INSIDE AN LENR REACTOR, IMPROVING OUTCOMES FOR REPLICATORS.

Alan Smith. February 2016.

"We have to learn again that science without contact with experiments is an enterprise which is likely to go completely astray into imaginary conjecture." Alfvén

ABSTRACT.

'Dusty plasmas' (DPs) are described and discussed in the contemporary context of LENR systems, with a look at the history of their study which embraces both terrestrial and cosmological examples.
Langmuir in the 1920's first reported his observation of the creation of dusty Tungsten plasma in a discharge tube containing inert gas. Langmuir's suspicion at the time that DPs would capture the interest of physicists was eventually proven to be correct. There was exponential growth in journal publications about DPs between 1981 and 2003/4, since when they have continued to appear in healthy numbers. This is because studies of fast ions with high energies compared to 'background' plasma ions play a key role in the investigation of both deep space plasmas and in controlled fusion research.
The potential similarities between the inner environment of a working LENR reactor and the hot, dusty, and highly energetic plasmas found in the atmospheres of Brown Dwarf stars, our sun, and the planet Saturn are described, with a view to considering the electromagnetic approach to LENR, with the aim of enhancing the outcomes of current replication attempts.

THE EARLY WORK.

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IRVING LANGMUIR, CHEMIST AND PHYSICIST. 1881-1957.

In 1924 while doing research into radio valves, Irving Langmuir made what was probably the first laboratory observation of dusty plasma. He was studying discharges in very low pressure (.004Bar) Argon gas tubes. Discharge was between a heated Tungsten wire cathode and an anode disc located 50 cm away.
When the heater current was switched off briefly, decreasing the level of thermionic emission a voltage spike caused the Tungsten to fragment. This caused minute 'globules' of tungsten to move through the tube at velocities of 10-30 cm/s, appearing as brilliant 'streamers,' Langmuir called it a 'streamer discharge.' He described the streamers as "phenomena of remarkable beauty which may prove to be of theoretical interest."

Langmuir was correct in foreseeing the great interest that DP's would engender in decades to come. A prolific researcher and Nobel Prize winner (1934) he invented the Langmuir Probe which is used to measure the density and temperature of plasmas and introduced the concept of electron temperature. He also discovered that molecular Hydrogen introduced into a tungsten-filament bulb dissociated into atomic hydrogen. Further investigations showed Langmuir had correctly predicted that the dust particles would be negatively charged and surrounded by a positively charged shielding cloud, and aligned modern theories of dust charging with his "theory of collectors.'

DPs IN SPACE – SATURN'S RING OF FIRE.

The rapid growth of DP research has been driven primarily by discoveries in the widely different areas of planetary science and applied plasma science. Back in the 1930's (Trumpler 1930, and Stebbins 1934/39) undertook photometric studies of the 'dark holes' in the Milky Way which showed that they were caused by obscuring dust clouds. Dust seems to be ubiquitous in our Universe, as it is in my laboratory. Particle sizes in various deep-space objects are now known to range from around 10Ā, to larger ones like those found in the dust-tail of comet P/Halley in1989. There is good reason to believe that the highly charged plasma environment encourages the transformation of diffuse gaseous clouds step-by-step into particulate clouds via first atomic, then molecular clustering, quasi-crystal formation and so on.

The Voyager space mission's observation of 'spokes' in Saturn's B ring, reported in 1982, and the ensuing attempts to provide an explanation were the impetus for an important article, "Dusty Plasmas in the Solar System," by Chris Goertz. (Review of Geophysics,1989). The idea that plasmas could 'self-organise' to produce dust particles was given further impetus by the realization that the contamination of semiconductor material in plasma processing tools was due to particles 'growing' in the plasma. Further details and images of this phenomenon can be found in an article by Merlino and Goree (Physics Today, 2004).

