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Letter to Editor

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How the *Tresino* phase-transition is driven to ignite Coronal Mass Ejections

Frederick J. Mayer

Mayer Applied Research Inc., USA

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***Corresponding author:**
Frederick J. Mayer
Mayer Applied Research Inc.
1417 Dicken Drive, Ann Arbor, MI 48103
USA
E-mail: fred@frederickjmayer.net

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Abstract

This letter describes the crucial role *tresino* phase-transitions and a second Compton-scale composite play in generating coronal mass ejections (CMEs).

Keywords: *Tresinos,* compton composites, coronal mass ejections

History and Introduction

Twenty-some years ago, my late colleague John Reitz and I published a paper [1] that described a *new* Compton- scale composite particle; we called it a *tresino*. As explained in previous papers, a *tresino* is a composite of two electrons closely bound to a proton in a balance between electrostatic and dipole-dipole magnetic forces. We later examined how this composite might play a role in the heat from the earth [2] and its possible role in cosmology [3]. In the latter paper we noted that because of its plasma characteristics, *tresinos* could play a role in the solar corona as well.

Readers unfamiliar with *tresinos* might benefit from reading the *Introduction* to my paper "Hidden Baryons" [4] because *tresinos* are crucial to understanding the physics in this letter; the *Introduction* includes a basic *classical* derivation of the *tresino* composite system.

After John passed away, I continued examining the possibilities of the *tresino* phase-transitions in the Sun in a series of papers beginning with [5], a paper that identified where the phase-transitions could be expected from the large solar observational data files of Avrett and Loeser, specifically their Model C7 of the *quiet* Sun. That paper was later followed by [6] that pointed out the important role that Debye spheres could play in the corona's instabilities, a topic further discussed below. In this letter, I show how the *tresino* phase-transition, activated beneath the solar surface, initiates a number of complex phenomena including coronal mass ejections (CMEs) that have been difficult to explain for decades without the formation energy (3.7 keV) of the *tresino* and a second Compton composite one that I have called *tandem electron-pairs*.

This letter reviews and then expands upon our prior work on the corona's connection to *tresino* phase-transition physics.

Significance of Debye Spheres

Each Debye sphere has a proton at its center somewhat insulated by equilibrium electrostatic fields of the surrounding electron clouds. Now notice that solar observational data I examined in [5] found that the plasma at 2350 *km* beneath the solar surface may be either *quiet* or *active* under different circumstances; here I will show how this might happen. In [5] I showed that the plasma parameters for the *quiet* Sun were found to be n_e = 1.6 10^9 and T_e = 17.5 eV. Furthermore, the electron temperature is expected to be higher in the *active* Sun.

Next notice that the electron temperature determines the "classical distance of closest approach" in the scattering of an electron [7] from the centrally located proton in a Debye sphere. This distance is only 213 λ_c in the *quiet* Sun. For the proton to make the transition into a *tresino* would require two such electrons to *simultaneously* be within the *tresino's* potential well. In our QM *model* of the *tresino*, we estimated [1] that the potential well diameter of larger than about 40 λ_c. This suggests that $T_e \geq 100$ eV would be required for two such electrons to be within the potential-well simultaneously to convert the proton into a *tresino*, a rather large increase above the temperature of the background plasma. However, there is an alternate possibility, now described, that has the same effect, namely a pair of *connected* electrons.

Tandem Electron-Pairs

From our earliest consideration of Compton composites [1], we often asked the question how do *tresinos* acquire their two electrons?" In a recent paper [8], I found one such answer, namely that electrons, under certain conditions, can pair-up" as another basic Compton composite, especially as *tandem electron-pairs*. FIG 1. illustrates how this can happen. In the left-panel (A) a *tandem electron pair* has been formed and penetrates the electron cloud of the Debye shield and is then attracted to the proton surrounded by its potential well, *the dashed circle*, of the Debye sphere. In the right panel (B) the *tresino* has been formed and then releases its formation energy (3.7 keV).

