Probable Astrophysical and Cosmological Implications of Observed Self-Similarity of Skeletal Structures in the Range 10^{-5} cm - 10^{23} cm

Alexander B. Kukushkin and Valentin A. Rantsev-Kartinov

Russian Research Center «Kurchatov Institute», Moscow, 123182, Russia

Abstract. We briefly discuss the probable role of a fractal condensed matter which has been suggested to be the responsible for self-similar skeletal structures observed in a very wide range of length scales in laboratory electric discharges and cosmic space. The presence of skeletons self-assembled from nanodust and embedded in, and to some extent hidden by, the ambient plasma was suggested to provide observed unexpected longevity of some filaments in laboratory plasmas. The hypothesis for the presence of similar internal skeleton in cosmic filaments allows, to our mind, to strengthen and substantially extend the H. Alfvén's approach to underestimated role of electrodynamics, including that of plasmas, in the Universe.

INTRODUCTION

The verification of the hypothesis [1(A)] via extending the range of the phenomenon, formerly revealed in the laboratory data (see a survey of them in [1(B)]), to larger and much larger length scales, including the powerful electromagnetic phenomena in the Earth atmosphere and cosmic space, revealed the phenomenon of skeletal structuring to be present in a very wide range of length scales, 10^{-5} cm - 10^{23} cm [1(C)]. The hypothesis [1(A)] suggested the long-lived filaments in plasmas of laboratory electric discharges to possess a skeleton which might be self-assembled during electric breakdown, prior to appearance of main plasma, from wildly produced carbon nanotubes or similar nanostructures of other chemical elements. The proof-of-concept studies showed the presence of skeletal structures of certain distinctive topology (namely, tubular and cartwheel-like structures, and their simple combinations) in

(i) the high-resolution (visible light and x-ray) images of plasma in tokamaks, Z-pinches, plasma focus, and laser-produced plasma (in the range 100 μm - 10 cm), including the images taken at electric breakdown stage of discharge in tokamak, plasma focus and vacuum spark [1(B)],

(ii) various types of dust deposits in tokamak T-10 (10 nm - 10 μm) [2(A)],

(iii) hailstones (1-10 cm), tornado (10^3-10^5 cm), and various objects in space (10^{11}-10^{23} cm), including the solar coronal mass ejection, supernova remnants, and some galaxies [1(C)].

The topological identity (i.e. the similarity) of the above structures (especially, of the cartwheel as a structure of essentially non-hydrodynamic nature), and the observed trend toward assembling of bigger structures from similar smaller ones (i.e. the self-similarity),

in the range 10^{-5}-10^{23} cm suggest all these skeletal structures, similarly to skeletons in the particles of dust and hail, to possess a fractal condensed matter of particular topology of the fractal [1(C)]. Specifically, this matter may be self-assembled from nanotubular blocks in a way similar to that in the skeletons found in the submicron dust particles [2(B)].

Note that recent findings in the physics of carbon nanotubes gave some support to suggested probable microscopic picture of skeleton's assembling and chemical composition, as well as to probable mechanisms for the macroskeletons assembled from carbon nanotubes to survive (i.e., possess an anomalous longevity) in hot plasmas (for more detail see [1(C)] and references therein).

Here we briefly discuss some probable implications of the phenomenon of skeletal structuring for astrophysics and cosmology, with a stress on the probable underestimated role of electrodynamics, including that of plasmas, in the Universe.

EXTENDING THE ROLE OF ELECTRODYNAMICS IN THE UNIVERSE

The presence of skeletons self-assembled from nanodust and embedded in, and to some extent hidden by, the ambient plasma was suggested [1(A)] to provide observed unexpected longevity of some filaments in laboratory plasmas. The hypothesis [1(A)] for the presence of similar internal skeleton in cosmic filaments as well allows, to our mind, to shed a new light on the H. Alfvén's approach [3] to underestimated role of electrodynamics, namely that of plasmas, in the Universe. The conjecture [3] implies that the long-living filaments of electric current («plasma cables») may form electric circuits at length scales of cosmic systems, in particular, of the Solar system. The hypothesis [3] was supported, at a rough qualitative level [1(D)], by the similarity of networking of filaments (of luminosity) in laboratory plasmas and space. The resolution of fine structure of filaments and their networks in space, Earth's atmosphere and laboratory electric discharges, as achieved, in particular, thanks to recent substantial progress in the imaging of cosmic objects by the space telescopes, enabled us [1(C)] to indicate phenomena which suggest the possibility to strengthen and substantially extend the approach [3].