Plasma plays a huge role in Saturn's planetary environment, as it does with that of our sun. Saturn itself has become more, not less mysterious as we study it. Even the length of a Saturnian day has not been determined reliably. With an internal Nickel-Iron core at an estimated temperature of 11,600K wrapped in a layer of metallic Hydrogen it will not surprise some students of LENR theory that its thermal output is some 250% more than its solar gain. There is also speculation that Saturn's outer plasma torus is even hotter than the solar corona, perhaps the Saturn hosts the hottest location in our entire solar system. Analysis of data from NASA's Cassini spacecraft shows a link between mysterious periodic signals from Saturn's magnetic field and explosions in this hot ionized plasma. Plasma clouds move around the planet producing a repetitive "thump" in measurements of Saturn's rotating magnetic envelope. Pontus Brandt, a Cassini team scientist based at the Johns Hopkins University said "The big question now is why these explosions occur periodically."

Cassini data shows how plasma injections, electrical currents and Saturn's magnetism are partners in an intricate ballet. Periodic plasma explosions form islands of pressure that rotate around Saturn. The islands of pressure "inflate" the magnetic field. An animation showing this linked behaviour is available at http://www.nasa.gov/cassini .

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Scientists are still investigating what causes Saturn's erratic magnetism, but there are strong indications that cold and dense plasma torn originally from Saturn's moon Enceladus rotates with Saturn. Centrifugal forces stretch the magnetic field until part of it snaps back, heating the plasma belt. One of the effects of this energy input is that plasma clouds circle Saturn at an amazing 200,000 mph. It goes without saying that these highly energetic plasmas are also exceedingly hot, even hotter (perhaps) than the exosphere of our sun.

OLD SOL'S HOTTEST SPOTS.

Plasma clouds and streamers are a visible feature of the sun's surface. A surface which it must be remembered is considerably cooler than the plasma in the sun's upper atmosphere. The rotation of the sun, and sub-surface pressure waves produce periodic electromagnetism in the convection zone giving rise to Alfvén waves. These waves travel through the chromosphere and transition zone and interact with the ionized plasma. The wave itself carries energy as well as some of the electrically charged plasma. Alfven waves may also be associated with the plasma jets known as spicules. It was theorized these brief spurts of superheated gas were carried by the combined energy and momentum of their own upward velocity, as well as the oscillating transverse motion of the Alfven waves.

ALFVÉN WAVES

An Alfvén wave in a plasma is a low-frequency (compared to the ion cyclotron frequency) travelling oscillation of the ions and the magnetic field. The ion mass density provides the inertia and the magnetic field line tension provides the restoring force.

The wave propagates in the direction of the magnetic field, although waves exist at oblique incidence and smoothly change into the magnetosonic wave when the propagation is perpendicular to the magnetic field.

The motion of the ions and the perturbation of the magnetic field are in the same direction and transverse to the direction of propagation. The wave is dispersionless.

Ex Wikipedia

In 2007, Alfven waves travelling towards the corona were reported for the first time, but the energy carried by these Alfven waves was insufficient to heat the corona to its enormous temperatures, for the observed amplitudes of the waves were not high enough. However, in 2011, McIntosh et al. reported the observation of highly energetic Alfven waves combined with energetic spicules which could sustain heating the corona to its 10^6 K temperature. These waves were over one hundred times more energetic than the ones observed in 2007 and of a higher frequency, thus able to transfer more energy into the coronal atmosphere.

THE DWARFS

A big topic of study in astronomy is the observation of the atmospheres of far stars in the optical range. New data on chemical composition, the formation of DP's, and their influence on light absorption/emission enable simulation of the atmospheric properties of such exotic objects as brown dwarf stars (BDs). These are typically around 10–80 Jupiter masses with a photosphere temperature of around 0.3–1 eV and a magnetic field strength of up to 1kGauss (0.1T)

Because BDs have so little mass, it can be easy to confuse them with gas giants like Jupiter. Similarly, their lack of hydrogen fusion can raise similar concerns. One way to tell the difference is that like all stars BDs create their own light. They shine in the red and infrared spectrum also emitting measurable amounts of X-rays. Some BDs are cool enough to maintain atmospheres- much like gas giants - in fact the coolest of them may have a surface temperature of no more that 200-300C. The International Astronomical Union has decided that any object big enough and hot enough to fuse Deuterium is a BD, while objects with less than that 13x Jupiter's mass are planets.

