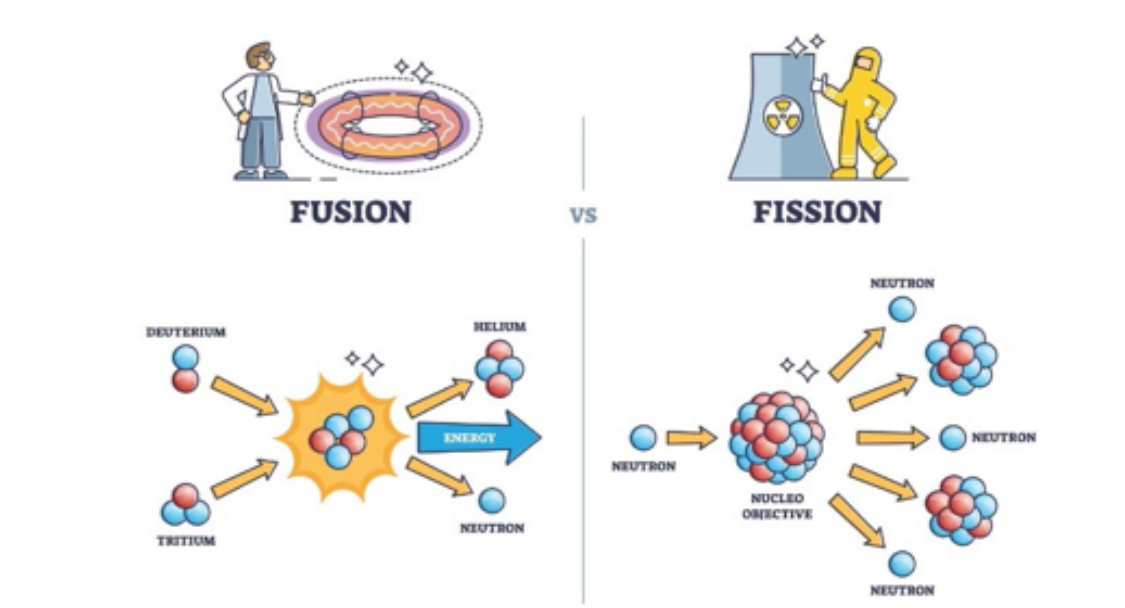
NUCLEAR FUSION WEAPONS: A DEJAVU

Giuseppe Cima
USIPD - Castiglioncello - Oct 2023



I assume everybody is familiar with the basic nuclear fission and fusion reactions, for an introduction refer to Wikipedia.
Italian prime Minister Mario Draghi spoke enthusiastically about fusion as an energy source in the last parliament plenary session and our ecological transition minister, Roberto Cingolani, routinely says on TV that fusion is the way to go since the sun uses it too.
The sun fuses hydrogen at a rate comparable to our metabolism, this very low power density is useless on earth, stars can be as bright as they are thanks to their enormous volume to surface ratio.
The propaganda also claims that deuterium tritium fusion power will be inexhaustible, clean and safe. Nothing is further from the truth: tritium doesn't exist in nature and it's very doubtful if it can be produced in sufficient quantity in a running reactor (M. A. Abdou et al., "Physics and technology considerations for the deuterium–tritium fuel cycle and conditions for tritium fuel self-sufficiency, Nuclear Fusion 61,

13001, 2021).
About radioactive waste and safety, at turn on, a magnetically confined reactor will radio-activate ten thousand tons of all metals it's made of and its magnets could explosively release hundreds of kg of TNT-equivalent magnetic energy with unpredictable consequences. What interests us here most is that fusion could also become a dangerous technology for arms proliferation.
There are three ways this could happen: breeding of fissile materials, making tritium available for thermonuclear weapon (if any will ever be produced) and showing how to manufacture directly-driven fusion explosives.
Fusion reactors are neutron factories, most of the energy produced exits the plasma as energetic neutrons. It would be easy to use this large neutron flux to transmute fissile material but we shouldn't be too concerned about it since it would be a lot easier to achieve it with a less complex and much more economical fission plant.
The most worrisome outcome, according to me, is the one of inertial confinement weapons described later in more detail.

