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Electromagnetism and the SSCP: Part I. Charged Particles, Electrostatic Fields and the Electromagnetic Field

> "The next great awakening of the human intellect may well produce a method of understanding the qualitative content of the equations."
>
> Richard Feynman

1. Introduction

The development of the SSCP from 1976 to 2006 has emphasized gravitational (G) interactions somewhat more than electromagnetic (EM) interactions for two primary reasons. Firstly, it has been my particular bias that gravitation is more foundational (e.g., the principle of equivalence, impervious to shielding, relates mass/energy to spacetime geometry, etc.) than electromagnetism. I hastily add that EM plays a very fundamental role in the balance of attractive and repulsive "forces" that defines stable objects on all Scales. It is also the source of light and other forms of EM radiation, governs almost all technology, and is the interaction that primarily determines the specific properties of multiparticle and "condensed matter" systems. Secondly, the physics of EM phenomena are usually presented in an abstract mathematical form, and so it has taken a long time for a non-mathematically-inclined natural philosopher like the present author to uncover what the symbols and relationships might actually *mean* in terms of specific physical objects and their motions.

Maxwell's equations of EM are among the crown jewels of mathematical physics. In one small set of reasonably straightforward equations we have an excellent mathematical model that can potentially explain a truly vast array of EM phenomena. If corrections to these equations are needed in the future, it seems likely that the *mathematical* corrections will be subtle refinements to the basic equations. On the other hand, there is a surprising amount of *conceptual* phenomenology involved in Maxwell's equations. This was fully acknowledged by Maxwell and he made major efforts, with little apparent success, to explain the underlying physical basis of the equations. What exactly *is* charge? What exactly *is* the electromagnetic field? Maxwell's equations describe *mathematically* how the phenomena of "charges", "electric fields" and "magnetic fields" will behave, but they do not provide an adequate physical and conceptual basis for understanding the mathematical formalism of the equations. It is in the struggle to develop this deeper conceptual understanding of Maxwell's equations that the SSCP might prove useful.

The present notes on the role of EM phenomena in the context of the SSCP are a first attempt at exploring the question of whether the discrete fractal paradigm can lead to a more intuitive, pictorial and fundamental understanding of EM, i.e., a natural philosophy of EM. Initially our goals are to provide physical concepts and definitions for the *words*: charge, electrostatic field and electromagnetic field. Given my limitations in mathematics and the more abstract aspects of physics, I can only offer initial and tentative thoughts on how the SSCP might change our understanding of EM. Translating these vague concepts into a formal and self-consistent mathematical framework will remain the challenge and goal for some future "Maxwell". It is hoped that successive technical notes on EM will improve upon the scope and accuracy of the ideas presented here, and offer that future "Maxwell" a guiding conceptual framework, as Faraday did for James Clerk Maxwell.

2. What Is A Charged Particle?

We know that protons, electrons and ions are archetypal examples of charged particles and that charge is an *invariant property*, which is the same for all observers. Charge, like mass/energy, is strictly *conserved*. We also know that the SSCP claims that there are self-similar analogues of protons, electrons and ions on all Scales. In the most general terms, the SSCP proposes that elementary charged particles on each Scale are *ultracompact* objects. For example, a Kerr-Newman black hole solution of General Relativity gives us a good first approximation model for both an Atomic Scale proton and its Stellar Scale analogue (see paper # 11 in "Selected Papers"). The SSCP proposes that there is an infinite hierarchy of these ultracompact, elementary charged particles, and that these proton/electron analogues dominate the physics of each discrete cosmological Scale comprising nature.

TABLE 1

COMPARISON OF CHARGED ANALOGUES ON 3 DIFFERENT SCALES

Self-Similar Analogues	**Mass** (grams)	**Spin** (erg sec)	**Charge** (Coulombs)
Stellar Scale p^+ ($\Psi_x = 0$)	2.84×10^{32}	4.7×10^{46}	1.5×10^{18}
Atomic Scale p^+ ($\Psi_{x-1} = -1$)	1.67×10^{-24}	5.3×10^{-27}	1.6×10^{-19}
Subquantum Scale p^+ ($\Psi_{x-2} = -2$)	9.8×10^{-81}	6.0×10^{-102}	1.7×10^{-56}

