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FROM MACROSCOPIC SIGNS OF NANODUST IN SPACE TO PROBABLE SIGNIFICANCE OF ELECTRODYNAMICS AT COSMOLOGICAL LENGTH SCALES

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1. "Plasma cables" in space

Plasma phenomena in space (seen as the filaments of plasma emissivity) were suggested to form the "plasma cables" and, thus, provide long-range electrodynamic bonds.

[1] H. Alfvén, "Cosmic Plasma", D. Riedel Publ. Co., Dordrecht, Holland, 1981.
[2] A. L. Peratt, "Physics of the Plasma Universe", Springer Verlag, 1992.
[3] IEEE Transactions on Plasma Science, 1989 **17**(2); 1990 **18**(1); 1992 **20**(6)

2. Strongly twisted magnetic flux ropes ("heteromacs")

Unusual structuring (Rantsev-Kartinov [4,5]) was revealed in the database from the former experiments in the Z-pinch facility – namely, waiving of the filaments of plasma emissivity, and the tree-like structure around main body of the Z-pinch plasma column, especially the presence of strata directed nearly transversely to the Z-pinch plasma column.

[4] A.B. Kukushkin, V.A. Rantsev-Kartinov. Laser and Part. Beams, **16,** 445 (1998).
[5] A.B. Kukushkin, V.A. Rantsev-Kartinov. *Current Trends in Int. Fusion Research: Review and Assessment* (Proc. 3rd Symposium, Washington D.C., 1999), Ed. E. Panarella, NRC Research Press, Ottawa, Canada, 2001, p. 121-148.

Interpretation of these data in the light of

(i) magnetic flux ropes in space (nearly force-free magnetic configuration, which are thought to be capable of self-sustaining) [6], and

(ii) success in confining the nearly force-free magnetic configuration in an electrically conducting chamber (experiments with spheromaks and reversed field pinches) [7],

have lead to a new magnetic configuration and a new source of fractality (Kukushkin [4,5]).

The assumption of a strong confinement of magnetic field in a flux tube, allowed the treatment of a long-lived filament in plasmas as an elastic thread. The latter can produce a compact, twisted loop directed transversely to the thread -- as it can be immediately checked via twisting the ordinary thread. In plasma, this would correspond to formation of an almost-closed helical heterogeneous magnetoplasma configuration (this configuration was called a *heteromac*). Such a branching-off process makes single filament a fractal, dendritic structure (Fig. 1).

[6] Physics of Magnetic Flux Ropes, Geophys. Monograph 58 (Eds. C.T.Russel, E.R.Priest, L.C.Lee), Am. Geophys. Union, 1990.

[7] J.B. Taylor, Rev. Mod. Phys. **58** (1986) 741.

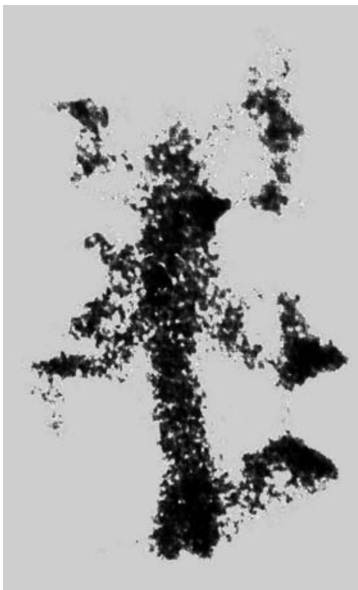
Fig. 1. A schematic drawing [4,5] of successive branching of an originally one-dimensional filament (left drawing), which produces the heteromac(s) (center) and makes individual filament a fractal formation (right).

Heteromacs are suggested to produce cellular, and bubble-like clusters and are identified in various Z-pinch data:

[8] A.L. Peratt, "Characteristics for the Occurrence of a High-Current, Z-pinch Aurora as Recorded in Antiquity." IEEE Transac. Plasma Sci., **31**(6), 1192-1214 (2003).

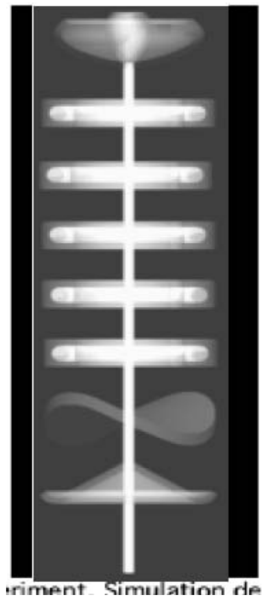
"The discovery that objects from the Neolithic or Early Bronze Age carry patterns associated with high-current z-pinches provides a possible insight into the origin and meaning of these ancient symbols (primarily, petroglyphs). This paper directly compares the graphical and radiation data from high-current z-pinches to these patterns…"

Petroglyph



Z-pinch image

Numerical modeling



The heteromac hypothesis still leaves open the question about the origin of the longevity of observed filamentation.

