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Super-carbon Nanotubes: An E-infinity Approach

Ji-Huan He*, Lan Xu

Modern Textile Institute, Donghua University, 1882 Yan'an Xilu Road
Shanghai 200051, China

Abstract: *Super-carbon nanotubes have widely potential applications such as field-emission displays, high-strength composites, hydrogen storage, and nanometer-sized semiconductor devices[1-3]. These materials with hierarchical geometrical structures always display quantum-like properties and have many fascinating nano-effects[4-6], such as a remarkable increase in strength, high surface energy and surface reactivity, excellent thermal and electric conductivity, and extraordinary fast flow in nanotubes[7]. However, the precise role of these intricate phenomena is unknown. Here we show that nanotechnology could be seen as a link between the deterministic classic mechanics and the indeterministic quantum mechanics, and E-infinity theory[8,9] could help in understanding various nano effects. We also found that the characteristics of super-carbon nanotubes depend mainly upon Hausdorff-fractal dimensions of their hierarchical structures. Furthermore, the E-infinity nano-model for super-carbon nanotubes could deal for the first time with seemingly complex properties of nanotubes. Particularly, for the specialists in designing, manufacturing and using super-carbon nanotubes, this will be of great practical importance.*

Recently Coluci *et al.* proposed a new structure of the so-called super-carbon nanotube[1,2], which can be either metallic or semi-conducting prototypes for electromechanical actuators, serve as hosts for large biomolecules, and have a wide range of potential applications[1-3]. Here we will show that the characteristics of super-carbon nanotubes depend mainly on their hierarchical structures.

Super-carbon nanotube is a hierarchical fractal, and as such it is like the ultimate building blocks of Nature as proposed by E-infinity theory[8]. As stated by Gerardus 't Hooft[10] discrete space time may be the most radical and logical viewpoint of reality[11]. Unfortunately most mainstream physicists are unwilling to adopt the picture that space and time consist of a collection of isolated points, where particles can be only on those points, but not in between[8,10,11]. E-Infinity theory[12-16] extends this notion to a transfinite setting where the collection of points can mimic the continuum[8]. Such a collection of unaccountably infinite set of points is said to possess the cardinality of the continuum and as such it is a compromise between the discrete and the continuum.

In view of this theory, nanotechnology[17,18] could be seen as a link between the deterministic classic mechanics and the indeterministic quantum mechanics[17,18]. It seems that there ought to be a law controlling the change from a classical object like a stone to

* corresponding author: E-mail: *jhhe@dhu.edu.cn*

a quantum object like an electron. Somewhere between these two scales these changes happen, but this does not happen abruptly. There is indeed a grey area between these two scales which is neither completely classical nor completely quantum. E-infinity theory[8] and probably also 't Hooft's deterministic quantum mechanics[10] may be valid for all these various scales and may provide strong candidates for dealing with the said grey area[11].

In recent years there has been a flurry of original papers published on the foundation and application of E-infinity theory[19-26]. The main application of E-infinity theory shows miraculous exactness, especially in predicting the theoretically coupling constants and the mass spectrum of the standard model of elementary particles[19-26].

In a theory of n dimensional spaces, what we mean by n dimension is simply that we need n numbers representing n coordinates to fix the position of a point in this space. In our classical space time, these are the familiar triple x, y and z; while in relativity we have a fourth coordinate or dimension, namely the time t. The formal dimension in E-infinity theory , however, is[8]

$$DF = \infty. \tag{1}$$

The physical interpretation of Eq.(1) in super-carbon nanotubes will be discussed later. The topological dimension of E-infinity theory is[8]

$$DT = 4. \tag{2}$$

The dimension 3+1= 4 means that as in our daily experience, the world at the nano-scale appears to us as if it were four-dimensional. In addition as we will show shortly there is also a Hausdorff dimension connected to this space equal to $4 + \phi^3 = 4.23606797$ where $\phi = (\sqrt{5}-1)/2$.

Hierarchical structure can be found everywhere in super-carbon nanotubes[1], as illustrated in Fig. 1. Let us sum up an infinite number of intersecting Hausdorff-fractal dimensions of infinite number of one dimensional Cantor sets, with Hausdorff dimension $(d_c^{(0)})^n$, where $n = 0,1,2,\cdots$.

Consequently we have[27,28]

$$\sum_{i=0}^{\infty}(d_c^{(0)})^n = 1 + (d_c^{(0)})^1 + (d_c^{(0)})^2 + \cdots \tag{3}$$

Here we assume the radius of the mother cylinder in Fig. 1 to be equal to 1, and $(d_c^{(0)})^n$ is the radius of n-th child cylinder. The expectation value for this sum in terms of $d_c^{(0)}$ is[27,28]

$$< d_c >= \sum_{i=0}^{\infty}(d_c^{(0)})^n / d_c^{(0)} = \frac{1}{d_c^{(0)}(1-d_c^{(0)})}. \tag{4}$$

This formula already implies that $D_F = \infty$ in super-carbon nanotubes. This is because we have been summing over $n = 0, \ldots, \infty$ and this is the formal dimension of E-infinity.

