs $p(E) = C \cdot \exp\left(-\frac{E}{kT}\right)$ and Pareto’s $p(m) = A \cdot m^{-n}$ power law (according to [18])

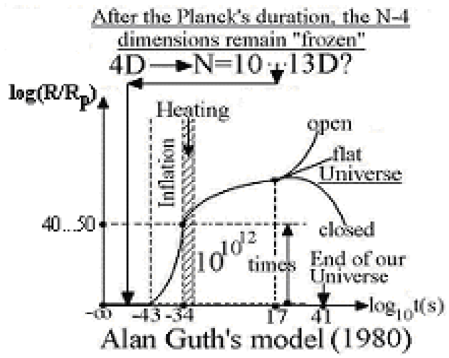

Fig. 8. The Guth version [19] of the Stanford model of Cosmology (SMC).

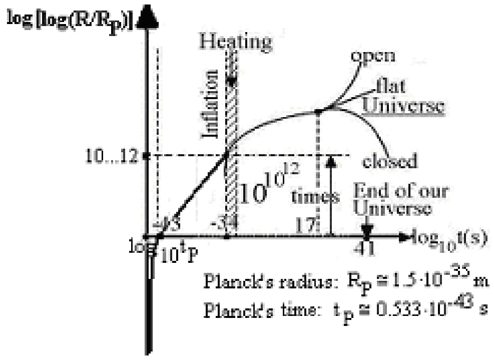

Fig. 9. The linearized approximation of the inflation stage of Linde's version [20c] of SMC.

From Figs. 7, 8 and 9 one finds that – for the complex systems that cover usually several organization levels of matter - the most convenient description uses the logarithms $\ln p$ of their corresponding physical parameters *p*. This finding is also supported by the Dalton's law of the "defined proportions", intervening in the theory of chemical reactions (somewhat similar to the phase transforms) [21a], p. 423: $d\xi = -\frac{d\nu_1}{\nu_1} = -\frac{d\nu_2}{\nu_2} = ... = +\frac{d\nu_N}{\nu_N}$.[5] One finds that the Dalton's relations lead also to the representation of some phase transforms (chemical reactions) by means of the typical numerical representation $\ln \nu_j$.

Given being the basic co-relations between different parameters are the linear ones, it results that the typical relation between a pair of parameters *p, q* – in the frame of complex systems – is given by the expression:

$$\ln p = \ln p_1 + s \cdot \ln q \text{, i.e.: } p = p_1 \cdot q^s . \qquad (3.2.1)$$

One finds so that the typical relations between the parameters of the complex systems are expressed by means of some *power laws*, with *irrational values* of the exponent *s*, generally. This result was confirmed by the discovery (1897) of Vilfredo Pareto's power law [18], describing the distribution of the individuals wealth. We have to underline that many power laws of Physics correspond to some *phase transitions*. E.g. the Domb-Fisher (power law) relation [22], [23]:

$$\frac{1}{\chi} = b(T - T_H)^n , \qquad (3.2.2)$$

---

[5] The sign "-" corresponds to the substances that disappear during the considered chemical reaction, while the sign "+" corresponds to the appearing substances. One finds that *the degree of advance* ξ *of the considered chemical reaction* can be expressed by means of $\ln \nu_j$, where ν_j is the amount (e.g. number of moles) of one of the substances participating to the chemical reaction.

describing the temperature dependence of the magnetic susceptibility between the Hopkinson's and Curie's temperatures, corresponds to the transition between the ferromagnetic and the paramagnetic phases [24].

In such a way, the power law: $B - \mu_i H = a \cdot H^n$, (3.2.3)

found by our work from Bul. Inst. Politehn. Bucureşti **29**(2) 25-41(1967) [referring to the dependence of nonlinear magnetization permeability on the magnetic field strength: $\mu(H) - \mu_i = a \cdot H^{n-1}$, where n is a non-integer number (with values between 1 and 2), specific to the studied ferri-magnetic material] is inscribed perfectly among the most important other power laws met in Physics, as:

a) the Müller's expression [25a] of the dependence of the quality factor of the seismic waves propagation through different rocks on these waves frequency:

$$Q = a \cdot \omega^{\gamma}, \qquad (3.2.4)$$

b) the expression: $r = r_1 \cdot f^n$ (3.2.5)

of the dependence of the viscous coefficient of the oscillations of the magnetization walls of magnetic materials on the magnetic field frequency [25b],

c) the Stevens' law of Psychophysics [25c]:

$$S = S_1 \cdot I^n, \qquad (3.2.6)$$

of the dependence of the sensation S on the stimulus (excitation) intensity I, etc.