Here, major difficulty is the unknown mechanisms for suppressing all the short-scale instabilities, which the plasma is rich with: the mater is that in the successful MHD simulations of filament’s dynamics these instabilities are ignored. For instance, the two-fluid description of plasma -- with allowance for the Hall effect-produced “loosening” of the boundary between the plasma column and the ambient magnetic field -- makes this boundary pretty unstable in contrast to observations [5] of long-lived filaments in the high-current electric discharges. The latter implies that successful MHD simulations may implicitly exploit the physics hidden at the length scales which are smaller than those treated in the MHD codes.

3. Phenomenon of self-similar skeletal structures [9]

[9] A.B. Kukushkin, V.A. Rantsev-Kartinov, Phys. Lett. A **306,** 175 (2002).

Experimental findings (Rantsev-Kartinov [4,5,10]):

(i) observations of transverse-to-electric current, few-centimeters long and ~1 mm thick straight filaments [4] of an anomalously long lifetime [5,10] in the plasma of gaseous Z-pinch, and

(ii) identification of opaque, “dark” filaments [4] in the Z-pinch and astrophysical objects.

[10] A.B. Kukushkin, V.A. Rantsev-Kartinov. *Advances in Plasma Phys. Research*, 2002, Vol. 2 (Ed. F. Gerard, Nova Science Publishers, New York), p. 1-22,

Theoretical models (Kukushkin [11,5]):

(i) prediction of self-similar skeletons composed of a fractal condensed matter, assembled from self-similar tubular structures, successively forming the “generations” of tubules, generally unlimited in size;

(ii) hypothesis for self-assembling of a skeleton during electric breakdown stage of discharge (or similar transient process) via electrodynamic coupling of nanoblocks, with dominant contribution of magnetic dipole attraction.

[11] A.B. Kukushkin, V.A. Rantsev-Kartinov. *Fusion Energy 1998* (IAEA, Vienna, 1999), Vol. 3, 1131-1134.

The proof-of-concept studies revealed (Rantsev-Kartinov [9,10,12]):

(i) skeletal structures of certain distinctive topology (namely, tubular and cartwheel-like structures, and their simple combinations) in the range 10^{-5} -10^{23} cm in

- various laboratory electric discharges of type (tokamaks, Z-pinches, plasma foci, laser plumes) [10]
- dust deposits in tokamak [12],
- severe weather phenomena (tornado, hailstones) [9],
- space (solar coronal mass ejections, supernovae remnants, some galaxies) [9], and

(ii) some signs of skeletal structuring in the galaxies redshift surveys, in the range 10^{24}-10^{26} cm.

[12] B.N. Kolbasov, A.B. Kukushkin, V.A. Rantsev-Kartinov, P.V. Romanov, Phys. Lett. A **269**, 363 (2000); Phys. Lett. A **291**, 447 (2001).

(See also the neighbouring posters by V.A. Rantsev-Kartinov)

Recent survey of self-similar skeletal structures:

[13] A.B. Kukushkin, V.A. Rantsev-Kartinov, “Evidences for and the models of self-similar skeletal structures in fusion devices, severe weather phenomena and space”, 6th Symposium «Current Trends in International Fusion Research: A Review», Washington, D.C., USA, March 7-11, 2005.
(see Preprint ArXiv: physics/0512245 and http://uni-skeletons.narod.ru/English-main.htm).

Further extension of substantial role of electrodynamics in the Universe, up to cosmological length scales:

Astrophysics:

Mechanical strength of skeletal matter may avoid the necessity to introduce a «dark matter» because unexpectedly fast motion of galaxies’ periphery and of galaxies in the clusters of galaxies (in the framework of purely gravitational dynamics and the empirical law «mass vs. luminosity») may be explained in a different way [14,15].

[14] A.B. Kukushkin, V.A. Rantsev-Kartinov, Preprint astro-ph/0205534 (2002).
[15] A.B. Kukushkin, V.A. Rantsev-Kartinov, In «Plasmas in the Laboratory and in the Universe: New Insights and New Challenges». Eds. G. Bertin, D. Farina, R. Pozzoli. AIP Conference Proceedings, v. 703, 2004, pp. 409-412.

