Seward, C., “Ball Lightning Events Explained as Self-Stable Spinning High-Density Plasma Toroids or Atmospheric Spheromaks,” IEEE Access, V2, p153-159, 5 March 2014

Spinning plasma toroids, or spinning spheromaks, are reported as forming in partial atmosphere during high-power electric arc experiments. They are a new class of spheromaks because they are observed to be stable in partial atmosphere with no confining external toroidal magnetic fields, and are observed to endure for more than 600 milliseconds. Included in this paper is a model that explains these stable plasma toroids (spheromaks); they are hollow plasma toroids with a thin outer shell of electrons and ions that all travel in parallel paths orthogonal to the toroid circumference — in effect, spiraling around the toroid. These toroids include sufficient ions to neutralize the space charge of the electrons. This model leads to the name Electron Spiral Toroid Spheromak (ESTS). The discovery of this new class of spheromaks resulted from work to explain ball lightning. A comparison is made between the experimental observations of spheromaks in partial atmosphere and reported ball lightning observations; strong similarities are reported. The ESTS is also found to have a high ion density of greater than 10^{19} ions/cm^3 without needing any external toroidal magnetic field for containment, compared, for example, to Tokamaks, with ion density limits of approximately 10^{15} ions/cm^3. This high ion density is a defining characteristic and opens the potential to be useful in applications. The ESTS is an FRC (field reversed configuration) plasma toroid.