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Review Article

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The Physics of the *Tresino* Phase-Transition beneath the Solar Surface

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Abstract

An earlier paper located the phase-transition of a recently-discovered composite-particle (which we have called a *tresino*) beneath the solar surface. It now appears likely that this phase-transition produces solar eruptions, especially coronal mass ejections (CMEs), the power of which has been difficult to explain with conventional physics. This paper details the important role Debye shielding plays in the phrase-transition, which produces a significant release of energy that helps explain the nature of CMEs and other aberrant behavior on or near the surface of the Sun.

Keywords: *Tresinos*, coronal mass ejections, solar eruptions

History & Background

Thirty years ago, during discussions about energy production in the early universe my late colleague, John R. Reitz, and I uncovered the possibility of a *new* particle (i.e., a *composite* particle that has gone overlooked since the early years of the development of atomic and nuclear physics). This oversight would have manifested itself in observations in some physical systems involving energy generation. The formation of this composite particle, which we named the *tresino*, would result in the release of a significant amount of "binding" energy. Later, we focused on the implications of the energy released from the Earth[1] as well as the implications relating to the energy in the Early Universe[2]. More recently, I published a paper [3] that examined the implications of *tresino* energy generation in the Sun. This latter paper was the impetus for the present work – it details the basic physics of the solar *tresino*-formation and explosive energy release.

On *Tresino* Formation

If the reader has not already encountered our previous work on *tresinos*, I recommend they look first at Refs. [1], [2], and [3]. Briefly, a *tresino* forms when two electrons bind to a single proton in a very tight formation – significantly closer to the proton than atomic composites. Unlike atoms, which are bound together by electrical forces, *tresinos* are bound together over much shorter distances in a balance between electrical and magnetic forces. This is possible when free electrons are forced very close to a free proton[1]. When this happens, two electrons can bind to one proton in a balanced bound-state that releases 3.7 keV of formation ("binding") energy. This process is briefly discussed in my paper[1] and other references therein.

To begin, it is important to understand where the *new* energy in the Sun comes from. Figure 1 displays an energy- level diagram that shows why this happens – specifically that the *ringed tresino*-composite lies well below the plasma background energy by 3.7 keV. So, in those situations where a *tresino* forms out of the plasma, it will release 3.7 keV to the local plasma. Notice in Figure 1 that the *tresino* is composed of two spin-opposed (green) electrons bound to one (red) proton. When the *tresino* forms, it then releases its "binding" energy to the local environment.

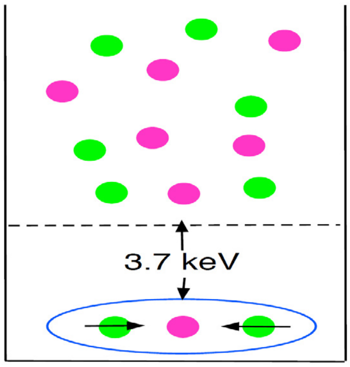


Figure 1. An energy level diagram - protons are (red) and electrons are (green) - (see text for explanation)

The Solar *Tresino*-Transition Data

The reader should recall the plasma density and temperature at the location of the transition found at 2350 km below the solar surface in [3] because the characteristic plasma values are required for the calculations that follow. These data were found in lines n = 26 through n = 29 of Avrett & Loeser's Model C7 of the *quiet* Sun. I have averaged the electron densities and temperatures for these observations and found the following: $< n_e > = 1.6 \times 10^9$ and $< T_{ev} > = 17.5$. These values are required in the calculations that follow. Note that this depth was calculated in my paper "The Phase-Transition beneath the Solar Surface" [3] and based upon observational data from Avrett & Loeser's Model C7.

Debye Shielding

The key to understanding how the Sun produces *tresinos* (which are responsible for solar eruptions, CMEs, and other aberrant solar behavior) is the Debye sphere.