ENTREPRENEURS FUSION

In the last two decades a flurry of new initiatives, 43 as today, have been started to speed up the quest of fusion for energy, the same fusion research which has been underway since the 50's in many national labs around the world.

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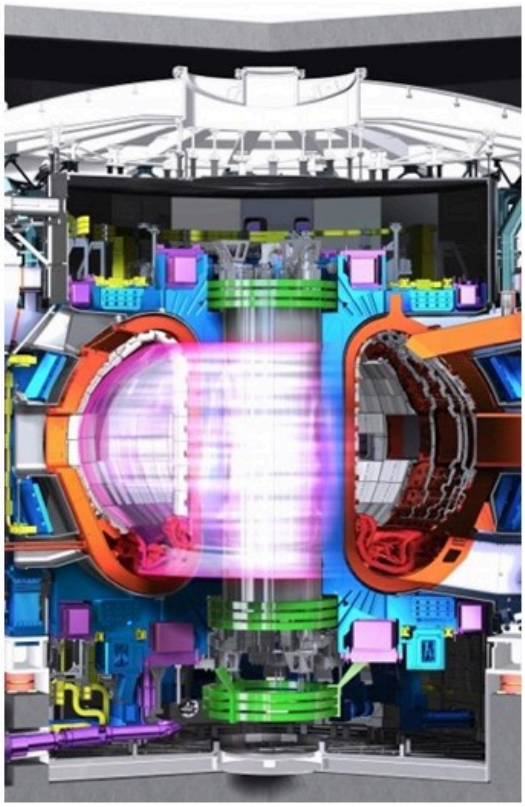
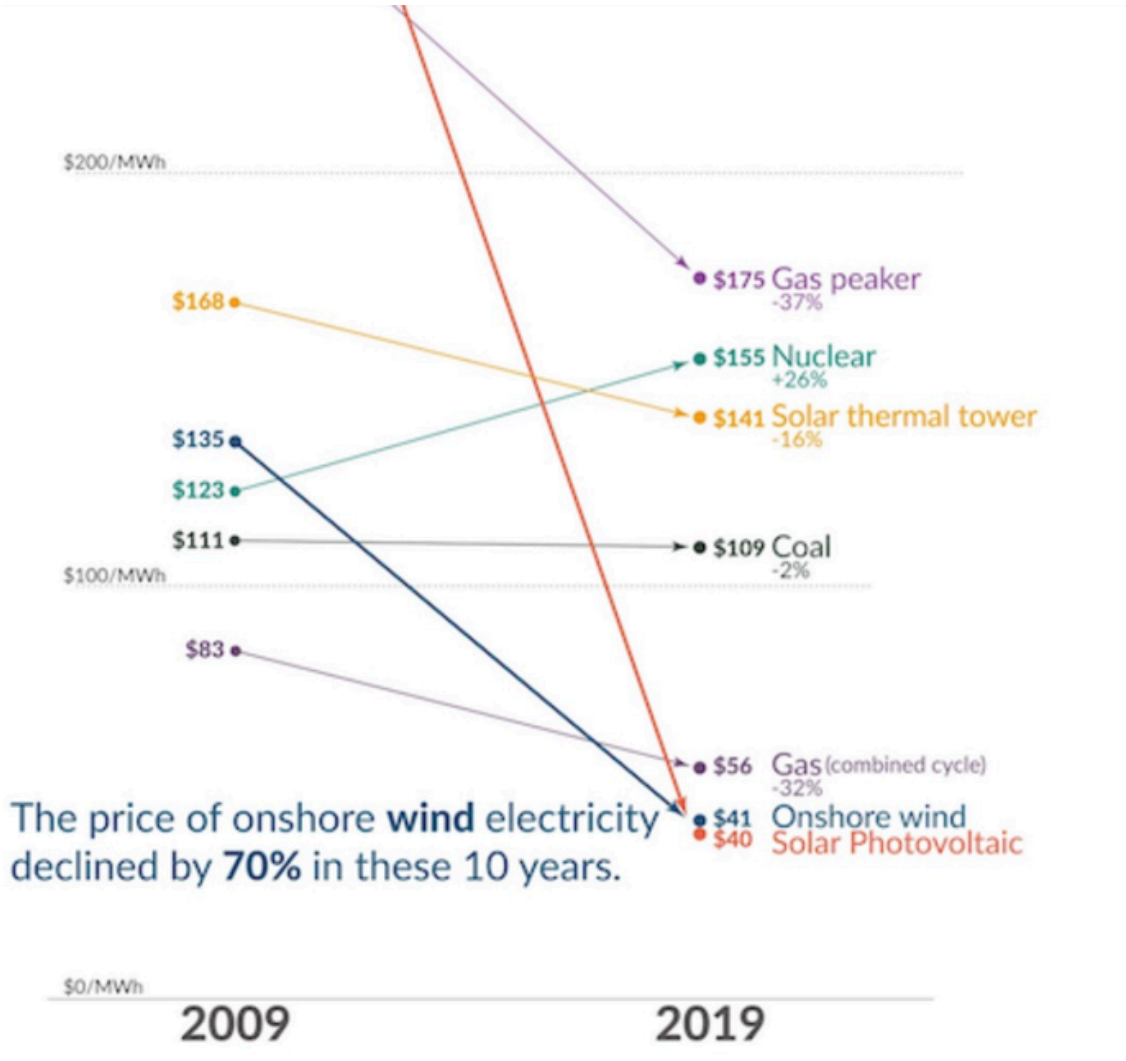