Based on the behavior of astrophysical objects that we can observe (stars, pulsars, quasars, microquasars, gamma ray bursts, AGN, radio galaxies, young stellar objects, planetary nebulae, novae, supernovae, etc.), the SSCP proposes that a charged particle on Scale Ψ_x is an object that emits a high-velocity plasma wind of self-similar charged particles of Scale Ψ_{x-1}. Because nature is organized into a discrete self-similar hierarchy, a Ψ_x charge emits Ψ_{x-1} charges, which in turn emit Ψ_{x-2} charges, and so on. This is a "recursive" or "continued" (in loose analogy to continued fractions) definition of charge in that we never get down to a point where "charge" is defined in terms of something other than lower Scale "charges". At some point in the future it might be possible to redefine "charge" in even more fundamental terms, such as the physical effects of the rotating ultracompact masses on the geometry of 4-dimensional spacetime, as was attempted by Elie Cartan in his efforts to unify GR and EM by including spin-related "torsion". For the present we must make do with the recursive (or continued) definition of a "charged particle", but at least we are now talking about physical objects and their motions.

Compared to Ψ_x charges, the Ψ_{x-1} charges are smaller by a factor of 5.2×10^{17} in size and less massive by the enormous factor of 1.7×10^{56}, i.e., they are virtually infinetessimal in relative comparison. A fundamental "particle" on Scale Ψ_x is envisioned as having nearly all of its mass (all but $\sim 5.1 \times 10^{-20}$ M_{total}) in a central singularity. Surrounding the central singularity is a relatively low-density envelope composed of lower Scale systems, primarily Ψ_{x-1} ultracompacts. The radius of the envelope is on the order of the system's Scale-appropriate Schwarschild radius. In the case of a *charged* Ψ_x particle, there is a net excess of (+) or (–) Ψ_{x-1} particles on the surface of this envelope, which gives the Ψ_x particle its overall net charge. Because of the net charge on the surface of the Ψ_x particle, it will emit a spherically symmetric plasma wind of Ψ_{x-1} particles of the same charge, driven by repulsion. This wind of plasma particles must be a very high velocity phenomenon, with individual particles approaching the velocity of light as they accelerate away from the Ψ_x charge.

2.1 An Observational Example Of The Relevant EM Phenomena

Physical phenomena that are closely related to what has been described immediately above can be indirectly observed during a solar eclipse. We have learned in Papers #1 and #2 of the "Selected Papers" section that the Sun is the Stellar Scale analogue of an ionic core in a highly excited atom with its outer electron in a high Rydberg state ($n \approx 168$). Assuming the entire system is in a neutral state, the Sun would be analogous to an ionic core with a charge of +1. Therefore the Sun should display the proposed EM phenomena that we have described above -- and it does! This can be seen most clearly during a solar eclipse when the sun's disk is blocked out by the Moon and the solar corona and solar wind streaming away from the sun's surface is silhouetted against the darkness of space. A computer search on "Solar Eclipses" will turn up many photos of these spectacular events, such as:

http://sunearth.gsfc.nasa.gov/eclipse/TSE98reports/TSE98reports.html .

Streaming away from all parts of the Sun's surface is a high-velocity (100-1000 km/sec, $\langle v \rangle \sim 600$ km/sec) plasma wind of charged Atomic Scale particles, which are primarily protons. The total mass flux is roughly 10^{12} g/sec, which corresponds to about 6×10^{35} protons/sec. Astrophysicists observe that the solar wind protons accelerate with distance from the Sun, but this "solar wind acceleration remains one of the unsolved problems of solar physics." Because the Sun is a rotating *subsystem* of a multi-component system, rather than being a single, unbound "elementary" charge like the Stellar Scale proton analogue, the plasma wind tends to be somewhat enhanced in the equatorial plane and lack full spherical symmetry. The dipolar morphology of the Sun's extended magnetic field is very clearly highlighted during an eclipse by the fine linear structures of the coronal streamers, and the latter bring to mind Faraday's "lines of force" concept. We are very fortunate that solar eclipses (which are possible only because of the remarkable coincidence of the roughly equal apparent sizes of the disks of the Sun and Moon!) allow us to observe the ephemeral solar corona phenomena and its large-scale morphological properties.

In summary, the Sun appears to be a Ψ_0 analogue of the charged ionic core (net charge = +1) of a highly excited Rydberg atom. It emits an enormous number of charged Ψ_{-1} protons in a high velocity plasma wind. Jupiter, on the other hand, has an enormously extended magnetic field and is a prodigious emitter of electrons. If we could view an analogous Atomic Scale system in the same energy state with virtually unlimited resolution, then the SSCP predicts that it would be highly, or exactly, self-similar to the Solar System in all of its physical properties. The *elementary* charges on any Scale would, of course, be far more compact. Their relativistic plasma winds would be more spherically symmetric and would also have a fairly high degree of temporal uniformity.

