A Solid State Ion Collider with Transient Current Pulses

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Abstract

We present experimental evidence for the appearance of strong forces inside the lattice of metallic conductors in the phase of transient excitation by a sequence of high power, high voltage but low energy electrical pulses.

1. Introduction

In a series of previous publications [1, 2] we analyzed the problem of wire fragmentation, which is associated with a long-standing controversy in Maxwellian electrodynamics. The first experiments in wire explosions under very high currents and voltages were made by Nasilowsky during the 60s. At the 80s, Pappas, Graneau and Rambaut and Vigier [3-6] repeated similar experiments and argued on the existence of longitudinal forces beyond the ordinary Maxwellian electrodynamics. Other attempts [7, 8] for a correct explanation in our opinion fail to provide a clear picture of the phenomena in terms of the Maxwell stress tensor. A corrected picture within the classical Maxwell theory has been presented in [1, 2] which is amenable to experimental verification based on the instantaneous forces between radiating dipoles created by the action of a transient high power current pulse.

Experimental results are reported in section 2 with a specially prepared pulse generator of very low internal resistance and low capacitor energy. An additional ongoing project for a microscopic study via simulations is explained in section 3. In the last section we discuss the possibility of using similar effects in order to create a solid state ion collider. Arguments are presented for the treatment of special metals and/or unstable isotopes by this method for low energy nuclear transmutations and possibly for neutralization of radio wastes.

2. Experimental investigation of bipolar forces

According to the macroscopic analysis presented in [1, 2] when a abrupt transient electrical pulse of an exponential shape akin to a capacitor discharge excites a long thin linear conductor (heretofore referred as the "wire"), the conductor during the transient excitation time interval behaves as a long transmission line. After the first moment of excitation, propagation of the electrical disturbance across the wire causes the temporary establishment of a system of stationary waves. This sets into motion additional secondary excitations inside the wire that cause the subsequent polarization of the metallic lattice in a time-dependent manner. In a simplified form, one may analyze this situation with the aid of Fig. 1 where a system of transient dipoles is shown along the wire.

This system was analyzed in [1, 2] in terms of classical Maxwell theory and the instantaneous forces between the dipoles were found to be given by the following formula

$$F(I,\lambda) = -180\frac{I^2}{c}\phi(1/\lambda), \lambda = L/2\pi D \qquad (1)$$

where D stands for the wire diameter, L is the wire total length and the function $\phi(1/\lambda)$ is a special integral from the dipole radiation formula that can be evaluated numerically.