The picture on the right shows a rendering of ITER , the 40 B$ program now at the forefront of this research, the product of traditional academic research in this field, presently under construction in the south of France. A plasma physics experiment, not a prototype energy producing reactor, with its 5 story tall core shown in the picture, well illustrates the wisdom of legitimate academic research to the pretentiousness of private enterprise when one compares it to the suitcase-size cold-fusion power plant, a now demonstrated scam.

In my view all present private initiatives in the field can be understood only as financial speculation, they mostly consist of avenues already explored in the past by academic research and judged not worth pursuing.

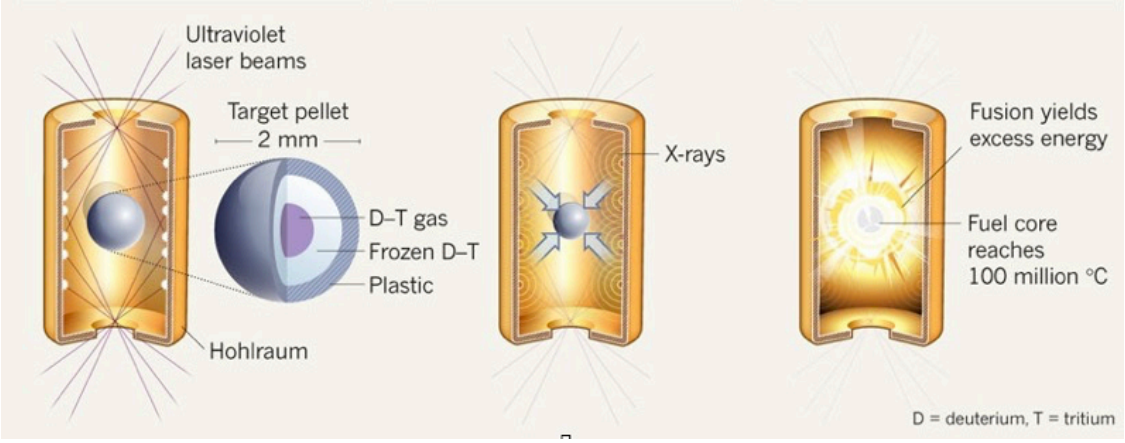
They are hardly startups, TAE for example opened up shop in 1998 and still, a couple of B$ later, has nothing relevant to show. In the private sector there is now more money invested than in the public one. One can never be sure that a new idea will not appear to make perspectives in this field brighter than they are now, I personally haven’t seen one yet though and this is why this field should still be pursued as purely academic research.

My main concern now is that these adventurous initiatives will soon provoke such a backlash of interest that all the legitimate work done till now will be forgotten.
This situation has already materialized in the two countries most advanced in fusion research. The economics of fusion, for now, is so much worse than fission, whose attractiveness is questionable anyway, that USA and Russia practically stopped funding this research more than 20 years ago at the apex of their expertise. It's indicative that the US investment in ITER is now more than ten times lower than the one of Italy, on a per capita basis.