The SSCP postulates that there are positive Ψ_x charges which emit relativistic plasma winds of positive Ψ_{x-1} charges, and the SSCP postulates that there are negative Ψ_x charges which emit relativistic plasma winds of negative Ψ_{x-1} charges. The positive Ψ_x charges would be "sources" of positive Ψ_{x-1} charges and would act as "sinks" of negative Ψ_{x-1} charges. The reverse would be true for negative Ψ_x charges. The picture that emerges has Ψ_x charges generating and removing infinitesimal Ψ_{x-1} charges to/from a universal, highly complex, relativistic plasma of infinitesimal Ψ_{x-1} charges. It is assumed that Ψ_x charges generate *equal numbers* of positive and negative Ψ_{x-1} plasma particles, that the particles distribute themselves in such a way as to minimize the overall energy state [(+) and (–) distributions tend to balance out]. However, it is also assumed that physical phenomena can lead to temporary separation of the Ψ_{x-1} charges and that resultant physical processes would then act to restore EM equilibrium. It is well-known that only modest amounts of net charge separation in a plasma can generate surprisingly large electromagnetic fields. Likewise only slight anisotropies in the motions of the plasma charges can lead to extremely strong magnetic fields.

3. What Is An Electrostatic Field?

Given an elementary Ψ_x charged particle, its spherically symmetric relativistic plasma wind of Ψ_{x-1} charged particles is emitted radially and isotropically, and constitutes the electrostatic field of the Ψ_x particle. The $1/r^2$ dependence of the strength of the electrostatic field is due to the spherical symmetry and constancy of the plasma wind. It is assumed that the Ψ_{x-1} charged particles accelerate at a rate that is inversely related to the distance from the source, until the limiting velocity of light is attained.

4. What Are Positive And Negative Charges?

A positively charged Ψ_x particle has a net excess of positively charged Ψ_{x-1} particles on the surface of its outer envelope and emits a plasma wind that is predominantly composed of positively charged Ψ_{x-1} particles. A negatively charged Ψ_x particle has a net excess of negatively charged Ψ_{x-1} particles on the surface of its outer envelope and emits a plasma wind that is predominantly composed of negatively charged Ψ_{x-1} particles.

Two Ψ_x particles with the same charge would repel each other since they both emit relativistic plasma winds of Ψ_{x-1} particles of the same charge, and these plasma winds would repel each other. Two Ψ_x particles with opposite charges would attract each other since they emit relativistic plasma winds of oppositely charged Ψ_{x-1} particles. The oppositely charged Ψ_x particles act as "sinks" for each other's Ψ_{x-1} plasma winds.

The "lines of force" concept that is familiar from classical EM can be envisioned as the streamlines of the relativistic plasma flow. Also, within the context of the EM model discussed here, the reasons for the curious similarities between the mathematical modeling of hydrodynamics and EM phenomena are now more clearly understandable.

Important questions concerning: (1) the detailed structure of the envelopes of the Ψ_x particles, (2) how Ψ_x charged particles generate and maintain a constant net excess of (+) and (–) Ψ_{x-1} constituents, and (3) how nature generates exactly equal charge values for both (+) and (-) unit charges, remain to be answered in future work.

5. What Is An Electromagnetic Field?

The origin of the Atomic Scale EM field will be described below because we are already familiar with much of its phenomenology. However, what is said for the Atomic Scale applies equally to all discrete Scales of nature's infinite hierarchy. Magnetic fields are produced by the motion of charges and electric fields. It would appear, therefore, that charged particles and the electric fields they produce are the fundamental components and ultimate origin of all EM phenomena. Protons are approximated as Ψ_{-1} Kerr-Newman black holes that emit huge numbers of relativistic positively-charged Ψ_{-2} proton analogues. Electrons are envisioned as Ψ_{-1} ultracompact objects that emit huge numbers of relativistic negatively-charged Ψ_{-2} electron analogues.

The Atomic Scale electromagnetic field is envisioned as the combined relativistic ($v \approx c$) plasma of Ψ_{-2} charged particles emitted by all Atomic Scale charged particles (mostly protons and electrons) in the Universe. It is hypothesized that the EM fields of each Scale, Ψ_x, are comprised of equal numbers of positive and negative Ψ_{x-1} particles. Given the attraction of opposite charges and the repulsion of like charges, one would expect the EM field to tend towards a roughly balanced and even distribution of plasma particles. However, being comprised of both positive and negative charges, the Ψ_{-2} plasma is polarizable and susceptible to charge separations. Large net charge imbalances and electric or magnetic fields are possible if enough energy is expended to achieve the required charge separation and/or motion. The high-velocity ($v \approx c$) of the Ψ_{-2} plasma particles and the polarizability of the plasma would seem to be the right properties for a medium that could generate and carry EM radiation without violating any requirements of Special Relativity. Also, the SSCP model for EM fields gives a clear physical explanation for how EM fields can involve significant amounts of momentum transfer. The Ψ_{-2} plasma would constitute an "aether" of sorts, but one whose properties are quite different from the 19th century "aether" and one whose physical properties can explain EM phenomena without violating the well-documented fundamental laws of nature.