Early in its life a BD shrinks, its core becoming hotter and more dense as it becomes smaller. Core temperature increases inversely with its radius in this phase until its density becomes high enough for degeneracy pressure (where the electrons are packed closely enough to begin to violate the Pauli Exclusion Principle) to dominate. At this point, a BD is the hottest it will ever be, internal temperatures range from several million K for massive BDs, to 0.5M K for the least massive. The temperature inside a massive BD is sufficient to initiate fusion in Deuterium and Lithium. Within a small BD only Deuterium can burn. Massive BDs reach their maximum core temperatures in about 300 million years after birth, which matches the time taken for small protostars to reach the main sequence. The least-massive brown dwarfs, in contrast, reach their maximum core temperatures after only 10 million years.

BD atmosphere researchers regularly use the DRIFT-PHOENIX (DP) model, which assumes that the highly ionised BD cloud layer contains condensates of Iron, Nickel, Aluminium, and Magnesium and their compounds with Silicon and Oxygen. In DP cloud simulations developed from these models, the formation of mixed molecular, atomic and dissociated Hydrogen clouds and the condensation of metal vapour from them in the form of rain – ie small particles - is seen. All of this takes place in the context of an active and constantly fluctuating magnetosphere and the periodic emission of X-rays and other charged particles. Food for thought.

For those who would like to know more about BD's I recommend:-

IONIZATION IN ATMOSPHERES OF BROWN DWARFS AND EXTRASOLAR PLANETS.
P. B. Rimmer and Ch. Helling
SUPA, School of Physics & Astronomy, University of St Andrews, St Andrews, KY16 9SS, UK
www.http://arxiv.org/pdf/1307.3257.pdf

PECULIARITIES OF LOW-FREQUENCY WAVES IN DUSTY PLASMA WITH FERROMAGNETIC GRAINS

V.N. Mal'nev, E.V. Martysh, V.V. Pan'kiv . Taras Shevchenko Kyiv National University

FROM STARS IN SPACE TO STARS IN JARS.

So how does the interior of a hot Nickel-Hydrogen reactor differ from the highly-charged DP atmosphere model above a cool BD star? The elephant in the room here is, of course, gravity. Or in the case of our laboratories, perhaps we should say there is NO elephant. Gravity is a vital factor in the formation of stars, since it creates the pressure which initiates core fusion. But in the BD cloud layer gravity plays a lesser role. It impacts upon the maximum size of those metal raindrops of course, the higher the gravity the smaller they will be, the limiting factor being the point where the force of gravity is sufficiently powerful to overcome the surface tension which holds the droplet together. So nano-sized rain, like the nano-particles in an LENR reactor is to be expected.

Gas pressure inside the reactor may be similar to that in a BD cloud layer, and the system temperatures of E-Cat and BD are match.

So if the fuel environment in our LENR reactor is a mix of solid nano-particles, metal vapour, Hydrogen plasma etc, it already bears a superficial resemblance to the BD cloud layer. There are of course other considerations, electrical charge, and fluctuating magnetic fields. These are present in a BD cloud, and as we shall shortly describe, in a Rossi reactor.

A big difference between E-cat and the BD dust-cloud is of course the close packing of particles in E-Cat, and the charge density. We cannot be certain how the charge density might differ between star and jar, but both gas (plasma) pressure and charge density affect the ability of mobile electrons to create charge-separation layers (screening) around dust particles. The table below suggests that in a fuelled E-Cat the Debye radius value is microscopic, and dust particles may thus bear 'naked charges', whereas in a BD cloud the Debye radius is macroscopic.

THE DEBYE LENGTH

In plasma physics, the Debye length, named after Peter Debye, is the scale over which mobile charge carriers (e.g. electrons) screen out electric fields in plasmas and other conductors. In other words, the Debye length is the distance over which significant charge separation can occur. A Debye sphere is a volume whose radius is the Debye length, in which there is a sphere of influence, and outside of which charges are screened.

In space plasmas where the electron density is relatively low, the Debye length may reach macroscopic values, such as in the Magnetosphere, Solar wind, Interstellar medium and Intergalactic medium (see table).