Cosmology:

Combination of the following observational facts, namely:

- skeletal structures in the range $\mathbf{10^{-5}}$ **cm -** $\mathbf{10^{23}}$ **cm,**
- the signs of skeletal structuring in the range $\mathbf{10^{24}}$**-**$\mathbf{10^{26}}$ **cm**,
- self-illumination of skeletal structures, in their critical, «burning» points, in the range $\mathbf{10^{-1}}$**-**$\mathbf{10^{22}}$ **cm,**
- anomalous blackness of self-similar skeletal matter (similar to that of the Carbon Black matter) in the range $\mathbf{10^{-5}}$**-10 cm**,

hints at the presence of a **baryonic cold skeleton** of the Universe (Kukushkin [14-16], which has to be in thermal equilibrium with the observed cosmic microwave background radiation, and may be compatible with

(i) very high isotropy of cosmic microwave background, and

(ii) high uniformity of Hubble's expansion.

Thus, ***BCS is dark because it is very cold and very black***.

[16] A.B. Kukushkin, Hypothesis for a Baryonic Cold Skeleton of the Universe as an Implication of Phenomenon of Universal Skeletal Structures. AIP Conference Proceedings, vol. 822: "1st Crisis in Cosmology Conference (CCC-I, June 2005, Monção, Portugal): Challenging Observations and the Quest for a New Picture of the Universe", AIP Press, 2006, pp. 40-47.

4. Probable mechanisms of electrodynamic aggregation of magnetized nanodust in space and the respective method of numerical modelling [17].

Despite the existing experimental evidences and theoretical models for extraordinary magnetism of carbon nanotubular dust need much stronger tests and confirmations, they justify explicit demonstration of the capability of magnetized nanotubular blocks to self-assemble the tubules of higher generations and sustain the integrity of the assembled skeleton. An analysis of the capability of magnetized one-dimensional rods to sustain the integrity of the hypothetically formed tubular skeleton (i.e. the tubule of the 2-nd generation) was carried out in [17] in the frame of a simple electrodynamic model suggested there for describing such a skeletal matter. The capability of the model was illustrated with the example of how a straight tubular skeleton, which is composed of 294 dipoles and carry circular electric current in its wall, may be wrapped up by a distant pulsed electric current to make a toroid-like structure (Figs. 2-5).

[17] A.B. Kukushkin, K.V. Cherepanov. Simple model of skeletal matter composed of magnetized electrically conducting thin rods. Preprint ArXiv: physics/0512234.

Simple model of skeletal matter composed of magnetized electrically conducting thin rods [17]

We treat the problem in as simple picture as possible. Thus, we assume the elementary block of the skeletons to possess the following electrodynamic properties:

- the 1D static magnetic dipole (such a dipole may be represented as a couple of magnetic monopoles located on the tips of the rigid-body dipole; this approximation seems to be good for the tubules and/or rod with the large length-to-diameter ratio),
- static positive electric charge, which is located in the center of the rod and is screened by the ambient electrons at some Debye-like radius (electric charging is due to inevitable field emission, at least thermal one, by the nanotubes),
- static electrical conductivity, which is high enough to enable the tubular skeleton to trap, without dissipation, the magnetic flux inside the tubule (i.e. sustain circular electric currents in the tubule's wall).

