Maisons Alfort the 18th of January 2019 / Rev. 2

Conclusion about the possibility of fusion by frontal collision in a linear device

This short paper explains why under realistic hypothesis, it cannot be hoped, from this fusion method, a system in which it can be generated more power that the one supplied (indeed a system interesting for electricity production).

The two previous papers of the author were not based on realistic hypothesis, this to avoid to be curbed as soon as started.

One of the freedom taken was not to consider limit on the voltages used. If, now, it is considered a realistic voltage taking account of the breakdown between electrodes, one will pass from tens of MV to hundreds of KV (for example, about 240 KV maximum for one cm between electrodes, in a high-vacuum system).

However taking under account a relatively “weak voltage” involves that the confined current is going to be necessarily weak because the radial force exerted by the Einzel lens will be much weaker because dependent on the applied voltage. It can be hoped to confine two 10 mA ions currents but not much higher.

It is reminded that the working principle of the linear device is to generate D2+ (or D+) ions at one extremity, T2+ (or T+) at the other extremity, to accelerate both towards the center and to confine them in the same time. The D2+ and T2+ ions are going to circulate along the device axis and fuse (besides other interactions : collisions, ionizations…). There is no or almost no ions-neutrals (I/N) fusions. Note that it is not possible to imagine a system mainly using I/N fusions because “Charge exchange” interactions type are widely more probable and make I/N fusions anecdotal, with, as well, a deplorable global efficiency.

In addition, to hope to have an interesting fusion power, it is necessary to start from a very fine beam. Indeed, one shows that the fusion power increases with the ionic density. For example, a straight beam of 40 nm of diameter would permit to generate (ideally) several hundreds of W by a small linear device.
The first problem would be to confine this beam because the space charge, which applied force at the beam interface is inversely proportional to the beam radius, becomes very large for weak diameter beams. However, it can be imagined that Einzel lenses of very small interior diameters (providing an important radial electrical field) could, possibly, be a solution.
But the main problem is that it does not exist ions sources supplying a straight beam of 10 mA on a cross section of 40 nm diameter. The ions trajectories in a beam are always either divergent or convergent (the beam emittance cannot be nil). Even the very bright GFIS ions sources have a beam aperture angle of 1° with a maximum current of about 10 nA (so very far away from the necessary 10 mA).

Even supposing that such ideal ions source be found, it would be necessary to :

- be able to align two 40 nm diameter straight beams,
- have beam aberrations much weaker that the beams section,
- have parts with geometries such that the electric field be almost perfect (coaxial and symmetrical),

which seems very difficult to obtain. Reversely, the required vacuum level (let's say P<1 mPa) is feasible.

In addition, taking into account the efficiency of the ions sources (< 0.2) and the thermo-dynamical efficiency (about 0.3), it would be necessary to generate, in fusion power, 20 times more the power injected by ions to have an interesting electricity plant.

So, it seems difficult, not to say impossible to imagine a fusion system to generate electricity, based on a linear device.

<u>Note about the focus possibilities of a ions beam</u>

As indicated above, the main problem is the focus of a large and divergent ions beam. If it would be possible to reduce a broad ions beam (let's say of 1 mm of diameter) necessarily a bit divergent in an almost straight beam of 40 nm of diameter, it would be the « jackpot ».

As far as the author knows, it exist several possibilities to focus a beam:

- The Einzel lenses: they make converge trajectories, by an edge effect. The provided electrical radial field is roughly proportional to the applied voltage and inversely proportional to the interior diameter. It is a simple and efficient device but difficult to calculate (formulas diverge from a paper to another).

- A magnetic field as in the Penning trap. If, for electrons, a reasonable field of 1 Tesla is sufficient, for ions which are much heavier than electrons, a 1 Tesla field has a weak effect. So it is not a solution.

- A rotating electrical field as in the Paul trap is not appropriate for fusion. Indeed, even if the provided radial force is not negligible inside a stability zone, it remains proportional to the applied alternative voltage. But this one can only be relatively weak for the necessary HF frequencies (let's say <5000 V for f>1MHz, to give an order of magnitude). So it is not a solution, either.