Ex Wikipedia

Plasma	**Density** $n_e(m^3)$	**Electron temperature** T(K)	**Magnetic field** B(T)	**Debye length** $\lambda_D(m)$
Gas discharge	10^{16}	10^4	--	10^{-4}
Tokamak	10^{20}	10^8	10	10^{-4}
Ionosphere	10^{12}	10^3	10^{-5}	10^{-3}
Magnetosphere	10^7	10^7	10^{-8}	10^2
Solar core	10^{32}	10^7	--	10^{-11}
Solar wind	10^6	10^5	10^{-9}	10
Interstellar medium	10^5	10^4	10^{-10}	10
Intergalactic medium	1	10^6	--	10^5

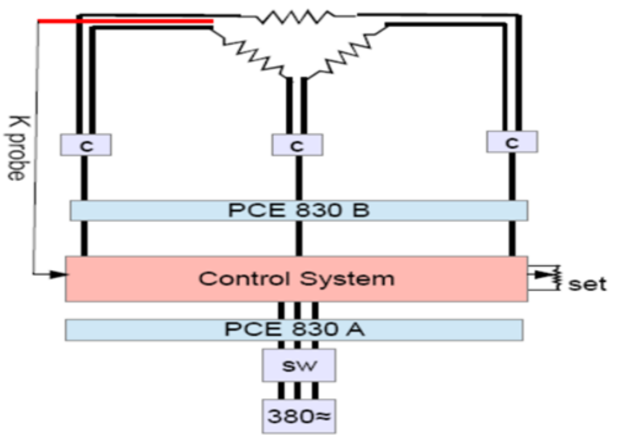
Source: Chapter 19: The Particle Kinetics of Plasma. http://www.pma.caltech.edu/Courses/ph136/yr2002/

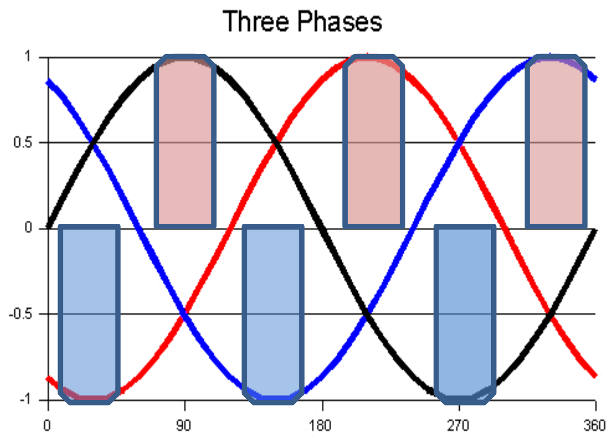
ELECTRIC AND MAGNETIC FIELDS IN AN E-CAT.

Thoughts on this topic have recently been provoked by a number of things, one of them being that the 'hit rate' of Eastern European / Russian replicators seems so much better than that of any others. Since MFMP and others (including me) have been using similar or identical raw materials, might there be something else involved? The most obvious thing seems to be the heater type and also –perhaps more significantly the heater drive current. Generally speaking successful replicators like Parkhomov have used fairly 'old school' industrial electrical equipment for at least some parts of the power supply, and these may well create interesting waveforms in the reactor heaters.
The role of the heating coils is very important. Originally described as a 'safety heater' it has become clear that it actually provides triggering for the LENR reaction. The trigger is heat, but heat alone is probably not enough. After all, a little E-Cat only requires a few hundred watts to heat it, there is no need at all for intermittent 3-phase pulsing at a claimed 40-50 amperes just to provide heat, a simple DC or single-phase AC system could easily provide the required energy level. So we must assume there is a reason for it, and at least consider that, as with a BD star, or the planet Saturn, EM fields play a part in what happens inside an E-cat. Possibly a very large part.

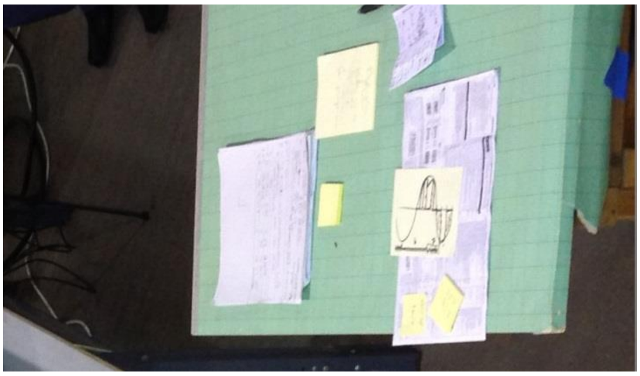
THE LUGANO E-CAT POWER SYSTEM – OUTSIDE THE CORE.