Besides the distinctive topology of general layout of bright spots within skeletal structures (first of all, in the cartwheels as shown in Figures 1-4 in [1(C)]), another evidence for the phenomenon of skeletons comes from the resolution of fine structure of luminosity around, at first glance, solitary bright spots. The best relevant evidence seems to be an electric torch-like structure which looks like the shining edge of a truncated straight filament which belongs to a skeletal network. Such a structuring, and its similarity at different length scales, suggests that the skeletons may work as a guiding system for (and/or a conductor of) electromagnetic signals. Indeed, local disruption of an electric circuit (e.g., its sparkling, fractures, etc.) and the presence of the open end (in particular when the circuit has a dendritic structure) may self-illuminate the circuit to make it observable. The self-illumination of skeletal structures in their critical points was found [1(C)] in various laboratory electric discharges, severe weather phenomena and cosmic space, that cover the range 10^{-2}-10^{22} cm. The smallest objects of such a type appear to be the «hot spots» in the high-current electric discharges (namely, Z-pinches and plasma foci) while the biggest ones are as large as the entire galaxy. The phenomenon of electric torch-like structures is

illustrated with typical examples in the laboratory, Figure 1, and cosmic space, Figure 2 (see more examples in Figures 5-7 in [1(C)]).

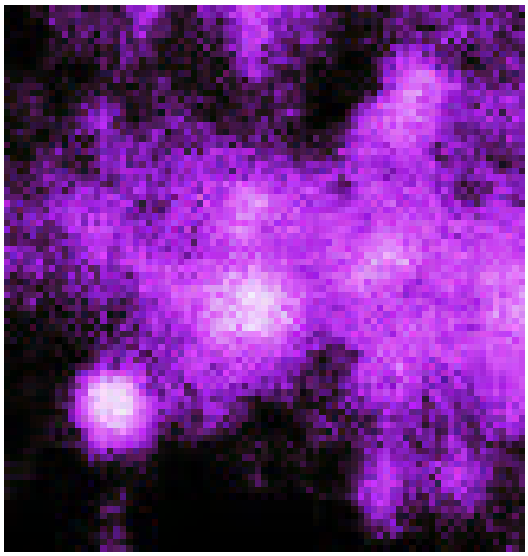

FIGURE 1. A fragment (6 cm wide) of the image taken at quasi-stationary stage of discharge in tokamak T-6 (minor radius of toroidal plasma column ~ 70 cm, toroidal direction is horizontal) with the help of electronic optical converter with time exposure ~ 1 μs (original data by V.A. Krupin). Diameter of bright spot seen in the left lower corner, on the edge of a straight filament, is ~ 1 cm.

At extra-galactic length scales, the self-illumination of the skeletal network in its certain, critical points continues working but the dramatic decrease, with increasing length scales, of the average density of *hot, radiating* baryonic matter leads to observability of exclusively dim dotted imprints of skeletons, like e.g. mysterious dotted images of arcs, circles, and ellipses. It appears that at largest observable lengths the more or less definite examples of distinctive skeletal topology may be found only in the redshift surveys of *thin* slices of space (the redshift surveys are believed to provide a three dimensional distribution of galaxies, which may give, in particular, the side-on view on a thin conical slice of space). Despite the structuring revealed at cosmological lengths (see Fig. 3 in [1(E)]) is obviously much less reliable than that at galactic and smaller lengths, the correlation revealed makes it reasonable to suggest an extrapolation of our hypothesis farther to cosmological scales.

The probable major implications of the observed skeletal structuring for astrophysics and cosmology are as follows.