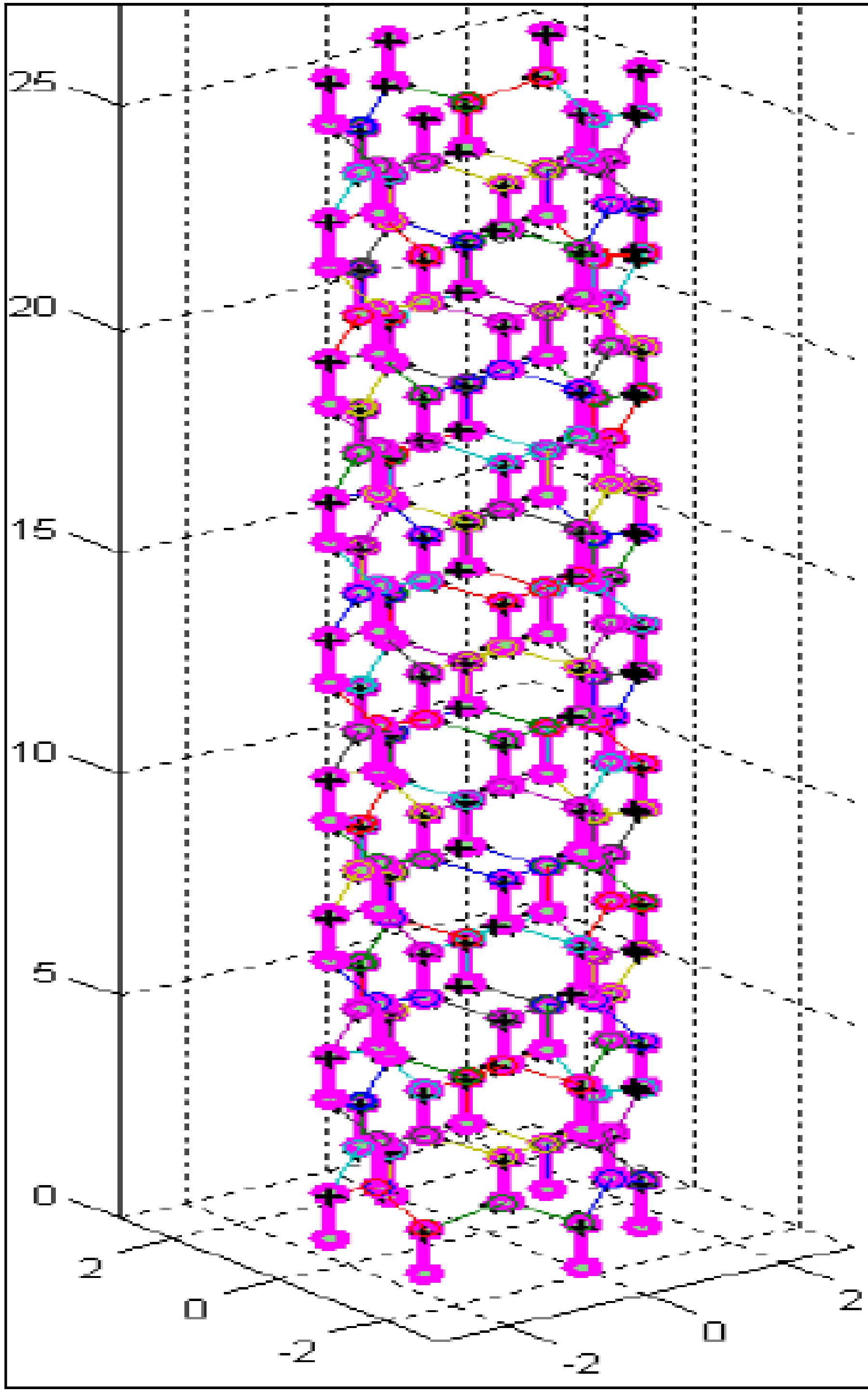
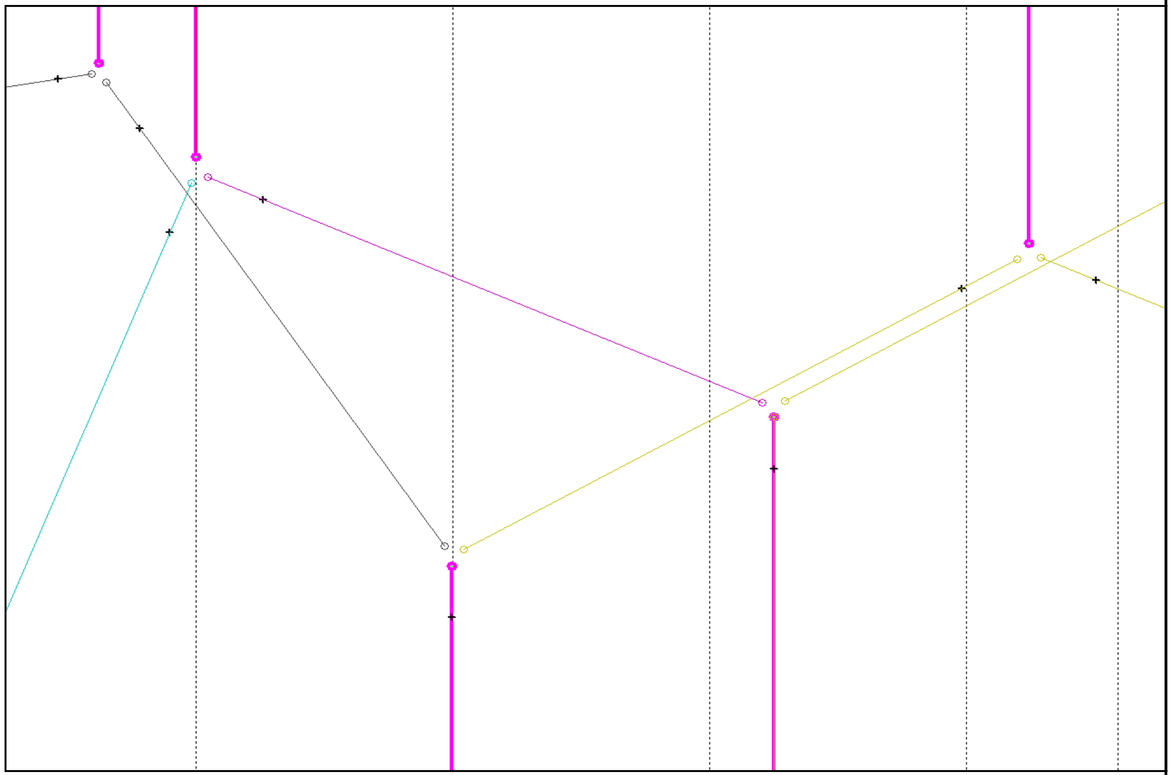