To quote from the report. 'The resistors (Kanthal wire heating coils) and the copper cables of the three-phase power supply are connected…in the classic delta configuration….The E-Cat's control apparatus consists of a three-phase TRIAC power regulator, driven by a programmable microcontroller; its maximum nominal power consumption is 360 W. The regulator is driven by a potentiometer used to set the operating point (i.e. the current through the resistor coils, normally 40-50 Amps), and by the temperature read by the reactor's thermocouple.'



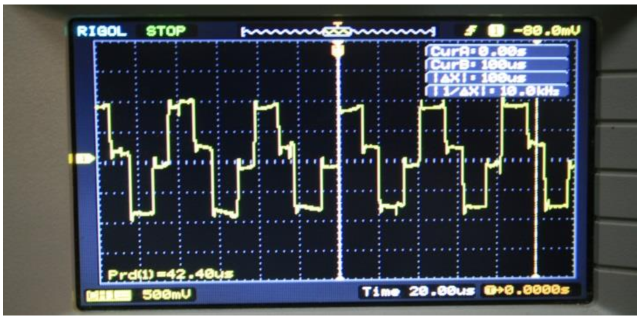


The circuit diagram (above left) shows how the 3-phase current was fed into the coils for the Lugano test. Instead of using a single coil of thick low-resistance wire with a DC or single-phase current feed – which replicators have found to be more durable than the thinner wires used on the E-cat - the Lugano device used three interlaced coils wound like a triple-start thread on the reactor body. If we then consider the effect of 'topping and tailing' the smooth sine waves of a 3-phase supply as shown by the pink and blue blocks (above right) you get a situation where at any given instant one of the three heater wires is receiving a sudden current pulse of (say) 40A. Since the polarity of the magnetic field that the current pulse produces inside the reactor depends on the polarity of the electrical feed at that moment, and since each heater wire receives in succession a pulse of opposite polarity, it becomes apparent that there is a rapidly changing magnetic field inside the reactor. Ultimate field strength may not be the only consideration, but rate of change of the 'B' field is very high in this scenario. Also, as the magnetic flux is a function of the number of turns in the heater coil, and the strength of the current flowing through it, it is obvious that a short sharp current of 40A will produce a much stronger (if briefer) magnetic field than a lower current maintained for a longer period. And this polarity change happens 50x/sec for each of the three wires, a total of 150 flux reversals inside the reactor every second. Since there is a separate wire for each phased pulse there is also a 'ripple and twist' effect (the twist is caused by the fact that the wires are helically wound around the ceramic.)



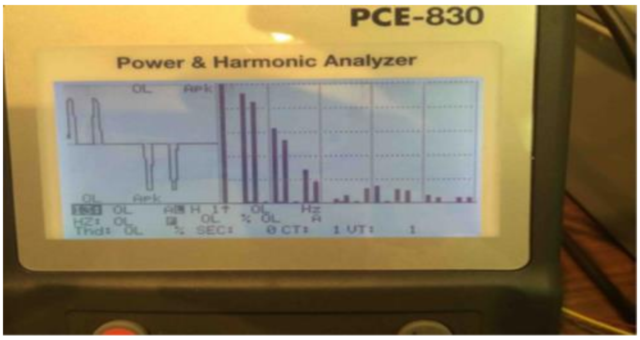
THE SKETCH ON Mr. ROSSI'S BENCH.

I noticed the cover picture on a blog post included this little detail, on a scrap of paper. It started a train of thought.
As you see, it's a doodle of a sine-wave with parts of it shaded out with pencil. The pseudo square waveform(s) created reminded me of the waveforms shown (with scant data detail) in the picture taken from the Lugano report.



