NEW ASPECTS OF ATMOSPHERIC ELECTRO-SCIENCES BASED ON EHD (ELECTROHYDRODYNAMICS) AND THEIR APPLICATION TO DESTRUCTION OF TORNADIC THUNDERSTORMS

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Theory of atmospheric sciences is usually based on dynamics of neutral or charged particles, HD (hydrodynamics) for non-ionized gases, MHD (Magnetohydrodynamics) for ionized gases or kinetic theory of gases. The first particle and the second fluid approach are well established apart from polarization effects due to external charges. However, EHD (Electrohydrodynamics) is so unfamiliar to scientists that this term has hardly been used, since EHD is very immature as a system of science in contrast to maturity and prosperity of HD and MHD; when rarely used, it is not a kind of 'dynamics' but is just 'Electrostatics' in content. This paper aims to summa- rize a newly developed EHD and polarization effects as its base and to apply them to tornadic thunderstorms, particularly indicating how to destruct them. A new equation of electric transport considers effects of space charge and displacement currents, namely electromagnetic convection, radiation, and production. When electric Reyn- olds number is high enough, namely $R_E \gg 1$, the electric transport equation is reduced to the so-called Kelvin-Helmholtz equation just like fluid vortex transport for $R \gg 1$ in HD and magnetic field transport for $R_M \gg 1$ in MHD, physically implying that the frozen-in field concept holds for all of them. Polarization effects on neutral particles and fluids give rise to new equations of motion of particles and fluids, opening new electrodynamics which have not been considered as yet. For instance, the presence of an electric quadrupole generates helical motion of even uncharged particles and fluid vortices. Invasion of a dust grain into an electric cusp, whether it is charged or un-

charged, results in electric reconnection, particle acceleration and/or EHD shock generation, being followed by critical velocity ionization, discharge channel formation and a consequent main discharge. When the grain is uncharged, a discharge channel is formed towards each pole as a result of X-type reconnection. For a negatively or positively charged grain, I-type reconnection occurs between the grain and positive or negative poles, respectively. For uncharged two grains, O-type reconnection be- tween both grains could be involved in addition to X-type between each pole, while for oppositely charged two grains, Φ-type reconnection could be involved between grains in addition to I-type between each grain and a pole with opposite polarity. For tornadic thunderstorms, quadrupole-like charge configurations could be a source-ori- gin of helicity and vortex generation besides thermo-hydrodynamic origin. In addi- tion, there may occur self-organization to coalescence of fluid vortex and electric displacement field lines at least in an initial stage of return stroke (rise time of some μs), since earth's magnetic field could be ignored. This also indicates that fluid vor- tex breakdown points also tend to merge electric cusps, X-type and O-type. Then the principle of dust-related electric reconnection could be replaced by dust cluster in- jection into electric cusps (X-type and O-type) in several ways. One is uncharged dust cluster injection, causing additional discharge towards a funnel top or cloud base. Then O-type discharge could be facilitated by injection of separate two un- charged dust clusters. Alternatively, charged dust cluster injection is also feasible. For negatively or positively charged dust clusters, I-type discharge occurs towards a positively or negatively charged cloud base, respectively. Further, injection of oppo- sitely charged two separate dust clusters causes Φ-type discharge between separate dust clusters and I-type towards a cloud base with opposite polarity. Thus a variety of dust cluster injection mentioned above could cause additional cloud-to-dust cluster discharges, expending electrostatic energy accumulated in thunderclouds considera- bly and destructing tornadoes consequently.

Reference

H. Kikuchi, *Electrohydrodynamics in Dusty and Dirty Plasmas*, Kluwer Academic Publishers, Dordrecht/The Netherlands, 2001.