Figure 2.

Tubular skeletal structure composed of 294 magnetic dipoles.

Magnetic charge of the dipoles shown as red thick rods is twice of that for thin rods.



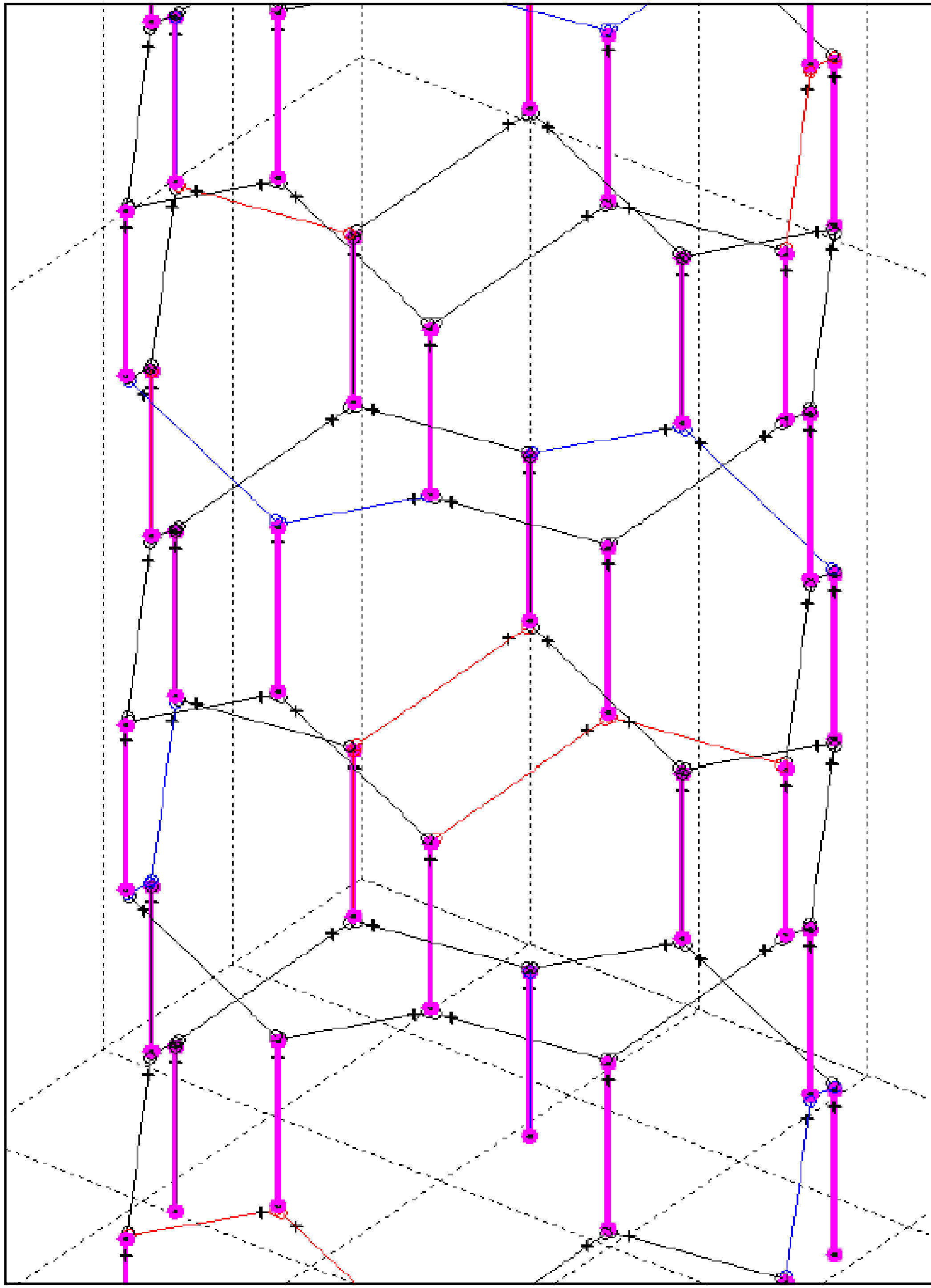


Figure 3. Magnified image of the part of tubular skeleton in Fig. 2. The crosses on the dipoles indicate north pole part of the dipole.

Magnetic charges Z_M=2 (red thick blocks)

Z_M=1, for all other blocks ,

Electric charges Z=1 for all blocks,

Screening (Debye) radius r_D=1,