A curious scaling property of the EM field, which will only be noted here, is that the major EM field constants such as c, Coulomb's constant, ε_0 and μ_0 are all *Scale invariant*, where Scale refers to cosmological Scale.

6. An Order Of Magnitude Test For SSCP Charge Scaling

Several authors (for example Ray, et.al., *Physical Review D*, vol. **68**, 084004, 2003) have pointed out that General Relativity implies that there is a maximum charge for a stellar-mass object:

$$Q_{max,\Psi=0} \approx [G]^{1/2} M \approx 2.5 \times 10^{20} \text{ Coulombs.}$$

We can test the proposed charge scaling of the SSCP, at least to an order of magnitude, by seeing if that charge scaling gives the correct order of magnitude for the maximum charge typically found for an Atomic Scale nucleus.

Given that $Q_\Psi = \Lambda^{2.087} Q_{\Psi\text{-}1}$, as discussed in a previous Technical Note [Oct 2006], we can retrodict that:

$$Q_{max,\Psi=-1} \approx Q_{max,\Psi=0} / \Lambda^{2.087} \approx 2.5 \times 10^{20} \text{ C} / 9.40 \times 10^{36} \approx \mathbf{2.67 \times 10^{-17} \text{ Coulombs}}.$$

We know that the proton has a unit charge of 1.6×10^{-19} C. The most massive and highly charged naturally occurring Atomic Scale nucleus (fully ionized) has a charge of about 100 times the unit charge.

Therefore: $Q_{max,\Psi = -1} \approx (100)(1.6 \times 10^{-19}\text{ C}) \approx$ **1.6×10^{-17} Coulombs**.

So we have demonstrated that the maximum charges for an Atomic Scale nucleus and a Stellar Scale ultracompact object appear to be correlated by the proposed SSCP charge scaling, at least to an order of magnitude. In fact the retrodicted and observed values differ by less than a factor of 2. Considering the assumptions and uncertainties that are unavoidable at this point, the degree of agreement is rather encouraging.

7. Conclusions

Future research on understanding EM phenomena within the context of the SSCP will hopefully include more thorough discussions of the interpretation of EM radiation in terms of wave phenomena in a relativistic, 2-component, polarizable Ψ_{x-1} plasma. In this context, it is of interest to note that scientists have demonstrated that light can transfer linear and angular momentum. Lasers can levitate small glass spheres and circularly polarized light can cause tiny objects to rotate.

Another interesting and closely related topic concerns the nature of photons. To the extent that they are actual physical entities, does our model for EM fields lend itself to a natural interpretation (e.g., solitons in the Ψ_{x-1} plasmas)? Alternatively, it may be more accurate to regard all quantization in the emission and absorption of EM radiation as being due solely to the quantized properties of the atoms and particles (i.e., no "second quantization").

Yet another topic for future discussions is a clear and well-defined physical explanation of magnetic fields, which are always generated by moving charges and are therefore apparently less fundamental than electric fields, especially as seen from the perspective of the SSCP's model for EM phenomena.

A serious and concerted effort will need to be made towards a reinterpretation of Schroedinger's Atomic Scale wavefunctions in terms of Ψ_{-2} plasma phenomena, wherein $[\psi^2]$ is the matter field of the Ψ_{-2} plasma and $[\rho\psi^2]$ is the charge density field of the Ψ_{-2} plasma. Ideas along these lines were suggested by Schroedinger, A.O. Barut, and others.

Interesting feedback properties shared by General Relativity and electromagnetism should be explored. In General Relativity, matter generates spacetime curvature, which governs the motion of matter. In EM, charges generate EM fields, which govern the motion of charges. These feedback loops would seem to be a very fundamental organizational property of nature, and deserve close scrutiny.

Finally, the rough notes presented here are merely a first small step towards a truly adequate conceptual model of EM phenomena within the context of the SSCP. We have introduced the main underlying concepts that appear to be required if the cosmos has an infinite discrete self-similar organization, and we have discussed some of the related topics, interpretations and conclusions. Clearly, much work remains to be done before a comprehensive natural philosophy of EM phenomena can be claimed. Moreover, the mathematical formulation of the proposed conceptual model for EM phenomena is still, literally, a blank slate.