Debye shielding is a basic plasma concept discussed in many plasma physics textbooks and others. However, I have found the paper by Martnez-Fuentes and Herrera-Velzquez[4] to be a particularly useful presentation of the basic plasma theory (and accuracy). Therefore using the plasma parameters as found at the *tresino*-transition from the paragraph above, the Debye length is:

$$\lambda_D = 7.43 \times 10^2 \sqrt{< T_{ev} > / < n_e >} = 0.0777 \text{ cm.} \quad (1)$$

Then the total number of electrons required to shield one proton (that is to say, making-up one proton Debye sphere) is given by:

$$(4\pi/3)\lambda_D^3 < n_e >= 3.1 \times 10^6 \quad (2)$$

Notice this is a rather large number of electrons to screen out the field of the centrally-located proton. It is now possible to determine the size of this Debye sphere. Reference [4] shows that the total electron-shielding number vs radius can be represented as:

$$N_e = \exp(-r/\lambda_D)/(4\pi r \lambda_D^2) - \delta(0) \quad (3)$$

where δ(0) is the Dirac-delta function representing the proton located at r = 0. Figure 2 is a partial-plot of Eq (3).

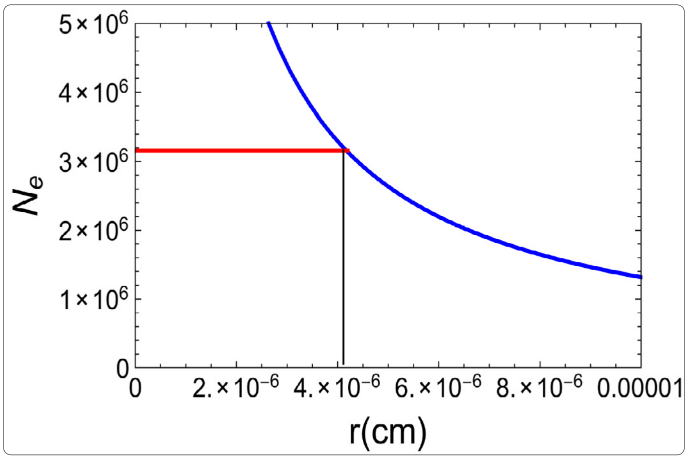


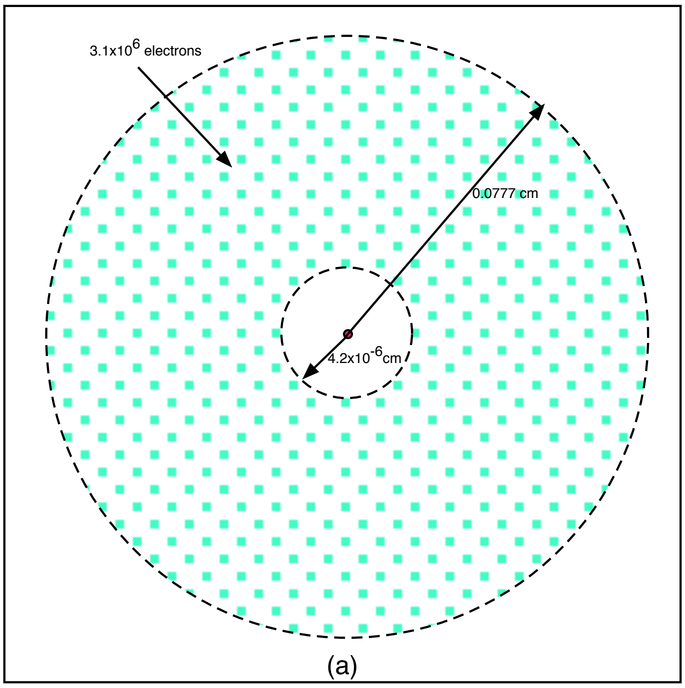
Figure 2. The blue line is a partial-plot of Eq.(3) relating the total number of electrons Ne and the radius of the shielding-electrons r(cm). The proton being shielded is located at r = 0.

