ELECTRIC SPACE:
EVOLUTION OF THE PLASMA UNIVERSE

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Abstract. Contrary to popular and scientific opinion of just a few decades ago, space is not an 'empty' void. It is actually filled with high energy particles, magnetic fields, and highly conducting plasma. The ability of plasmas to produce electric fields, either by instabilities brought about by plasma motion or the movement of magnetic fields, has popularized the term 'Electric Space' in recognition of the electric fields systematically discovered and measured in the solar system. Today it is recognized that 99.999% of all observable matter in the universe is in the plasma state and the importance of electromagnetic forces on cosmic plasma cannot be overstated; even in neutral hydrogen regions ($\sim 10^{-4}$ parts ionized), the electromagnetic force to gravitational force ratio is $10^7$.

An early prediction about the morphology of the universe is that it be filamentary (Alfvén, 1950). Plasmas in electric space are energetic (because of electric fields) and they are generally inhomogeneous with constituent parts in motion. Plasmas in relative motion are coupled by the currents they drive in each other and nonequilibrium plasma often consists of current-conducting filaments. This paper explores the dynamical and radiative consequences of the evolution of galactic-dimensioned filaments in electric space.

1. Introduction

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Among the earliest predictions about the morphology of the universe is that it be filamentary (Alfvén, 1950, 1981, 1990). Plasmas in electric space are energetic (because of electric fields) and they are generally inhomogeneous with constituent parts in motion. Plasmas in relative motion are coupled by the currents they drive in each other and nonequilibrium plasma often consists of current-conducting filaments. This paper explores the dynamical and radiative consequences of the evolution of galactic-dimensioned filaments in electric space.

In the laboratory and in the Solar System, filamentary and cellular morphology is a well-known property of plasma. As the properties of the plasma state of matter is believed not to change beyond the range of our space probes, plasma at astrophysical dimensions must also be filamentary.

Additionally, transition regions have been observed that delineate the ‘cells’ of differing plasma types (Eastman, 1990). On an astrophysical scale, these transition regions should be observable at radio wavelengths via transition radiation signatures.

The suggestion that the universe be filamentary and cellular was generally disregarded until the 1980s, when a series of unexpected observations showed filamentary structure on the Galactic, intergalactic, and supergalactic scale. By this time, the analytical intractibility of complex filamentary geometries, intense self-fields, nonlinearities, and explicit time dependence had fostered the development of fully three-dimensional, fully electromagnetic, particle-in-cell simulations of plasmas having the dimensions of galaxies or systems of galaxies. It had been realized that the importance of applying electromagnetism and plasma physics to the problem of radiogalaxy and galaxy formation derived from the fact that the universe is largely a plasma universe.

Any imbalance in the constitutive properties of a plasma can set it in motion [if, in fact, it has not already derived from an evolving, motional state (Bohm, 1979)]. The moving plasma, i.e., charged particle flows, are currents that produce self magnetic fields, however weak. The motion of any other plasma across weak magnetic fields produces and amplifies electromagnetic forces, the energy of which can be transported over large distances via