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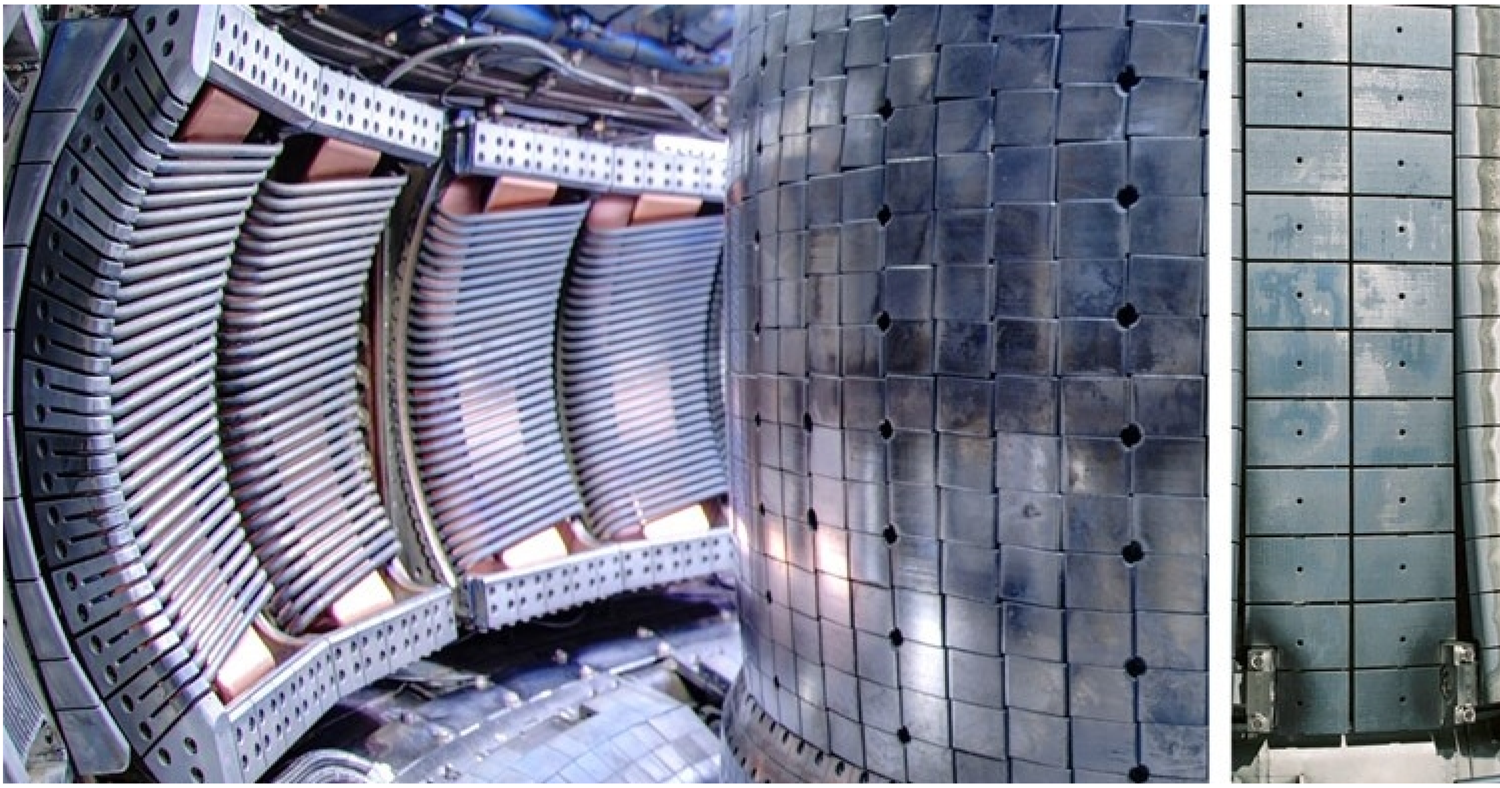
The paper is the effort between important international institutions and describes a new technique for the efficient generation of high-energy ions with electromagnetic ion cyclotron waves in multi-ion fusion plasmas.



Interior view of Alcator C-Mod (left) and JET (right) *tokamak* reactors where experiments reported in the Nature Physics paper were carried out. Source: Plasma Science and Fusion Center, Massachusetts Institute of Technology and EUROfusion.