Brake coefficient $k_{br}=100$,

Current-current force $F_{0JJ}=2$,

Current-external-current force $F_{Jext}=50$

External electric current flows along X-direction, the line of current is located in the point {Y=-15, Z=15} and acts from time t=0 to t=1.

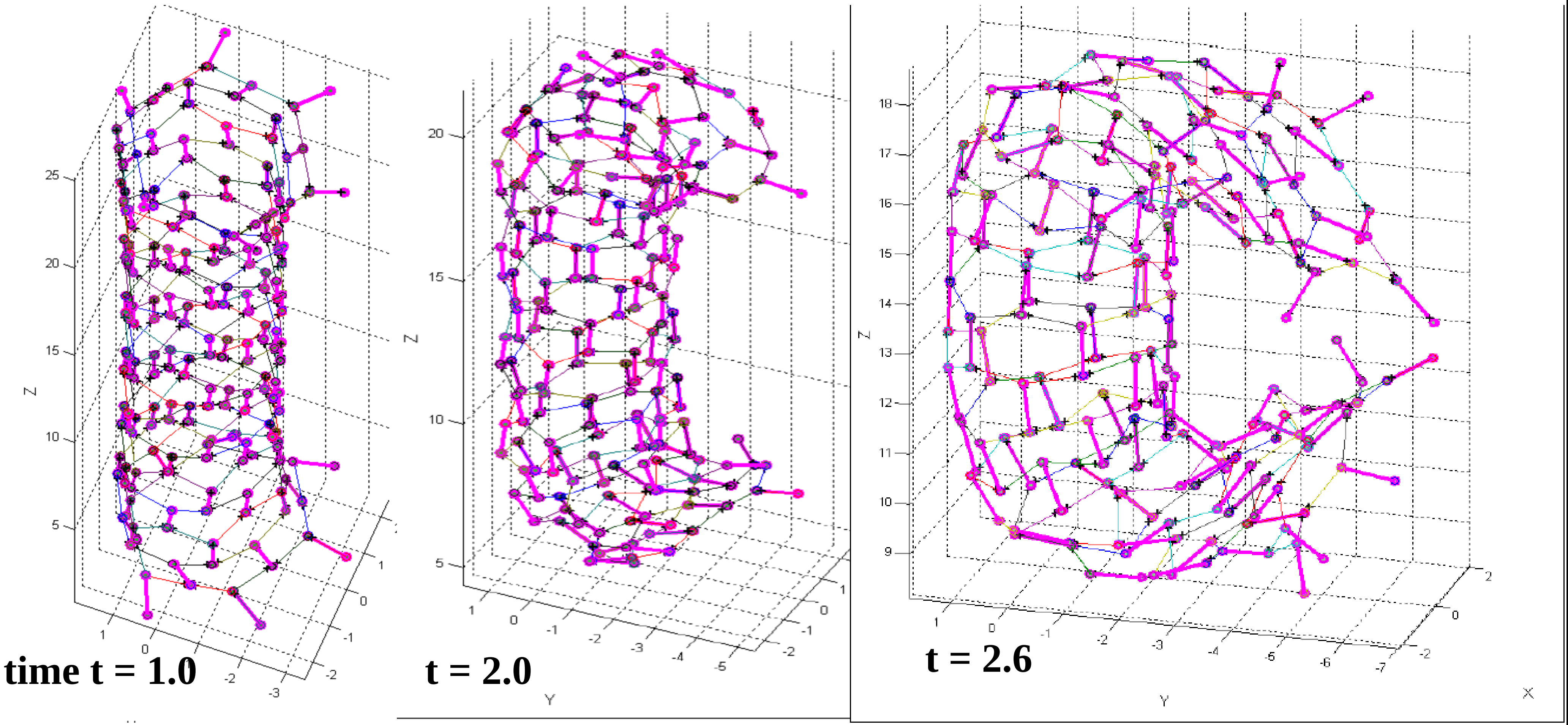


Figure 4. Evolution of the originally straight skeleton of Fig. 2 under the action of external bending force (namely, distant external electric current in X direction).