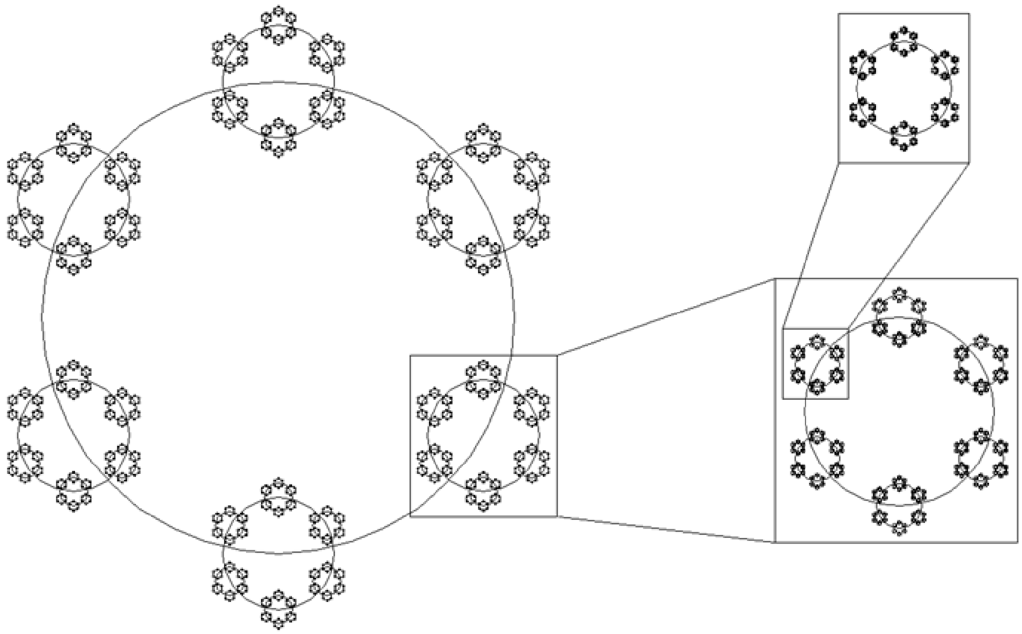

Figure 1: The Hierarchy of a super-carbon nanotube. E-infinity theory could explain nano-effects including unusual strength, high surface energy, high surface reactivity, high thermal as well as electric conductivity depend strongly upon the hierarchical structure of the super-carbon nanotubes and especially upon the ratio of r_{n+1}/r_n.

In case of $d_c^{(0)} = 1/2$, we have $< d_c >= 4$. This means that when $d_c^{(0)} = r_{n+1}/r_n = 1/2$, where r_n and r_{n+1} are the radius of the n-th and (n+1)-th carbon cylinders respectively, the super-carbon nanotube will behave like those in four dimensional spacetime. More explicitly super-carbon nanotubes with $<d_c> = 4$ have the same characteristics as a single-walled carbon nanotube from which they are built.

In case of $d_c^{(0)} = 1/2$, we can easily find that the average Hausdorff dimension is larger than 4 and in case of $d_c^{(0)} = \phi = (\sqrt{5} - 1)/2$, we have a spacetime filling structure with $\langle d_c \rangle = 4 + \phi^3 = 4.236067977$. Such a super-carbon nanotube displays quantum-like properties and has many fascinating nano-effects[4-6], such as a remarkable increase in strength, higher surface energy and surface reactivity, as well as better thermal and electric conductivity. We see that the preceding Cantor set based on a hierarchical geometrical picture could help in understanding these nano effects.

We have proposed an E-infinity nano-model for super-carbon nanotubes dealing for the first time with a seemingly complex properties of critical importance in nanotechnology. Particularly, for the specialists in designing, manufacturing and using the nanotubes, this will be of great practical importance. This E-infinity model is able to give a complete theoretical description of a complex dynamic process. Of course the authors understand that no matter how rigorous, more experimental verifications are needed to validate the model. We hope the present study will stimulate further experimental studies for verifying our prediction that main characteristics depends upon Hausdorff dimension of the hierarchy structure, and E-infinity theory might turn out to have more important ramifications in nanotechnology than hitherto believed possible.

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References

[1] Coluci, R., Galvao, D. S. and Jorio, A. Geometric and Electronic Structure of Carbon Nanotube Networks: 'Super'-Carbon Nanotubes, *Nanotechnology*, **17**, 617–621 (2006).

[2] Coluci, V. R., Dantas, S. O., Jorio, A. and Galvão, D. S. Mechanical Properties of Carbon Nanotube Networks by Molecular Mechanics and Impact Molecular Dynamics Calculations, *Physical Review B*, **75**, 075417 (2007).

[3] Wang, M., Qiu, X. M. and Zhang, X. Mechanical Properties of Super Honeycomb Structures Based on Carbon Nanotubes, *Nanotechnology*, **18** 075711(2007).