4. Conclusions

The analysis of the basic features of the studied work points out that:

a) it was elaborated after:

(i) a thorough preliminary documentation on the previously published French, American, German, and even Japanese and Romanian specialty studies published during approximately 80 years (1885-1964) prior to its printing,

(ii) the consultation of the best Romanian (Rodica Cătuneanu, Ioana Voinea-Stanciu) and of some of the international specialists (Jeanine Neuberger, Marlene Bicalis-Marinescu [26]) in the field of the magnetic materials for electrical engineering and electronics, as well as of some outstanding specialists in the field of electronics measurements (V. Tanach, Adrian Rusu, Alexandru Lupaşcu), and Laser interactions with solids (Physics PhD advisers Ion M. Popescu and Constantin Cristescu).

b) the printing of the studied paper was followed by:

(i) the publication of almost 40 other scientific studies strongly related to its topics and chosen experimental methods,

(ii) elaboration of some devices (JF-01, LFR-01) for magnetic measurements [27], [28], which do not have correspondent in the classical sets of didactic and basic research devices intended to both high-school and research units [29],

(iii) while the studied work (Bul. IPB 1967) and the following almost 40 papers published papers, strongly related to the studied work, were reviewed (with 0.5 … 1 pages content descriptions) by the main abstracts international reviews (Phys. Abstr., Chem. Abstr., Bull. Signalétique, etc), but were not cited outside the "perimeter" of their authors, no less than 500 devices JF-01 built on the principles of the studied work were sold at the price of approx. 200 $ per device,

c) the descriptions of the elaborated devices were accepted, presented and published (with good appreciation) in the frame of several international Conferences, particularly in the countries (Czech Republic [30a], France [30b]) contributing somehow (indirectly) to their elaboration.

d) the studied work (Bul. IPB 1967) and its following related publications contributed strongly to make evident some basic features of the investigated complex magnetic materials, as their phase transforms and power laws. These results were highly appreciated by the Romanian sciences Academy, being awarded with the "Ştefan Procopiu" prize [14a], and the "Grigore Moisil" prize [14b] of these Academies.

All the above findings lead to the conclusion that the studied work (published 50 years ago) opened an important research field, with multiple didactic, industrial and even scientific (in the field of Complexity Theory) implications, some of them presenting

Acknowledgements

The author thanks very much to all his collaborators from the Romanian institutions, or from other countries (see the text and the References of this work).

REFERENCES

[1] *W. Gitt* "In the beginning was information", Master Books, 1st printing 2006, 3rd printing 2014, Green Forrest, AR – USA.

[2] С. В. Вонсовский "Магнетизм", Москва, Наука 1971 (see table 23.4, especially)

[3] *M. Ben-Elieser*: a) Phys. Abstracts 8=18361, b) Chem. Abstracts 68/7683 n.

[4] a*) J. A. Ewing*, Phil. Trans. **176**, 523(1885); b) lord Rayleigh, Phil. Mag., **23**, 225(1887).

[5] *W. Legg*, Bell Syst. Techn. J., **15**, 39(1936).

[6] *L. Néel:* a) Cah. Phys., **12**, 2(1942), **13**, 18(1943); b) Ann. Univ. Grenoble, **22**, 229(1946).

[7] a) L. Lliboutry "L'aimantation des aciers dans les champs magnétiques faibles: effets du temps, des tensions, des chocs, des champs magnétiques transversaux", Thèse, Paris, 1950; b) I. Epelboin "Délimitation du domaine de Rayleigh dans les champs alternatifs à la lumière de récents travaux théoriques et expérimentaux", Journ. de Phys. et le Rad., **12**, 361(1951); c) J. L. Snoek "Conférence sur les propriétés magnétiques des ferrites", ibid., **12**, 228(1951); d) Ch. Guillaud "Propriétés magnétiques des ferrites", ibid., **12**, 239(1951); e) Ch. Guillaud "Étude des ferrites mixtes de manganèse dans les champs alternatifs faibles", ibid., **12**, 498(1951); f) Ch. Guillaud "Les propriétés des ferrites de manganèse et

zinc et les procès physiques qui les gouvernent", Proc. IEE **104**(1957), part B, suppl., nr. 5, pp. 165-173; g) A. Kassiliev "Les ferrites", Annales de radioéléctricité **12**, 337-362(1957).

