Toroidal plasmoid generation via extreme hydrodynamic shear

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Abstract: Saint Elmo’s fire and lightning are known forms of naturally occurring atmospheric pressure plasmas. As a technology, non-thermal plasmas are induced by artificially created electromagnetic or electrostatic fields. Here we report the observation of a unique case of a naturally formed plasma created in the air at room temperature without external electromagnetic action by impinging a high-speed microjet of deionized water on a solid dielectric surface. We demonstrate that triboelectrification from extreme and focused hydrodynamic shear is the driving mechanism for generating energetic free electrons. Air ionization results in a plasma that, unlike the general family, is topologically well-defined in the form of a coherent toroidal structure. Possibly confined through its self-induced electromagnetic field, this plasmoid is shown to emit strong luminescence and discrete frequency radio waves.

Bio: Professor Morteza (Mory) Gharib received his Ph.D. in Aeronautics (Fluid Mechanics) from the California Institute of Technology in 1983. Since graduating from Caltech, he has been a faculty member in the Department of Applied Mechanics and Engineering Sciences at the University of California, San Diego (1985-1993), and then a Professor of Aeronautics at the Graduate Aeronautical Labs at the California Institute of Technology (1993-2001). Professor Gharib is currently a Hans W. Liepmann Professor of Aeronautics and Technology, the Chair/Director of the Graduate Aerospace Department/Laboratories, and the Booth-Kresa Leadership Chair for the Center for Autonomous Systems and Technologies. His main research interests cover a range of topics in fluid dynamics and aeronautics. These include vortex dynamics, active and passive flow control, autonomous flight, underwater systems and robotics, as well as advanced flow-imaging diagnostics. His biomechanics and medical engineering research activities can be categorized into two main areas: the fluid dynamics of physiological machines (such as the human circulatory system and aquatic breathing/propulsion), and the development of medical devices (such as heart valves, cardiovascular health monitoring devices, and drug delivery systems.