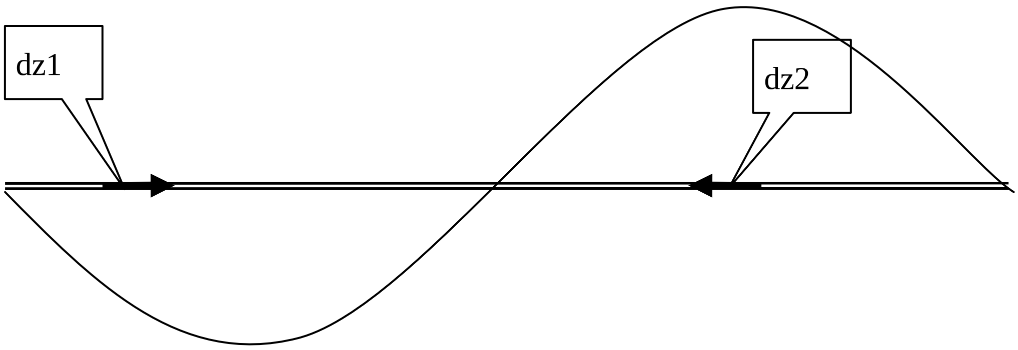

Fig. 1

The overall function force factor $\phi(1/\lambda)$ is shown in Fig. 2

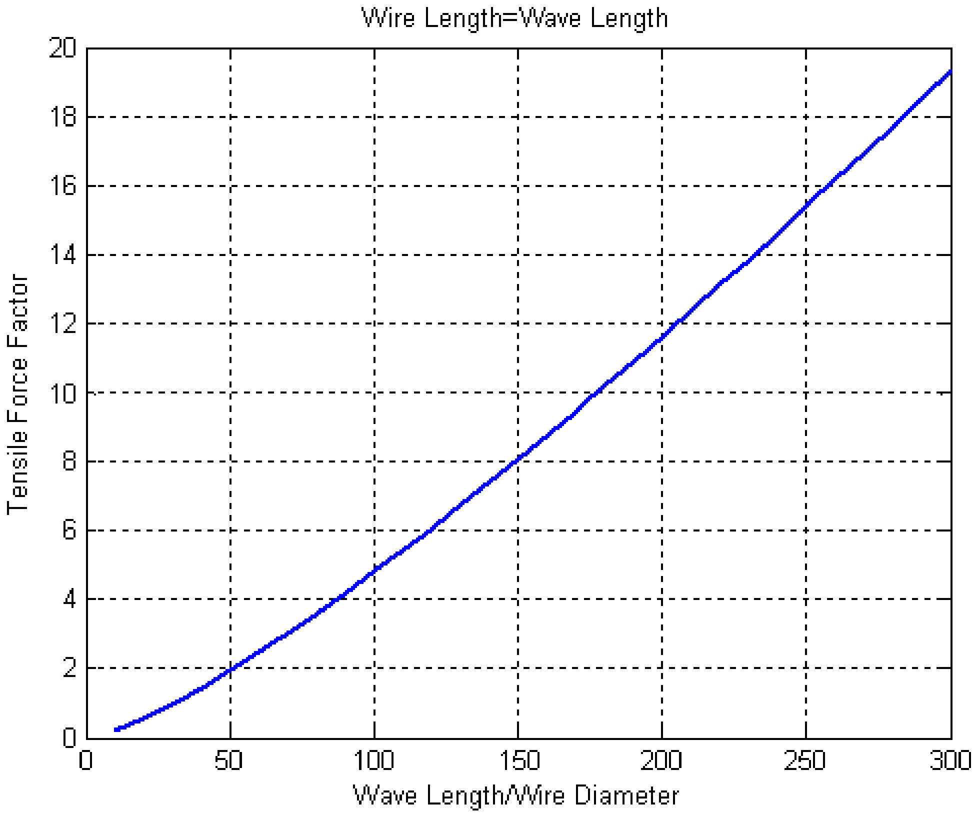

Fig. 2

In order to prove the existence of strong ionic collisions inside thin wires a special pulse generator was designed. The basic circuit is shown in Fig. 3. The aim behind this design was to have the overall internal resistance of this circuit to lie in a range of some mΩ's. For this, a special set of capacitors and a thyristor of very low internal resistance were chosen.

The current pulses were created by the discharge of the capacitor bank composed of 4 capacitors in parallel, each of 3 μF with 12 μF total capacitance (4.3), with the aid of a special digital controller circuit (4.6) that allowed both a single pulse or a sequence of consecutive pulses (see Fig. 3). The duration between subsequent pulses in the sequential mode was of the order of 3 seconds. These were then applied to a variety of wires of variable diameters and a constant length of approximately 27 cm.

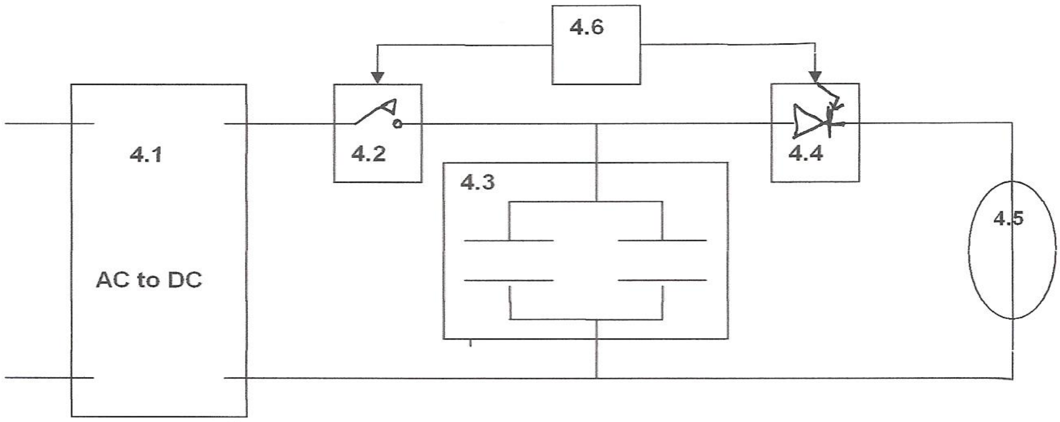

Fig. 3

The exercised voltage of the capacitors was nearly 1000 Volts and the discharge resistances including the circuit and the additional wire resistance were from 20 mΩ to 200 mΩ. The time constants of the occurring discharges were thus in the range of several μsecs.
The values of the instantaneous currents exerted on the wires from these current pulses were estimated in the range of 5000A-30000A. It was not possible to measure the magnitude of the fundamental harmonic but its existence could be detected by the appearance of longitudinal vibration of the thin wires that could be detected visually and easily could be captured by a high resolution camera.
Direct inspection showed that during the first pulse, a cloud of metallic dust gets violently expelled from the wire surface. This is speculated to be the result of the bipolar forces on defects and dislocations in the metallic crystal lattice. After several pulses depending on the wire diameter some of the wires get cut not necessarily near the center of the total length. This apparent discrepancy with the theoretical prediction of section 2 is probably due to the simultaneous coexistence and action of several different wavelengths due to the continuous spectrum of the discharge curve.
A number of wires with a steel core and a conductive metallic layer deposited with an electrolytic bath were also tried to show that it is possible to increase the tensile strength to avoid fragmentation. Indeed, the type of fatigue of the conductive metallic layer remained the same although the wire did not get cut despite a large number of pulses applied sequentially for a long time interval of several minutes up to half an hour.
In particular, the specific type of fatigue appearing in a set of experiments with copper wires of 27cm length and an average resistance of 100 mΩ was shown to be characterized by three major effects.