[8] a*) J. L. Snoek* "New developments in ferromagnetic materials", New York-Amsterdam, Elsevier Publ. Comp., 1947; b) D. Polder "Ferrite materials", Proc. Inst. Electrical Engineers, **97**, part II, 247(1950); c) G. T. Rado, H. Suhl "Magnetism", 3 vol., New York-London, J. Wiley, 1964.

[9] a) *K. Sixtus,* Z. Physik, **121**, 100(1943); b) E. Kneller "Ferromagnetismus", Berlin, Göttingen, 1962.

[10] a) *K. Ohta, T. Yamadaya* "Induced magnetic anisotropy and dis-accomodation of manganese-zinc ferrites", Proc. International Conference on Magnetism and Crystallography, 1961, vol. I, pp. 291-295; b) S. Chikazumi "Physics of Magnetism", New York-London, J. Wiley, 1964.

[11] a) *S. Procopiu*, C. R. Acad. Sci. Roumanie, **7**, 43(1943-1945); b) K. Koblenz "Des éléments magnétiques de communtation", in the frame of papers collection "L'utilisation des ferrites en télécommunications", Bucarest, 1959.

[12] a*) J. Smit, H. P. Wijn* "Ferrites", Philips Technical Library, Eindhoven, 1959; b) S. Cedighian "Ferrites" (in Romanian), Technical Printing House, Bucharest, 1966; c) N. Soltz, K. A. Piskarev "Ferrites for radio-frequencies" (Ferriti dlia radio-tchastot, in Russian), Izd. Energia, Moscow, 1966; d) *** "Standard Guide to methods of determination of magnetic properties of soft magnetic materials", IEC/TC – 68 (1990).

[13] a) *D. Iordache, A. Lupaşcu, L. Daniello, S. Teodorescu* "Instructions for the use of the device intended to the study of the materials' behavior in magnetic fields, type JF-01" (in Romanian), Printing House of the Polytechnic Institute of Bucureşti, 1978, 19 pages; b) D. Iordache, A. Lupaşcu, V. Iancu, V. Iordache "Device for the evaluation of the low frequency dynamic parameters of the soft ferrimagnetic materials", 3rd Romanian Saloon of Inventions, Technologies and New Products PROINVENT'99, Bucharest, October 1999.

[14] *R. Dobrescu, D. Iordache:* a) "Complexity Modeling" (in Romanian), Politehnica Press Printing House, Bucharest, 2007 (awarded with "Ştefan Odobleja" prize of the Academy of Romanian Scientists); b) "Complexity and Information", Romanian Academy Publishing House, Bucharest, 2010 (awarded with "Grigore Moisil" prize of the Romanian Academy).

[15] *S. Solomon:* a) Annual reviews of Comp. Physics II, pp. 243-294, D. Stauffer ed., World Scientific, 1995; b) with E. Shir "Complexity: a science at 30", Europhysics News. **34**(2) pp. 54-57, 2003.

[16*] P. W. Anderson*: a) "More is different", Science, **177**, 293, 1972; b) Proc. Natl. Acad. Science (USA), **92**, pp. 6653-6654, 1995.

[17] *K. G. Wilson* "Renormalization group and critical phenomena", Phys. Rev. B, **4**, 3174, 3184, 1971.

[18] *R. N. Mantegna, H. E. Stanley* "An introduction to econophysics: correlations and complexity in finance", Cambridge University Press, 1999.

[19] *A. Guth*: a) Physical Review D, **23**, 347-356(1981); b) with P. J. Steinhardt "The Inflationary Universe", Scientific American, p. 116, May 1984; c) "The inflationary Universe. The quest for a new of cosmic origins", Addison-Wesley, Reading, 1997.

[20*] A. Linde*: a) "Inflation and Quantum Cosmology", Academic Press, 1990; b) "Particle physics and inflationary cosmology", Harwood Academic Publishers, Swiss, 1990; c) "The Self-Reproducing Inflationary Universe", Scientific American, pp. 48-55, November 1994.

