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Evidences for Skeletal Structures in Tornado and Probable Role of Nanodusty Plasma in Severe Weather Phenomena

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1. Introduction. Evidences for the similarity of skeletal structures of certain topology (tubule and, especially, cartwheel, as a structure of non-hydrodynamic origin) and for the trend toward fractality/self-similarity (i.e. toward assembling a structure from similar ones of smaller size) in a very broad range of length scales [1(A)], including the severe weather phenomena (primarily, tornado), enable us to extend to this and other severe weather phenomena our former hypothesis [1(B)] for the probable role of nanodust (first of all, carbon nanotubes) in formation and longevity of filamentary structures observed [1(C,D)] in plasmas of laboratory electric discharges. Here we summarize the results of analyzing the existing databases on visual observations of tornado (video and high-resolution photos) - in extension of [1(A)] where the first evidences for skeletal structuring in tornado were reported, and suggest a hypothesis for the contribution of nanotubular dust to initiation of tornadoes, due to ability of the hypothetical skeleton inside the thundercloud to provide fast long-range transport of electricity.

2. Skeletal structures in tornadoes: phenomenology. Major features of skeletal structures found with the help of the method of multilevel dynamical contrasting of the images [1(E)] in the available databases of tornado's images, are as follows ([1(F)]).

2.1. Skeletal structures (tubules, cartwheels, and their simple combinations) are present in the main body of tornado and its close vicinity. These structures are similar to those formerly found in a wide range of length scales, including the dust deposits in high-current electric discharges [2] and the hailstones [1(A)].

2.2. General layout of skeletal structures in the main body of tornado is similar to that in a straight Z-pinch. First, the cartwheels on the axle-tree outside the main body of tornado are directed transversely to the main body – similarly to cartwheels seen at the periphery of hot plasma column of the Z-pinch (cf. Fig. 1(c) in [1(F)] and the images of a gaseous Z-pinch in [1(B,C,D)]). Second, the main body of tornado possesses large tubular structures which are also directed transversely to the funnel (Figs. 2(b), 3 in [1(F)]). Similar structuring appears in the funnel arising from the ground (Fig. 4 in [1(F)]).

2.3. The resolvability of skeletal structures in the photos taken with large enough exposure suggests that these structures are moving slowly as compared to motion of gaseous component -- and therefore are, to a large extent, decoupled from the motion of this component.

2.4. Transient region between tornadic thundercloud and the funnel appears to possess distinct skeletal structures with a complicated junction of blocks (Figs. 2(c,d) in [1(F)]).

2.5. Tornado's main body may exhibit dendritic structuring [1(A)] (Fig. 5(a) in [1(F)]).

2.6. An electric torch-like structuring (the shining butt-end of truncated straight filament) of tornado's funnel (Fig. 5(a) in [1(F)]) is similar to that found in a very broad range of length scales [1(A)].

2.7. Low-precipitation supercell may produce an intense hailstorm with large enough hailstones (Fig. 6 in [1(F)]).

2.8. It appeared difficult to identify the trend toward self-similarity in the available images of tornadoes. However, this trend is quite distinct in the hailstones (Figs. 7(a,b,c) in [1(F)]).

2.9. Sometimes hailstorms exhibit the signs of a regular structuring and presumably take place at a low enough speed of falling dawn that allows the hailstones to survive in their collision with the ground.

2.10. The existence of areas of highest tornado activity (first of all, Tornado Alley in Kansas, USA) may be associated with the delivery of nanodust material from volcanoes in Africa, according to identified statistics of atmospheric transport (Fig. 8 in [1(F)]).

3. A hypothesis for the role of nanodust in the origin of tornado. The current status of treating the tornado's mystery may be illustrated with the recent findings [3] from the project VORTEX (Verification of the Origins of Rotation in Tornadoes Experiment): "VORTEX has produced a number of troubling new findings. For example, it appears that perhaps *many fewer* supercells and mesocyclones produce tornadoes than scientists originally believed… Further, we have learned that the *difference between tornadic and non-tornadic mesocyclones can be very, very subtle*…" The conclusions [3] well justify a search for the contribution of an unrecognized mechanism to initiation of tornadoes. Below we formulate a hypothesis for the possible contribution of nanodust (or generally speaking, of a fractal condensed-matter component) to the origin of tornadoes.

