Alternative approach to nuclear fusion energy at German lab takes important first step

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On December 10, 2015, an experimental device 14 years in the making, called Wendelstein 7-X, achieved an important first milestone in its mission to prove that fusion, the process that powers the sun, can be harnessed by mankind for power generation. The device produced its first helium plasma—more on what this actually means later.

Wendelstein 7-X, known more technically as a stellerator, is located at the Max Planck Institute for Plasma Physics (IPP) in Greifswald, Germany and is the result of an international collaboration, with funding coming predominantly from the German government and the European Union (EU). To commemorate its "maiden voyage," the event was streamed live to fusion laboratories across Europe. It received widespread media coverage in Germany and abroad.

The source of the excitement surrounding the operation of the device derives from what it hopes to achieve. The scientists and engineers who designed and built the stellerator are attempting to show that a new type of reactor design could provide a more attainable path to the coveted prize of commercial fusion power. Fusion could be the silver bullet for humanity's energy woes; it is carbon-neutral, and its source of fuel is cheap and practically limitless. Moreover, fusion reactors would produce far less troublesome radioactive waste than nuclear fission and there is no risk of chain reactions like the one that caused the Chernobyl disaster.

However, it has been notoriously difficult to prove that a viable fusion reactor can be created: the physical conditions necessary for fusion to occur are extreme. An individual fusion reaction requires two small, positively charged atomic nuclei, composed of protons and neutrons, to "fuse" together. The result is a comparatively large amount of energy, in accordance with Einstein's famous equation, *E=mc2*, but since the nuclei are both positively charged and so repel each other, they need to be travelling at high speeds to overcome this barrier.

Correspondingly, the fusion fuel must attain temperatures about ten times hotter than the centre of the Sun. At these temperatures, the fuel enters the fourth state of matter, known as plasma: the electrons and nuclei that are typically bonded in atoms become partially or completely disassociated (or ionized). Evidently, there are no materials capable of containing such energetic charged particles without themselves disintegrating, and one scheme to confine the fuel plasma is to use magnetic fields of extraordinarily high magnitude.

As a stellerator, Wendelstein 7-X uses numerous, strangely shaped electromagnetic coils in a "toroidal" or donut arrangement to create a correspondingly bizarre magnetic cage.

This complex design required over ten years of planning and theoretical calculations conducted on incredibly powerful supercomputers to produce what the physicists hope will be an optimal result. The 70 coils, each about 3.5 metres tall and weighing a few tons, are made of expensive superconducting material and needed to be placed with millimetre precision. In all, the magnets and supports weigh 425 tons and must be enclosed in a cryogenic vacuum vessel, all cooled to a few degrees above absolute zero.

It is hoped that this arrangement will optimally confine the fusion plasma, avoiding the instabilities and particle losses endemic to other strategies. The December 10 event marked the first plasma produced in Wendelstein 7-X using helium atoms as fuel. A further step was taken on February 3, 2016 using a different fuel, hydrogen. This is important because the ideal fusion reaction is between isotopes (i.e., heavier forms) of hydrogen.

Of course, to reach this impressive achievement and conquer the numerous complexities, many man-hours and extensive funding were necessary. In total, over one million assembly hours and €370 million for components, rising to €1.03 billion if operating costs are included, were required. Such logistics are not uncharacteristic of large-scale, international scientific endeavours. A related project to build the world's largest fusion reactor, called ITER, has a current estimated cost of between €13 and €15 billion, earning the title of humanity's most expensive experiment, and construction will not likely be completed until the early 2020s.

Cutting-edge science is necessarily costly in every sense of the word, but some context is required to evaluate whether enough resources are being directed towards fusion research. An apt comparison is with the fossil fuel industry, since fusion will one day enter the energy market. Minimal new research funding has been directed to fossil fuel extraction because it is a fairly mature industry, but in 2013 alone, it is estimated by the IEA (International Energy Agency) that global government subsidies for the fossil fuel industry totalled $530 billion.

This is staggering to contemplate. Even if the costs for the most expensive science experiment in the world, viz. ITER, were condensed into one year, this would still only account for about 3 percent of the amount governments spend in supporting the consumption and production of fossil fuels. Even more perplexing is the fact that the scientific community widely accepts that fossil fuels are the main contributing factor to anthropogenic climate change.

In this light, it would seem foolish to quibble over the comparatively minor budgets of scientific research projects that could directly assist in providing clean, abundant energy. Yet the exact opposite is the case. For instance, NCSX, a similar device to Wendelstein 7-X, which was being built at the Princeton Plasma Physics Laboratory (PPPL) in the United States, was cancelled by the Department of Energy due to cost overruns. Similarly, the ITER project is at risk because of its budgetary woes, construction delays, and the looming threat that the US government may pull its support.

Such a contrast in funding and neglect of foresight can only be explained by a global political and economic system that is completely subservient to short-term profits and capital accumulation. It is solely through a mass movement of the working class that this system can be overturned, so that science is at liberty to solve humanity's problems and fully conquer nature.