Barcelona Supercomputing Center researchers, Mervi Mantsinen and Daniel Gallart, have participated in the paper “Efficient generation of energetic ions in multi-ion plasmas by radio-frequency heating”, currently available as Advance Online Publication on the **Nature Physics** website.

The paper describes a new technique for the efficient generation of high-energy ions with electromagnetic ion cyclotron waves in multi-ion fusion plasmas. The method is especially suited for strong wave absorption by a very low number of resonant ions. This study has been a collaborative effort between EU and US scientists together with contributions from a large number of international institutions.

The potential of the method is demonstrated on the world-largest plasma magnetic confinement device, JET (Joint European Torus, Culham, UK), and the high-magnetic-field *tokamak* reactor Alcator C-Mod (Cambridge, USA). The results of this study demonstrate efficient acceleration of helium-3 ions to high energies in dedicated hydrogen-deuterium mixtures.

The new scheme has opened up new ways to heat fusion reactor plasmas such as those in ITER and DEMO to high temperatures needed for fusion to occur. The developed technique can also be applied to explain observations of energetic ions in space-plasma environments, in particular, helium-3 rich solar flares.

Some of international institutions that have contributed to this work are the Laboratory for Plasma Physics - LPP-ERM/KMS (Brussels, Belgium), the Culham Centre for Fusion Energy- CCFE (Culham, UK), the Plasma Science and Fusion Center (Massachusetts Institute of Technology, MIT) and the Barcelona Supercomputing Center (BSC), among others.

The role of BSC

At BSC, ICREA Prof. Mervi Mantsinen and the La Caixa PhD student Dani Gallart were actively involved in the design of the experiments at the JET *tokamak* and modelling of the experimental results. Their simulations confirmed the observed high-efficiency of the electromagnetic power absorption by a tiny amount of helium-3 ions and assessed the resulting modifications in the distribution function of the resonant ion species.

Prof. Mervi Mantsinen is the Fusion Group Manager at BSC. The research of this group is directed towards the development of nuclear fusion as a future energy source. They focus on the numerical modelling of experiments in magnetically confined fusion devices in preparation for ITER operation. Their overall objective is to enhance the modelling capabilities by code development, validation, integration and optimization, with the ultimate goal of helping improve the performance of ITER and future fusion reactors.

About

Fusion energy is released when hydrogen nuclei collide, fusing into heavier helium atoms and releasing tremendous amounts of energy in the process. ITER is constructing a *tokamak* device for the fusion reaction, which uses magnetic fields to contain and control the plasma – the hot, electrically charged gas that is produced in the process.

Alcator C-Mod was a compact, high-magnetic field, diverted fusion device, allowing it to access unique experimental regimes. Located at the Massachusetts Institute of Technology (MIT), it was operating between 1993 and 2016 and was one of the major fusion research facilities in the United States. In 2016 it achieved the record for highest volume average plasma pressure, which is an important metric for fusion performance.

The Joint European Torus (JET) is located at the Culham Centre for Fusion Energy in Oxfordshire, Great Britain. JET is presently the largest and most powerful fusion reactor in the world and studies fusion plasmas in conditions approaching those needed for a fusion power plant. It is the only existing magnetic confinement fusion device capable to operate with D-T plasmas as will be used on ITER. **The work for this project at the JET *tokamak* was carried out under EUROfusion.**

EUROFUSION is the ‘European Consortium for the Development of Fusion Energy’ and manages and funds European fusion research activities. The EUROfusion consortium is composed of the member states of the European Union plus Switzerland and Ukraine as associated members.

Fusion for Energy (F4E) is the EU organisation managing Europe’s contribution to ITER. It was established in April 2007 for a period of 35 years. Its seat is in Barcelona.

ITER is the international nuclear fusion R&D project, which is building the world's largest experimental *tokamak* nuclear fusion reactor in France. ITER aims to demonstrate that fusion energy is scientifically and technologically feasible by producing ten times more power than is needed to start and maintain the fusion reactions.

Reference:

Kazakov YeO, Ongena J, Wright JC, Wukitch SJ et al including Mantsinen MJ & Gallart D (2017). Efficient generation of energetic ions in multi-ion plasmas by radio-frequency heating. Nature Physics, advance online publication, 19 June 2017; **http://dx.doi.org/10.1038/nphys4167**

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