On the Sun's Electric-Field

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Introduction

Most investigators who are sympathetic to the Electric Sun Model have come to agree that the Sun is a body that acts much like a resistor with a relatively high voltage across it. It also serves as the central anode in a spherical plasma discharge. The cathode (ground) in this discharge is a *virtual cathode* – a surface located at a large distance from the Sun, several times the distance of the outermost planets. The entire volume from the Sun out to the cathode contains plasma. Thus the name *solar plasmasphere* is used to describe it. The outer surface of this plasmasphere is called the *heliopause* and is probably a plasma *sheath* – either a single or double layer (DL) of electrical charge.

The action of the plasma inside the solar plasmasphere is akin to the classical electric plasma discharge seen in a *Geissler Tube*[1]. In the laboratory this is often in the form of a simple glass cylinder with an anode (high voltage electrode) at one end and a cathode (low – or reference voltage anode) at the other. The tube is filled with low-pressure gas, a voltage is applied to the electrodes, and an electric plasma discharge takes place inside the tube[2].

This discharge can be in the *dark mode*, *glow mode*, or *arc mode* depending on several variables, most notably – the value of the electric current density that exists within the main body of the plasma.

The cylindrical shape of the typical laboratory plasma discharge tube is quite different from the spherical shape of the plasma surrounding the Sun. One purpose of this paper is to investigate the analytic consequences of that spherical geometry.

Assumptions

The Sun is a body at a positive voltage. It continuously radiates (dissipates) some 4×10^{26} W which is the product of its voltage, *V*, times the current, *I*, passing through it. Like any body in space, it also can carry an electrical charge. For example the charge carried by Earth results in an electric field of as much as 100V/m at its surface.

1. The Sun is not an isolated point charge within a vacuum. It is a body that exists surrounded by a sea of plasma. So the application of classical (free-space) electrostatic analyses to the solar environment is inappropriate.
2. The solar plasma is generally quasi-neutral[3], which means that the number of free electrons and the number of positive ions within any reasonably sized volume ($1m^3$ to $1km^3$) are equal. This is not to say that quasi-neutrality is strictly adhered to in all regions within the solar plasmasphere. It clearly is not. Maxwell's equations can be used in limited and well-defined ways – especially in those regions of non-quasi-neutrality.

3. The solar plasma (as any plasma) is not an ideal, zero-resistance entity. However, plasma generally cannot support high-valued electric fields. Typically, if a high-valued voltage drop is imposed between two points in plasma, a DL will form somewhere between those points such that the greater part of the applied voltage difference will occur within it. Because of this, only low-valued electric fields can and do exist within the solar plasmasphere (along with one or more such DLs).

The Sun's E-field

To quantify the Sun's electric field, we apply Maxwell's equations to its inherently spherical geometry. One of those equations states: the divergence of the electric intensity, $D = \varepsilon E$, at any point, is equal to the charge density, ρ, at that point. The quantity ε is the permittivity[4] of the medium.

$$div\ \varepsilon E(r) = \rho(r) \tag{1}$$

or

$$\nabla \cdot \varepsilon E(r) = \rho(r) \tag{2}$$

This can also be written in integral form as

$$\oint \varepsilon E \cdot dS = Q \tag{3}$$

This means that the total electrical flux emerging perpendicularly from the surface surrounding any closed volume is equal to the net electrical charge enclosed within that volume. In other words, electric fields begin on positive charges and end on negative charges. A total charge, *Q*, within a spherical volume whose surface area is *S*, will produce an electric field external to *S*. Because the surface area of a sphere is $4\pi r^2$, we have from (3)

$$\varepsilon E 4\pi R_S^2 = Q \tag{4}$$

where R_S is the radius of the Sun's anode surface (the radius of the effective outer limit of the Sun's internal electric charge).

or

$$E = \frac{Q}{4\pi\varepsilon R_S^2} \tag{5}$$

The value given by expression 5 is the strength of the Sun's outwardly directed (assuming *Q* represents positive charge) electric field immediately above its surface. We know little or nothing about the strength of this field because we have no way of calculating or measuring the value of *Q* or *E*. In writing the above, we are implying that the electric field vector has no altitudinal (latitudinal) or azimuthal variation – it is isotropic, being a function only of *r*, the radial dimension. We recognize, however, that this is almost certainly not the case at high solar latitudes or along the polar axis external to the Sun's surface.