(1) Certain mechanical strength (rigidity) of skeletal structures at galactic and extra-galactic length scales suggests the possibility to avoid the necessity to introduce a «dark matter». Indeed, the well-known controversy between «apparent masses» and their gravitational dynamics may be resolved because the bright spots, which belong to skeletons, may move faster than predicted by their masses estimated from their luminosity. Also, the skeleton may involve the ambient gas/plasma in a faster motion. The proposed reinterpretation is applicable to both historic sources of introducing a dark matter, namely to the periphery of rotating galaxies and especially to the clusters of galaxies because the effect of rigidity is stronger just at larger lengths.

(2) A combination of observational facts, including (i) skeletal structuring in the range 10^{-5} cm - 10^{23} cm [1(C)], and (ii) the signs of skeletal structuring in the range 10^{24}-10^{26} cm [1(E)], hints at the presence of a *baryonic cold skeleton* of the Universe. At cosmological scale the temperature of the overwhelming part of such a skeleton, i.e. excluding its critical, burning points, should be equal to that of cosmic microwave background radiation (CMBR). A qualitative analysis of probable radiative and mechanical properties of skeletons suggest them to have no unavoidable conflicts with the ultrahigh isotropy of CMBR and the high uniformity of Hubble's expansion of the Universe. Generally speaking,

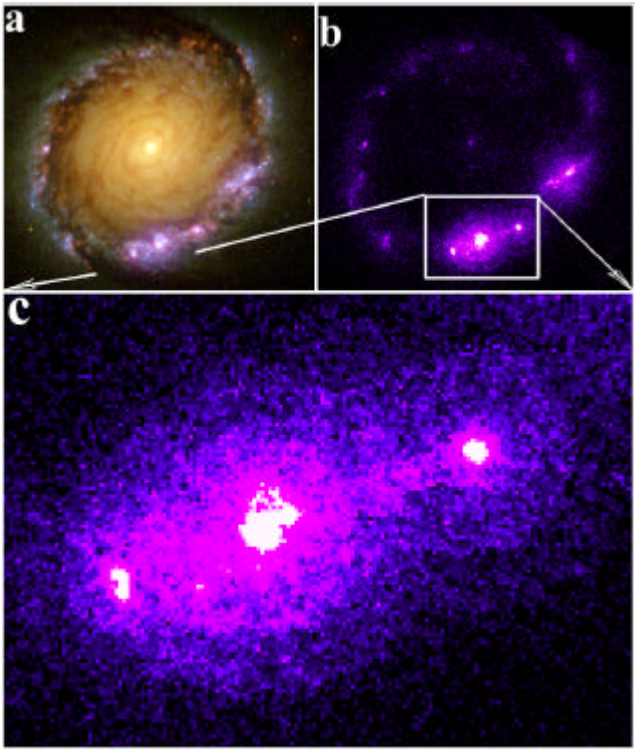

FIGURE 2. The electric torch-like structure in the 2,400 light-year-wide core of the spiral galaxy NGC 1512, which is 30 million light-years away and 70,000 light-years across. (a) Color-composite image of the core, (b) similar image in the 2200 Å light, (c) contrasted image of a part of the image «b» (diameter of straight filament with a bright spot on its edge, seen in the upper right, is ~ 60 light-years). (NASA Hubble Space Telescope, http://hubblesite.org/newscenter/archive/2001/16).

purely gravitational description of large-scale structure of the Universe is likely to be appended with a contribution of quantum electrodynamics because the latter is needed to describe the fractal condensed-matter skeletons.

Besides giving an alternative to «dark matter» approaches, an addition of hypothesis for such skeletons to conventional description of plasma phenomena in the laboratory and in the Universe extends the role of electrodynamics throughout the respective, very wide range of length scales. Practically, phenomenon of skeletons suggests a direct possibility to simulate various cosmic phenomena in the laboratory, including the phenomena with substantial contribution of plasmas.

The partial financial support from the Russian Federation Ministry for Atomic Energy and the Russian Foundation for Basic Research is acknowledged.

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