This shows how the radius of the shielding-electrons decreases as the total-number of screening-electrons increases to shield the proton at the center. The red-line locates the point where the number of electrons screening the proton obtains the level required at the transition's plasma values. Further, note that at this intersection the radius of the electron-cloud is 4.16×10^{-6}cm.

Figure 3 is a schematic-diagram presenting: (a) the Debye sphere as calculated above and (b) the same Debye sphere that is on the verge of "exploding" because it has just acquired its two electrons from the instability of the electron-shell surrounding its proton. Note that Figure 3(b) is not to scale, the diameter of the *tresino* is about 3 million times smaller than the electron-shell. In this figure many electrons have "flooded" the interior volume close enough to the proton such that two electrons have fallen into the *tresino's* potential-well, capturing them, producing a bound state, and releasing its 3.7 keV of "binding" energy. As you will see, this release of binding energy is quite significant, and is, I believe, the source of CMEs and other large explosions near the surface of the sun.

Scale of the Phase Transition Explosions

The size of the energy release can be estimated from the proton density and the size of the zone that had been formed. Assuming the numbers of Debye spheres/cm^3 are the same as the proton numbers/cm^3 the energy released will come from the 1.6 x 10^9/cm^3 of protons, the same as the electron density. So, if each of these spheres ignites releasing its 3.7 keV, the resulting energy release would be 5.9x10^6 MeV/cm^3 - an energy release equivalent to about 141 grams of TNT. This is a remarkably large amount of energy, comparable to nuclear scales. In fact, the energy released in one km^3 is equivalent to 141,491 megatonnes of TNT, clearly a gigantic explosion. If these estimates are correct it is likely that explosions at this scale are the source of the coronal mass ejections and other disruptions on the Sun that have been observed but not adequately explained for decades. The standard explanation for corona energy is magnetic field reconnection, but the energy produced from this phenomena would be far too small to account for the size of these explosions.



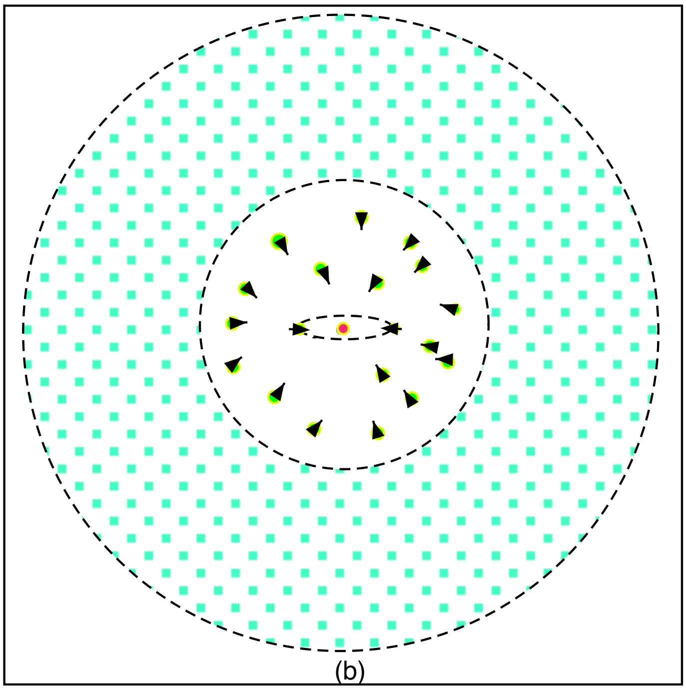


Figure 3. Two proton Debye spheres (a) and (b) (see text for explanation).

Parker Solar Probe

The recently launched Parker Solar Probe may be able to examine the plasma-outflow from the corona and hopefully from CMEs. As a result, I am closely monitoring the results of this mission.

Dedication

I dedicate this paper to my mentor, collaborator, and friend Dr. John R. Reitz, without whose efforts this work would not have been possible.

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