What is the strength of the *E*-field at some point, *r*, farther out from the surface? If the Sun's surroundings contain no net electrical charge, then we can answer, similarly as in expression 5:

$$E(r) = \frac{Q}{4\pi\varepsilon r^2} \tag{6}$$

But, *r* is now the radius of an imaginary sphere that is larger than the Sun ($r > R_S$). The idea, of course, is that this larger sphere still only contains the original amount of charge,

Q, that is on the Sun. Expression 6 tells us that as long as there is no additional net charge located outside of the Sun's surface, the strength of the electric field emanating from it decreases inversely as the square of the radial distance at which it is measured. This is the only result acceptable to those who ignore the possible existence of charge densities within the plasma that surrounds the Sun. It represents an over-simplification and, as such, yields a result that is generally invalid.

For example, suppose there is a layer (spherical shell) of charge density beginning out at some distance, r_1. One of Maxwell's equations (expressions 1 and 2) identifies the E-field that would be produced in any such case. The general expression for divergence in spherical coordinates is

$$div\overline{D} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 D_r\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}\left(D_\theta \sin\theta\right) + \frac{1}{r\sin\theta}\frac{\partial D_\varphi}{\partial\varphi} \qquad (7)$$

where $D = \varepsilon E$. Assuming an isotropic spherical geometry (in which there is no azimuthal or altitudinal variation) the last two terms on the right have zero value and so expression (7) simplifies to the ordinary differential equation:

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2 \varepsilon E(r)\right) = \rho(r) \qquad (8)$$

By referencing the structure of typical laboratory plasma discharges[5], it is well-known that the first layer above the anode surface, called the anode dark space (*ADS*), can contain either positive or negative charge. In either event, the charge density in this space is essentially a constant, ρ_{ADS}. Thus, for values of r in that region, we have

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2 \varepsilon E(r)\right) = \rho_{ADS} \qquad (9)$$

This is satisfied by

$$E(r) = \frac{\rho_{ADS}}{3\varepsilon} r \qquad (10)$$

The ***E***-field within any such layer is thus a ramp function in distance, whose slope depends on the value (and algebraic sign) of ρ_{ADS}. Within such a region of uniformly dense positive space charge, the electric field strength will increase linearly. Within a region of uniformly dense negative space charge, the electric field strength will decrease linearly. From (8) we conclude that the Sun's ***E***-field cannot be discontinuous in regions where there are only finite charge densities. This enables us to plot the strength of the Sun's electric field in such regions.

Above the anode dark space there are several different charge shells (layers). All of these are assumed to contain uniform positive, negative, or zero valued charge densities and thus expression (10) is valid there. We must remember that r is measured outwardly *from the Sun's center.* Matching beginning and end-point values of the $E(r)$ functions obtained from (8) is accomplished by adding suitable constants of integration to achieve these boundary values.

In general, equation (8) is valid for a variety of possibly non-uniform charge density distributions within the solar plasma. In this expression, $\rho(r)$ is the 'excess' charge density. If the plasma is truly quasi-neutral, then $\rho(r) = 0$. If there are more positive ions than electrons in a given region, then $\rho(r) > 0$ there. If there are more electrons than +ions, $\rho(r)$ is a negative quantity ($\rho(r) < 0$).

Let us postulate several different functions for $E(r)$ and determine the $\rho(r)$ function that will produce each of them via expression (8). See the table below.

