Check for updates

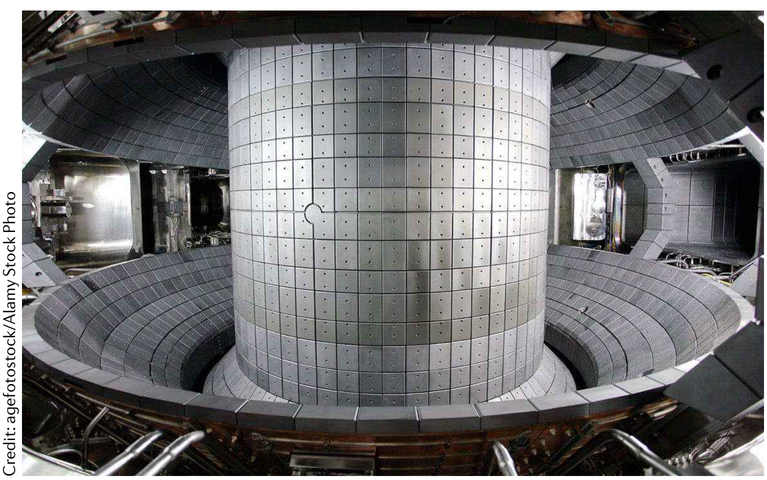
Nature Reviews Physics | https://doi.org/10.1038/s42254-022-00434-6 | Published online 18 February 2022

NUCLEAR FUSION

Machine learning helps control tokamak plasmas

Controlling the magnetic field confining the plasma inside a tokamak is not an easy feat. To create different configurations of the plasma, the magnetic field is adjusted by fine tuning tens of magnetic coils (30 in the case of Korea Superconducting Tokamak Advanced Research (KSTAR), pictured). This adjustment is a well-understood, yet challenging, optimization problem. Writing in *Nature*, Jonas Degrave and colleagues show that reinforcement learning — a type of machine learning where agents try to find the best action in order to maximize a reward — can solve this problem and help create a variety of plasma configurations, including ones that hadn't been achieved before.

Once an objective for the experiment is given (for example, the type of plasma configuration that is desired), the reinforcement learning algorithm finds the optimal 'control policy' by interacting with a tokamak simulation. This simulation is accurate enough from a physics perspective, while staying relatively computationally cheap. The control policy is then directly implemented in real time on the tokamak hardware, that of Tokamak à Configuration Variable, the fusion reactor at the École Polytechnique Fédérale de Lausanne. The desired plasma configurations, some simple, some more complex and an unusual one with two separate plasmas ('droplets'), were successfully realized in experiments. These configurations can be realized with traditional control methods, but the reinforcement learning approach is more straightforward. Moreover, this architecture could be swiftly implemented in new tokamaks.



Credit: agefotostock/Alamy Stock Photo

Reinforcement learning has already been explored for the control and optimization of particle accelerators and light sources, so the study from Degrave et al. adds to the growing machine learning toolbox for experimental physics.

Iulia Georgescu

ORIGINAL ARTICLE Degrave, J. et al. Magnetic control of tokamak plasmas through deep reinforcement learning. *Nature* https://doi.org/10.1038/s41586-021-04301-9 (2022)
RELATED ARTICLES Kates-Harbeck, J., Svyatkovskiy, A. & Tang, W. Predicting disruptive instabilities in controlled fusion plasmas through deep learning. *Nature* **568**, 526–531 (2019) | Kain, V. et al. Sample-efficient reinforcement learning for CERN accelerator control. *Phys. Rev. Accel. Beams* **23**, 124801 (2020)