Start-up fusion

Publicly funded nuclear fusion laboratories are experiencing competition from the private sector, giving new energy to the field.

A large part of the academic research undertaken by physicists is, in one way or another, driven by the pursuit of practical applications. But actual, sellable products based on ideas explored in academia are rarely designed, let alone produced, in universities or research institutes. Rather, this typically happens, as soon as a proof of concept has been demonstrated, in start-up companies spun off from research organizations or completely independent ones.

In certain technological sectors — electronics and biotechnology are good examples — the valuable role of start-ups is well established. For applied research done at big facilities, the situation is somewhat different. An interesting case in point is nuclear fusion research, with its main aim of a power plant exploiting the notion that energy is produced when lightweight nuclei fuse.

To make fusion reactions happen, one needs to heat and confine matter into a plasma, in which electrons, protons and neutrons are no longer arranged into atoms. Although creating plasma is relatively easy, achieving a steady state of self-sustained fusion reactions has turned out to be an enormously complicated endeavour. For decades, scientists and engineers in publicly funded laboratories, sometimes run as international collaborations, have been working on obtaining sufficient control over a fusion plasma as a crucial step towards energy from fusion. Despite gradual overall progress, including a better understanding of fundamental aspects of plasmas and the development of diagnostics¹ and robotics², the sobering truth is that we still do not have a working reactor capable of delivering net fusion power. In fact, we will most likely not have one until at least 2035, which is when ITER, currently being built in France and set to become the world's largest fusion reactor, is projected to reach fusion power operation mode — which would still not be a power plant delivering electricity to a grid³.

A breakthrough could come sooner, though. Since relatively recently, several start-up companies have emerged with the sole goal of doing exactly what the big, state-sponsored facilities have failed to do so far: build a fusion machine that can achieve

net fusion power production. At first sight, it seems normal enough to see the appearance of start-ups dedicated to cracking the fusion nut. Developing a scientific concept into a product, in a commercially viable and scalable way, is what start-ups do. But a closer look would make anyone considering to privately invest in fusion research think twice. Is it really likely that a small enterprise, starting from scratch, can deliver in a few years what international collaborations in academic institutions have been working on for decades? Is it really worth spending billions of dollars on it, with the risk of it all being in vain?

It is. The motivation of fusion scientists, both in the public and the private sector, for dedicating their career to the dream of energy from fusion is explored in Arthur Turrell's recommended reading *The Star Builders: Nuclear Fusion & the Race to Power the Planet*⁴ (reviewed in a [Books & Arts](#) by Bart Verberck in this issue). Given that fusion energy would be almost limitless and almost green, it is more than understandable that entrepreneurs want to give it a go. And, along with them, funders — including the likes of Jeff Bezos, Bill Gates and Peter Thiel⁴.

What is interesting about the coexistence of publicly and privately funded fusion research facilities (the International Atomic Energy Agency curates a handy list of fusion devices worldwide at <https://nucleus.iaea.org/sites/fusionportal/Pages/FusDIS.aspx>) is the competition, and with it the tension, it creates — a theme also explored in Turrell's book⁴. A common reaction from scientists at the big governmental facilities is scepticism. Given the complexity of the task, it may indeed look unlikely that some small collective will solve the matter in a few years. Plus, 'alternative' fusion research outside of the established laboratories has had a bit of an image problem. Perhaps one shouldn't refer to it, but the pathological-science case of 'cold fusion' — the claim of fusion reactions in a test tube at room temperature — has not done the community any good⁵. Also, announcements from within the private sector of imminent success, followed by silence, or adjusted estimated times of delivery, have undermined trust⁴.

The main issue regarding the credibility of the fusion start-ups is that they generally do not, understandably, disclose all the details of their technologies. This makes it somewhat difficult to distinguish the serious players from the quacks. It is, however, reassuring to see — and to be applauded — that several start-ups choose to publish some of their results, including in *Nature Physics*⁶.

Naturally, the arrival of start-ups may make researchers at the governmental institutes nervous. What if a start-up hits the jackpot? Expensive facilities such as ITER would surely be put under heavy scrutiny. But despite the scepticism and the nervousness, many fusion scientists would agree that the diversified fusion research landscape is a good development — competition drives the field forward. Some start-ups are pursuing non-mainstream technologies that definitely are worth investigating. Another noteworthy development is that private companies and state-funded labs are joining forces (e.g. <https://www.psfc.mit.edu/sparc>).

Several fusion scientists have embraced the start-up way of life, with its non-bureaucratic and project-management-style *modus operandi*⁴. One might even argue that fusion start-ups, by providing attractive job opportunities, could very well motivate a new generation of students choosing to study (plasma) physics or nuclear engineering — again, a grander goal than pursuing virtually limitless and clean energy is hard to think of. Openness, as so often, seems the right attitude. Time will tell which path is the quickest to net-energy-from-fusion success. Meanwhile, all (genuine) attempts welcome. □

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