A third column in the table lists a voltage distribution function, $V(r)$, that is consistent with the electric field function listed in the first column. By definition, the ***E***-field is the negative of the voltage gradient. In an isotropic spherical geometry this is:

$$E(r) = -\frac{\partial V(r)}{\partial r}\, r \text{ , all for } r > R_S. \qquad (11)$$

Given any $E(r)$ function, we integrate (11) to find each voltage profile:

	$E(r)$	$\rho(r)$	$V(r)$
1	0	0	k
2	E_0/r^2	0	$E_0/r \pm k$
3	E_0/r	E_0/r^2	$-E_0 \ln(r) \pm k$
4	E_0	$2E_0/r$	$E_0 r \pm k$
5	$E_0 r$	$3E_0$	$E_0 r^2/2 \pm k$

Table 1. Corresponding electric-field, charge density, and voltage as functions of radial distance.

The first row of functions is simply a special case of expression (6) where $Q = 0$ and therefore $E_0 = 0$. This is the case of an uncharged (non-electric) Sun where the value of V_0 is arbitrary (dependent on what reference datum is chosen).

The second row indicates that, if there is no external 'excess' charge density, the electric field will follow an inverse square law.

Rows #3 and #4 suggest that, if there are more positive ions than electrons in the atmosphere of the Sun, that the electric field will be stronger farther out from the Sun than in case #2. In fact, in case #4, we see that an excess charge density that tapers off inversely as the first power of distance, will produce a constant strength E-field (independent of distance). It is often the case in electrical discharges that a somewhat higher density of positive charge is found near the anode, so these cases (#3 and #4) are of more than just academic interest.

The fifth row of functions is a restatement of expression 10. Consider that the heliopause (the outer edge of the solar plasmasphere) serves as the virtual cathode for the overall discharge. We often find an excess of secondary electrons near the cathode of a plasma discharge. Any non-zero electric field must end on a shell of electrons. For a long distance inside the heliopause, as we travel outward from the Sun, the solar plasma has been quasi-neutral. The excess charge density has been essentially zero-valued. Therefore, according to the functions in row #2, the *E*-field has been varying inversely as the square of radial distance.

Suppose that the heliopause consists of a layer of electrons whose density is a constant (negative value) for some distance beyond its inner edge. This corresponds to the 5th row of functions with E_0 being a negative constant. Thus the electric field in that region would be negative and would increase rapidly in strength with increasing distance, *r*. This increasing negative *E*-field would represent an increasing *inward* force on any positively charged particles in that vicinity. The strength of the voltage drop corresponds to the observed “cathode drop” which is often the strongest such change in the entire discharge.

Implications for the Safire Experiment

It may be difficult to get accurate estimates of the ***E***-fields that are produced within a small laboratory plasma discharge such as the Safire[6] project. The results shown in Table 1 (expanded if necessary) may be useful in estimating the value of those fields from voltage vs. distance data obtained from a Langmuir probe.

Conclusions

The application of Maxwell’s equations to the correct spherical geometry of the Sun’s environment suggests a set of non-zero-valued electric-fields that EU theorists have long felt existed, but have not, until now, described quantitatively.

DES (Updated March 2013.)

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[1] Available: http://www.sparkmuseum.com/GLASS.HTM

[2] Scott, D.E. *Primer on Gas Discharges,* Available: http://electric-cosmos.org/PrimerAboutGD.pdf

[3] We avoid the unqualified word *neutral* in order not to erroneously imply *inert*. Ionization of even a fraction of the atoms in a given plasma makes it an extremely good conductor.

[4] Hannes Alfvén noted that the permittivity of plasma could be approximated as being

$$\varepsilon = \varepsilon_0 \left[1 + \left(\frac{c}{V_{MH}} \right)^2 \right]$$

where ε_0 is the permittivity of free space and V_{MH} is the velocity of a hydromagnetic wave in that plasma.

[5] Scott, D.E. *ibid*

[6] A Real World Test of the Electric Sun, Available: http://www.thunderbolts.info/wp/2013/01/30/safire-a-real-world-test-of-the-electric-sun-part-1/