3.1. Tornadic thundercloud may possess an internal skeleton which is hidden in the water vapor, air-based dust, etc. The skeleton may be composed of the nanodust. The nanodust particles (presumably, carbon nanotubes or similar nanostructures involving other chemical elements) in the skeleton may, as it was suggested [1(B)], be magnetically coupled by the magnetic flux trapped in the nanotubular block. Such a skeleton is flexible and restructurable, being a sort of the fractal aerogel. The fractality of the skeleton is suggested by the totality of the following observations (Sec. 2): (i) similarity of skeletal structuring at different length scales (e.g., the presence of cartwheels both in tornado column and in hailstones), (ii) self-similarity in the hailstones of cartwheel-like form, (iii) correlation between low level of precipitation and high intensity of hailstorms for some supercells.

3.2. The skeleton in tornadic thundercloud may be responsible for the fast long-range transport of electricity (e.g., with respect to electric charge acquired by the skeleton during condensation of charged water drops on it) and for accumulation of large enough electric charge in certain points determined by the geometry/morphology of the skeleton (e.g., at the skeleton's edges).

This implies that actually the difference between tornadic and non-tornadic thunderclouds is determined by the transport properties (in particular, by the very presence) of an internal skeleton, namely by the ability of the skeleton to collect, transport and focus the electric (and magnetic) energy. In particular, skeleton as a condensation center may substantially speed up the conversion of the latent heat into gas/plasma motion.

3.3. The localization of large enough electric charge on/around the skeleton initiates a sort of electric breakdown between the thundercloud and the Earth. Thus, the initial phase of tornado may be treated as an electric breakdown process which is eye-visible in the real time. Presumably, most frequently the cathode is the thundercloud, the virtual anode is on the Earth surface. Thus, tornado's initiation is suggested to be an electrostatic instability caused exclusively by the presence and special, skeletal structuring of the nanodust.

3.4. Tornado's column/funnel may be interpreted as a long-lived filament of (low-magnitude) electric current which is being resulted from the process of aforementioned electric breakdown. The skeleton of this filament is being formed by the restructured blocks of the skeleton in the thundercloud during a «pullout» of the parent thundercloud's

skeleton downwards by the electric force which disturbs the balance of the forces in the stable state of thundercloud. (Here, longevity implies that the lifetime largely exceeds that of the lightning).

3.5. Rotation of tornado's column/funnel seems to be an implication of local restructuring of the skeletal component inside the thundercloud. That's why the rotation in the tornadic mesocyclone is actually not a source of tornado's initiation (cf. [3]). Therefore, the problem of tornado rotation may be decoupled from the problem of tornado's initiation and has to be treated in terms of the behavior of the ambient gaseous and aerosol components of the thundercloud in the presence of electric (and magnetic) field provided by the skeleton in the course of its restructuring.

3.6. The early diagnostics of tornado has to be aimed at identifying a skeleton inside a thundercloud and especially at those patterns of skeleton's behavior/restructuring which might be dangerous for tornado's initiation.

4. Conclusions. Tornado, because of its exceptional property of concentrating the energy density in severe weather phenomena, seems to be the best candidate for verifying both the phenomenon of skeletal structuring as itself and the hypothesis for the crucial role of a fractal condensed matter (most probably, nanotubular dust) in severe weather phenomena. The evidences for skeletal structures in tornado suggest them to be a carrier/source of major electrodynamical properties of tornado. This implies that the main body of tornado may be interpreted as a special type of atmospheric dusty plasma. The above approach suggests the probable directions of (i) modeling, in a laboratory electric discharge, the suggested electrodynamical properties of tornado, and (ii) elaborating the technique for early diagnostics of tornado and other severe weather phenomena. The respective laboratory experiments have to model the experimental conditions favorable for electric breakdown in the presence of the nanodust.

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[3] The US National Severe Storm Laboratory (NSSL) report of Summer/Fall 1998 «New findings on the origins of tornadoes from VORTEX » (http://www.oar.noaa.gov/spotlite/archive/spot_nssl.html).