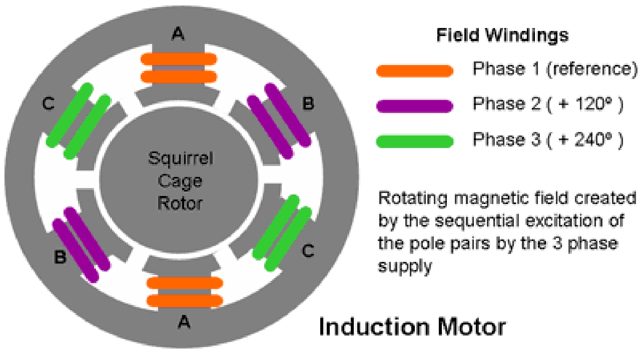
PULSE-WIDTH MODULATION (PWM) AND SQUARE-WAVE DIRECT CURRENT.

In this picture taken in my own lab you can see a typical waveform created by PWM of a relatively smooth DC voltage. The scope probes were loose-coupled btw. Note the – 'skyscraper' appearance of square waves stacked one on top of another.



LUGANO TEST, THE WAVEFORMS.

This picture taken from the Lugano report shows similar 'skyscraper' waveforms to the one above. The report mentions Triac control was used, but since most Triacs are 'Zero Crossing' and only turn on or off when the line voltage is zero, it would appear that some other form of PWM switching was used, possibly phase control.



This diagram of a 3-phase induction motor shows how without any sophisticated switching or brush-contact as used in most simple DC motors a 3-phase power supply can be used to create a rotating magnetic field. This rotating field induces in the rotor windings a current creating an 'opposing' magnetic field which makes the rotor turn.

INSIDE THE E-CAT.

It is –I hope- now apparent that inside the E-cat we have a rapidly changing 'B' magnetic field. Faraday showed that when a conductor is moved into a magnetic field – or when a changing magnetic field is created in the vicinity of a conductor - then an electric current flows through that conductor.
This situation is best summed up by the Maxwell–Faraday generalisation of Faraday's law. This states that a time-varying magnetic field – the B field - is always accompanied by a spatially-varying, non-conservative electric field 'E', and vice versa. The Maxwell–Faraday equation can also be written in an **integral form** by the Kelvin-Stokes theorem.

$$\oint_{\partial\Sigma} \mathbf{E} \cdot d\boldsymbol{\ell} = -\int_{\Sigma} \frac{\partial \mathbf{B}}{\partial t} \cdot d\mathbf{A}$$

Where **Σ** is a surface bounded by the closed contour ***∂*Σ**, **E** is the electric field, **B** is the magnetic field, d$\boldsymbol{\ell}$ is an infinitesimal vector element of the contour ***∂*Σ**, and d**A** is an infinitesimal vector element of surface **Σ**. If its direction is orthogonal to that surface patch, the magnitude is the area of an infinitesimal patch of surface.

Of course there are no conducting wires inside the E-Cat (as far as we know) but there are certainly ferromagnetic grains of Nickel which are. of course, conductive. Nickel itself has a low Curie temperature of 354C. Curie temperature is the point at which certain materials lose their permanent magnetic properties, to be replaced by induced magnetism. While each nano-grain of Nickel may be above its Curie point in a hot E-cat, it still conducts current, and therefore still has a transient B field. So it will respond by motion (it has 'motional emf) through the field, and also since the field is rapidly changing –thanks to those reversing square waves - the induced voltage will be high – the greater the rate of change the higher the induced voltage.

Of course, a principal objection to this hypothesis is that when a cold E-cat is cut open the contents are caked (sintered) into a mass, often plastered onto the reactor wall. But this may be misleading, since what is visible at room temperature in a 'dead' E-cat is not necessarily what we would see inside one running at 1000C plus.

SUMMARY.

I have attempted to draw some parallels between fairly well documented but not totally explicable (at least to me) phenomena in astrophysics and the internal workings of a Nickel-Hydrogen E-cat system. The key point is to point out that the safety heater is no such thing, but a is the trigger mechanism for LENR reactions. Perhaps the best course for replicators is to consider the methods they use for reactor heating, and how they might be modified to be a little more Rossi-like.

Alan Smith.