Toward Ignition

In [6] I estimated the energy released in large-scale solar explosive events, driven by the *tresino* phase-transitions. It appears that to generate such large amounts of energy requires an explosion driven in a manner similar to that of chemical explosives, i.e., similar to detonation waves. This sort of reaction is possible due to the fact that individual Debye spheres are so close together – less than about 0.0009 cm. So, it appears that this is a new type of detonation wave driven by *tandem electron-pairs* where the wave proceeds when a *tresino* forms, releasing its binding energy, and delivers another *tandem electron-pair* to a close-by proton in its protective Debye sphere.

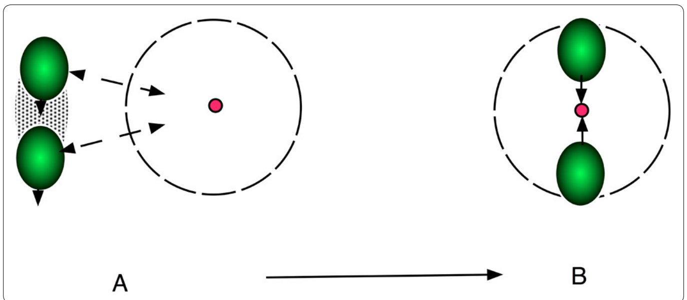

Figure 1. The left panel (A) shows the *tandem electron-pair* being attracted into the *tresino's* potential well - *the dashed circle*. The right-panel (B) shows the newly-formed *tresino* now ready to release its formation energy. Electrons are green, protons are red, and the *hazing* between the electrons locates their *spin-mediated* magnetic attraction, once aligned, the two electrons can be pulled closely together through magnetic attraction [8]

Triggers

There may be a number of mechanisms that can *trigger* the ignition of the *tresino* phase-transitions, (those within the appropriate *tresino* phase-transition zone). All of them must first generate a *tandem electron-pair* in order to be captured by the proton at the center of a Debye sphere, as depicted in FIG.1. The situation that seems most likely is via the *electron streams* generated by magnetic-field reconnections [9, 10] within the *tresino* phase-transition zone. A second *trigger* mechanism is possible when the Debye spheres undergo thermally-driven instability such as a burst of electron heating from a newly formed, close-by, *tresino* that has just released its 3.7 keV of binding energy. The Debye sphere can be driven unstable and tries to return to electrostatic stability by increasing the total electron numbers (see the basic calculation in [6]) from its nominal value by a new, much larger number of electrons (note the rapid increase of N_e in FIG. 2 of [6]). Some of these *newly created electrons* could then "pair up" becoming a *tandem electron-pair*. Notice that this sequence is clearly suggestive of a type of chain reaction in near-by Debye spheres producing the large energy releases.

Entrainment

As just mentioned, magnetic-field reconnection may *trigger* the explosive energy release of the *tresino* phase-transitions at the depth of 2350 *km* below the solar surface. Furthermore, the currents and magnetic fields in this region can be *entrained* by the explosion that it initiates. If the energy release is sufficiently large, a section of magnetic-field *ropes* (probably anchored at the reconnection point) as well as plasma can be carried out by the explosion *up through* the corona and become visible as *coronal loops* [11]. Such *loops* are, of course, frequently observed on the Sun but their origin has been difficult to understand for many years.

Closing Comments

The important understanding in this letter is that the lesser known Compton composites, *tandem electron-pairs*, are required to drive the observed detonation-like character of the CMEs. The extremely large scales of some CMEs, themselves, suggest that some sort of phase-transition such as the *tresino* phase-transition must be involved. Perhaps some other mechanism is possible. However, if this is the case, there remain many connections that will have to be understood similar to those that I have presented in this letter.

Of course, many theoretical and observational studies will be required before this theory may be confirmed as the source of CME generation.

Dedication

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

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