[21] *E. Bodegom, D. Iordache* "Physics for Engineering Students", Politehnica Press, Bucharest: a) vol. 1, 2007; b) vol. 2, p. 2008.

[22] *C. Domb, M. F. Sykes*: a) Proc. Roy. Soc., A **240**, p. 214, 1957; b) J. Math. Phys., **2**, 63, 1961; c) Phys. Rev., **128**, p. 168; 1962.

[23] *M. E. Fisher*, Physica, **25**, p. 521, 1959.

[24] a) *C. Domb, S. Green* “Phase transitions and critical phenomena”, Academic Press, New York, 1976; b) J. Zinn-Justin “Quantum field theory and critical phenomena”, Oxford University Press, 4th edition, 2002.
[25] a) G. Müller “Rheological properties and velocity dispersion of a medium with a power-law dependence of *Q* on frequency”, J. Geophysics, **54**, pp. 20-29, 1983; b) L. Daniello, D. Iordache, I. M. Popescu, I. Socol, D. Hornea “"Study of the frequency dependence of the viscosity coefficient of the Bloch wall oscillations", Rev. Roum. Phys., **25**(2) 193-198, 1980; c) S. S. Stevens: (i) “Hearing: its Psychology and Physiology”, Wiley, New York, 1938; (ii) “On the psychological law”, Psychological Review, **64**, 153-181, 1957; (iii) “Psychophysics: Introduction to its Perceptual, Neural, and Social Prospects”, Wiley, New York, 1975.
[26] a) *A. Timotin, M. Marinescu* “Fluxul de dispersie al unui circuit magnetic cu magnet permanent”, Studii şi cercetări de energetică şi electrotehnică, **20**, 53-79(1970); b) A. Timotin, M. Marinescu “Die optimale Projektierung eines magnetischen Kreises mit Dauermagnet für Lautsprecher”, Archiv für Elektrotechnik, **54**, 306-317(1971); c) Marlene Marinescu “Elektrische und magnetische Felder”, 3. Auflage, Springer Vieweg, 2012; d) Marlene Marinescu, Nicolae Marinescu “Elektrotechnik für Studium und Praxis” (Gleich-, Wechsel- und Drehstrom, Schalt- und nichsinusförmige Vorgänge), Springer Viewig, Germany, 2012.
[27] *D. Iordache, D. McClure* “Selected works of computer aided applied sciences”, vol. 2 – Technical and Didactic applications, Printech Publishing House, Bucharest, 2002.
[28] a) *D. Iordache, A. Lupaşcu, L. Daniello, S Teodorescu, L. Frangu* “Devices for the determination of the main dynamic magnetic parameters of the ferro- and ferri-magnetic materials intended to the education laboratories”, Proc. 1st Symp. on Magnetic Materials (in Romanian), Bucharest, May 1979, pp. 442-450 and [27], pp. 423-428 (English); b) D. Iordache, L. Daniello, A. Lupaşcu, C. Onulescu “On the evaluation of the parameters of the low frequency dynamic magnetization of the ferro- and ferrimagnetic materials”, Proc. 1st Symp. on Magnetic Materials (in Romanian), Bucharest, May 1982, pp. 76-82 and [27], pp. 336-340 (English); c) D. Iordache, L. Burileanu, L. Daniello, V. Iordache “Devices and Computer Codes for the evaluation of the dynamic magnetic parameters of the ferrimagnetic materials”, Proc. of first Romanian Conf. on Magnetism and Magnetic Materials, Bucharest, November 1990, pp. 65-76 (in Romanian) and [27], pp. 429-438 (English).
[29] Yearly revisited and completed editions of the catalogues of didactic and research products of PASCO scientific (Roseville, California, USA) manufacturer (1965-today).
[30] a) *D. Iordache, Vl. Iancu, L. Fara, V. Iordache* “Device and Minilibrary of Computer Programs Intended to the Evaluation of the Main Physical Properties of the Soft Ferrimagnetic Materials”, Proceedings of the 4th Seminar “Experiments and Measurements in Engineering Education” (EMEPE-98), Brno (Czech Republic), 15-17 October 1998, p. 82-85; b) D. A. Iordache, C. Florea, V. Iordache “Frequency Power Laws of the Oscillations of some Microscopic Structures”, in Proceedings of the European Conference on Micro- and Nano-structures (EMN-04), pp. 69- 73, Noisy le Grand (Paris), 20-21 October, 2004.