[4] He, J. H., Wan, Y. Q., Xu, L. Nano-effects, Quantum-like Properties in Electrospun Nanofibers, *Chaos, Solitons & Fractals*, **33**, 26-37 (2007).

[5] Xu, L., He, J. H., Liu, Y. Electrospun Nanoporous Spheres with Chinese Drug, *International Journal of Nonlinear Sciences and Numerical Simulation,* **8**, 199-202 (2007).

[6] He, J. H., Liu, Y., Xu, L., *et al.* Micro Sphere with Nanoporosity by Electrospinning, *Chaos, Solitons & Fractals*, **32**: 1096-1100 (2007).

[7] Majumder, M., Chopra, N., Andrews, R., *et al.* Nanoscale Hydrodynamics-Enhanced Flow in Carbon Nanotubes, *Nature*, **438**: 44 (2005).

[8] El Naschie, M. S. A Review of Applications and Results of E-infinity Theory, *International Journal of Nonlinear Sciences and Numerical Simulation*, **8**, 11-20 (2007) *www.esi-topics.com/erf/2004/october04-MohamedElNaschie.html*

[9] El Naschie, M. S. From Pointillism to E-infinity Electromagnetism, *Chaos, Solitons & Fractals*, **34:** 1377-1381(2007).

[10] 't Hooft, G. *In Search of the Ultimate Building Blocks.* Cambridge University Press, 1997.

[11] El Naschie, M. S. Deterministic Quantum Mechanics Versus Classical Mechanical Indeterminism, *International Journal of Nonlinear Sciences and Numerical Simulation,* **8**, 5-10 (2007).

[12] El Naschie, M. S. The Cosmic Da Vinci Code for the Big Bang–a Mathematical Toy Model, *International Journal of Nonlinear Sciences and Numerical Simulation,* **8**, 191-194 (2007).

[13] El Naschie, M. S. On the Universality Class of all Universality Classes and E-infinity Spacetime Physics, *Chaos, Solitons & Fractals*, **32**: 927-936 (2007).

[14] El Naschie, M. S. SO(10) Grand Unification in a Fuzzy Setting, *Chaos, Solitons & Fractals*, 32: 958-961 (2007).

[15] El Naschie, M. S. Determining the Number of Fermions and the Number of Boson Separately in an Extended Standard Model, *Chaos, Solitons & Fractals*, **32**: 1241-1243 (2007).

[16] El Naschie, M. S. On an Eleven Dimensional E-infinity Fractal Spacetime Theory, *International Journal of Nonlinear Sciences and Numerical Simulation,* **7**: 407-409 (2006).

[17] Elnaschie, M. S. The Political Economy of Nanotechnology and the Developing World, *International Journal of Electrospun Nanofibers and Applications,* **1**, 41-50 (2007).

[18] El Naschie, M. S. Nanotechnology for the Developing World, *Chaos, Solitons & Fractals*, **30**: 769-773 (2006).

[19] Giordano, P. Numerical Analysis of Hypersingular Integral Equations in the E-infinite Cantorian Spacetime, *International Journal of Nonlinear Sciences and Numerical Simulation,* **7**: 451-460 (2006).

[20] Sigalotti, L. D. G., Mejias, A. On El Naschie's Conjugate Complex Time, Fractal E-infinity Space-Time and Faster-Than-Light Particles, *International Journal of Nonlinear Sciences and Numerical Simulation,* **7**: 467-472 (2006).

[21] Iovane, G. E1 Naschie E-Infinity Cantorian Spacetime and Lengths Scales in Cosmology, *International Journal of Nonlinear Sciences and Numerical Simulation,* **7**: 155-162 (2006).

[22] He, J. H. Nonlinear Dynamics and the Nobel Prize in Physics, *International Journal of Nonlinear Sciences and Numerical Simulation,* **8** (1): 1-4 2007.

[23] He, J. H., Xu, L., Zhang, L. N., *et al.* Twenty-Six Dimensional Polytope and High Energy Spacetime Physics, *Chaos, Solitons & Fractals*, **33**: 5-13 (2007).

[24] He, J. H. On the Number of Elementary Particles in a Resolution Dependent Fractal Spacetime, *Chaos, Solitons & Fractals*, **32**: 1645-1648 (2007).

[25] He, J. H. The Number of Elementary Particles in a Fractal M-theory of 11.2360667977 Dimensions, *Chaos, Solitons & Fractals*, **32**: 346-351(2007).

[26] He, J. H. E-infinity Theory and the Higgs Field, *Chaos, Solitons & Fractals*, **31**: 782-786 (2007).

[27] He, J. H. Application of E-infinity Theory to Turbulence, *Chaos, Solitons & Fractals*, **30**, 506-511 (2006).

[28] He, J. H. Application of E-infinity Theory to Biology, *Chaos, Solitons & Fractals*, **28**, 285-289 (2006).