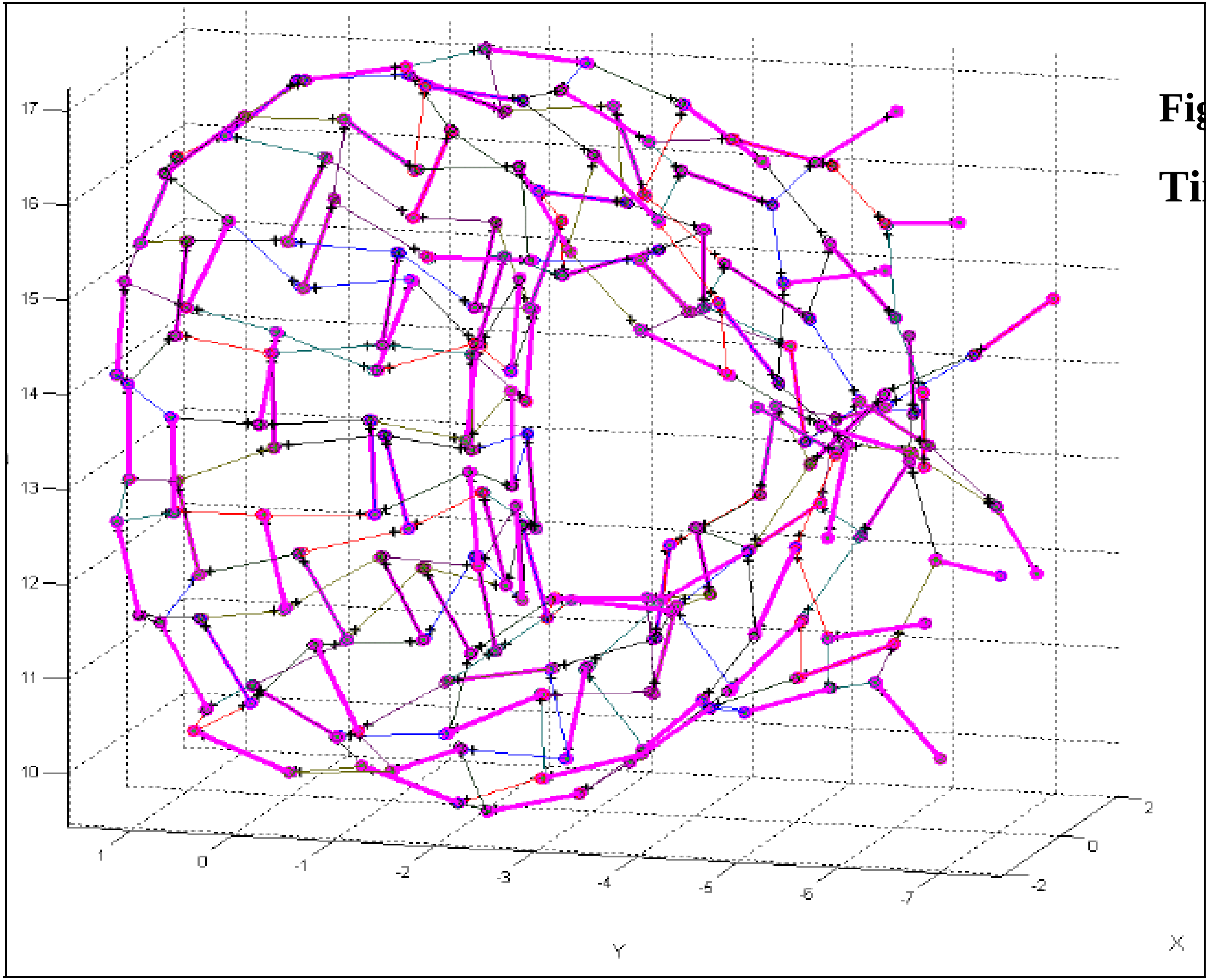


Figure 5.