a) A number of almost periodic burns on the external surface of the wire that is probably associated with the wavelengths of higher harmonics.
b) An overall zig-zag shape obtained by a loose wire and a subsequent length shortening that is strongly suggestive of the opposite local dipole polarities ,due to the action of several harmonics, at certain sections of the wire.
c) At some of the experiments sparks appeared to emanate from points of the surface totally unrelated with the final break point. Some of these were captured with the

video camera and may be related with local charge concentrations on previously created cracks of the metal surface.

Observation of the condition of the wires surface took place at the Laboratory of Metallurgical Microscopy of the National Technical University of Athens. Results were photographed and are shown in the pictures of Fig. 4 Examination of these samples revealed both vertical as well as helical cracks on the metal surface.

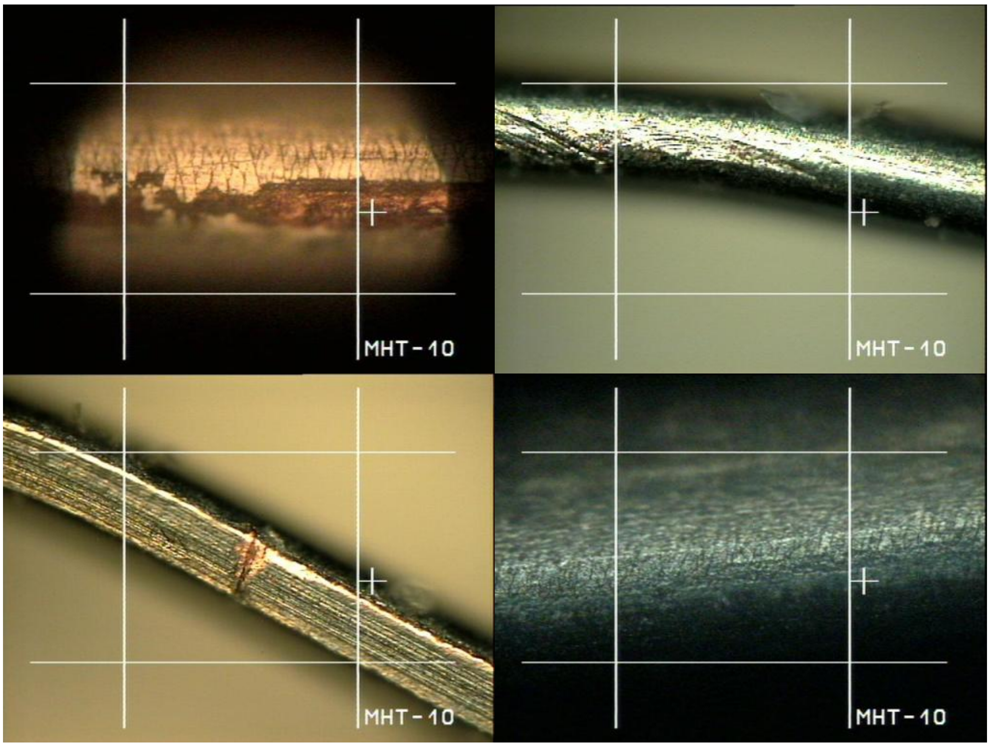

Fig 4. Condition of a wire surface after a succession of high power current pulses.

Another question concerning the appearance of the characteristic “neck”-like configuration of a metal near the break point due to increased metal plasticity as usually predicted was not verified. The final breaking mechanism may require separate study but our purpose in these experiments was rather to prevent the wires from reaching their tensile strength threshold in order to create a sustainable mechanism for exerting bipolar forces on a metallic lattice without breaking.

3. Conclusions

Both theoretical analysis and experimental evidence suggests the appearance of very strong forces inside the crystal lattice of metallic conductors which cause certain fatigue to the surface of the conductors. Although their macroscopic analysis in the present study was based on the abstract notion of ideal Hertzian dipoles, it is more than obvious that in the microscopic reality of the lattice, these forces will be of a purely Coulmobic nature due to the local strong polarization phenomena. This implies that in the short transient phase that the lattice moves strongly away from equilibrium, there will be a severe increase in the kinetic energies of the associated phonon-phonon and electron-phonon scattering events that could be utilized in cases where one would like to study the effects of strong ionic collisions without the use of an accelerator. It is also possible to use this technique in order to study the influence of such phenomena in the case of unstable or even radioactive metals of heavy Actinides.

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