INERTIAL CONFINEMENT FUSION

As far as nuclear arms proliferation is concerned the most “promising” area of fusion research is the one of inertial confinement .



H bombs are a form of inertial confinement where the thermonuclear fuel is ignited by a fission explosion. Most modern weapons are actually boosted by a fusion stage but they remain primarily a fission device. In what we are discussing here the fusion fuel must be ignited by an alternative, non fission, driver. This is the case for recent National ignition Facility successful experiments.
These less than one year old experiments have demonstrated ignition but not wall-plug to wall-plug energy balance. There is still at least a couple of orders of magnitude gap to fill to get to energy breakeven, nevertheless they show a small burning pellet explosively releasing its thermonuclear energy of around one kg of TNT.
The picture above shows the geometry of the arrangement, not a simple, or inexpensive, target but a working one, the target technology has been perfected.
Before getting to a deployable weapon a smaller and less expensive driver needs to be invented to replace the one used now. The 192 laser beams employed to ignite the pellet took two decades to build and occupy the space of a couple of football fields.
A similar setup is available presently also in France at the Mégajoule Laser (LMJ), CEA, Direction des Application Militaires.
Both experiments are the result of multi billion dollar budgets

provided by the military.
Private enterprises are working in this field too, claiming non military objectives: Marvel Fusion in Bavaria for example and, with a completely different approach, First light Fusion, a British company with shock-tube technology. If they would turn out to be successful more affordable weapons might become available too.

INTERMEDIATE DENSITY FUSION

There is an alternative way to reach ignition with the help of both magnetic confinement and fast compression of the fuel called intermediate density fusion.
An example is the one of General Fusion, best known for being richly endowed by the patron of Amazon, Jeff Bezos.

In the past there have been other attempts, for example at ENEA's Colleferro Laboratories in the 70s ("50 years of fusion research in Italy" edited by ENEA's Paola Batistoni) which were abandoned then for lack of interest but something similar is now being revived in the States (Boosting Inertial-Confinement-Fusion Yield with Magnetized Fuel, John D. Moody, LLNL). Is this an alternative way to get to practical fusion weapons?

MILITARY APPLICATIONS

The New York Times

Breakthrough in Nuclear Fusion Offers Hope for Power of Future

European Team Reports Brief Million-Watt Yield

WORLD'S APPETITE FOR U.S. PRODUCTS IS STILL INCREASING

Billions of dollars military financing is the smoking gun of this research main objective even if the Comprehensive Nuclear-Test-Ban Treaty (CTBT) is often used to justify the investment. These micro-explosions have a yield small enough to be treaty compatible. and they could be useful to understand more of matter in these extreme conditions.

It's kind of interesting that the opposite has been true, classified fission explosions have been performed to experiment with millimeter size fusion targets, see for example *Breakthrough in nuclear fusion*, the New York Times, March 21, 1988, A, Pg. 1.

Contrary to what often claimed in the press NIF experiments have minimal relevance for energy production, repeating these explosions at the required high rep rate seems now impossible. Fusion weapons will come a lot sooner than peaceful applications

These miniature but deadly devices sound very attractive for an invading army: a territory free from defenders, and immediately walkable after the explosion, is every general's dream.

In the proliferation context one should ask how would these weapons work as a deterrent and I have never heard of any war scenario investigating neutron bombs.

CONCLUSIONS

what would they think today?

To conclude, wind and photovoltaics are making fusion for energy unattractive before it has been emonstrated and military applications should discourage from digging deeper in this research. But many question marks are still here.
Is this "science" stoppable? Given their potentially small yields would new fusion weapons be an opportunity for less destructive conflicts rather than a nuclear war threat? How difficult would it be to acquire such a weapon?
Fusion research was born questioning the genesis of the stars, does it have other applications? It’s not a frontier science but a form of “nuclear chemistry" with potentially aberrant applications.
For now it’s a very demanding technology, not for garage experimenters, its advancement depends on our collective choice, but it’s already more advanced than when Szilard involved Einstein to get to Roosevelt to promote the construction of the first A bomb.
The genie is about to come out of the lamp.