Time t = 2.8

Laser-induced production of large carbon-based toroids

M. Elizabeth Lyn, Jibao He, Brent Koplitz*

Applied Surface Science 246 (2005) 44–47

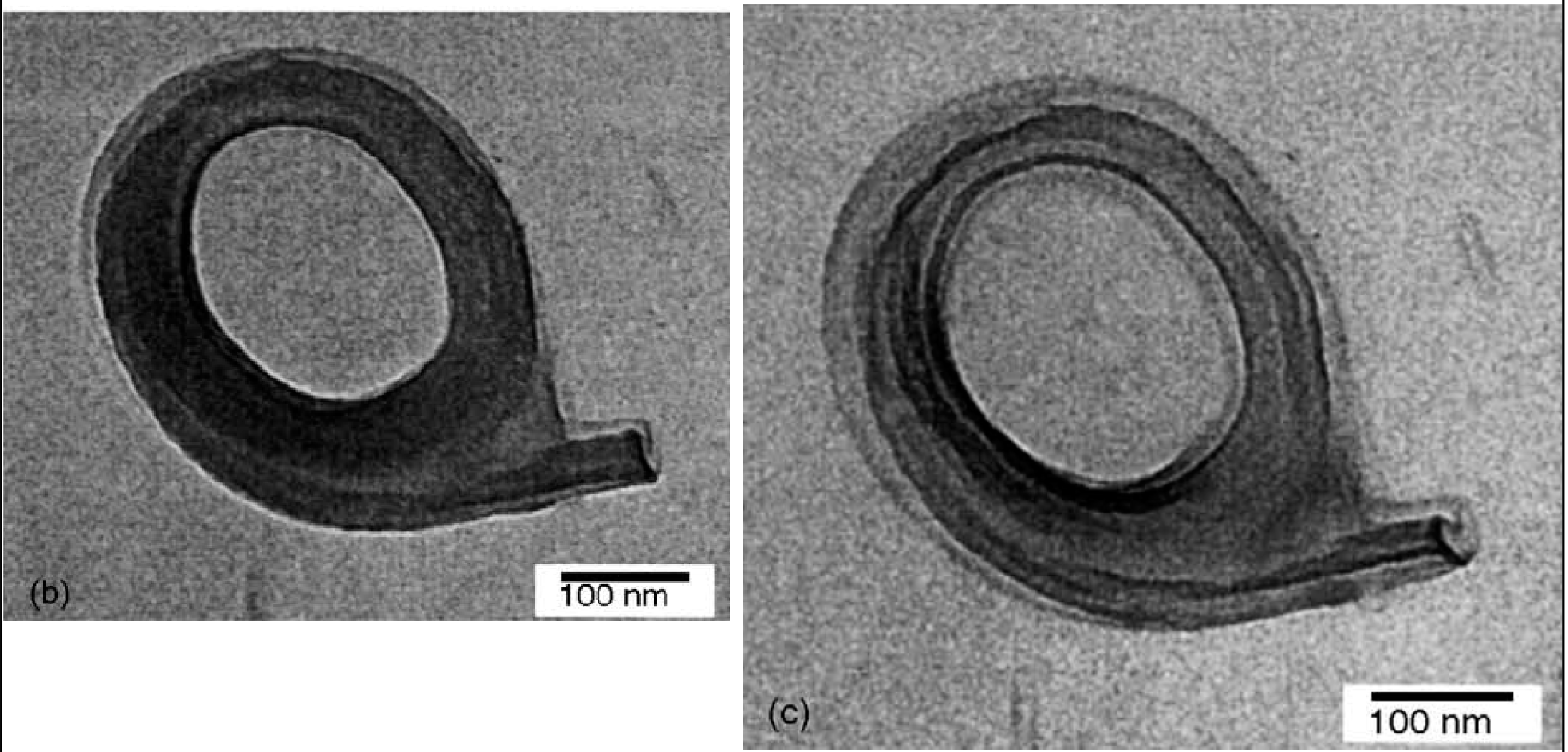


Fig. 3. TEM images of a Q-shaped CBT after (a) 30 s, (b) 330 s, and (c) 630 s of irradiation with 80 kV electron beam.

The results [17] may be interpreted as an illustration of the possibility of such skeletons -- if formed in the high-current electric discharges or under similar conditions - to form the torodal-like and cartwheel-like structures
(cf. laser-induced production of large carbon-based toroids reported in [18], see the Q-shaped toroids in Fig. 3 of this paper).

[18] M.E. Lyn, J. He, B. Koplitz. Laser-induced production of large carbon-based toroids. Appl. Surf. Sci. **246**, 44–47 (2005).

Acknowledgments. The present research is supported by the Russian Foundation for Basic Research (project # 05-08-65507).