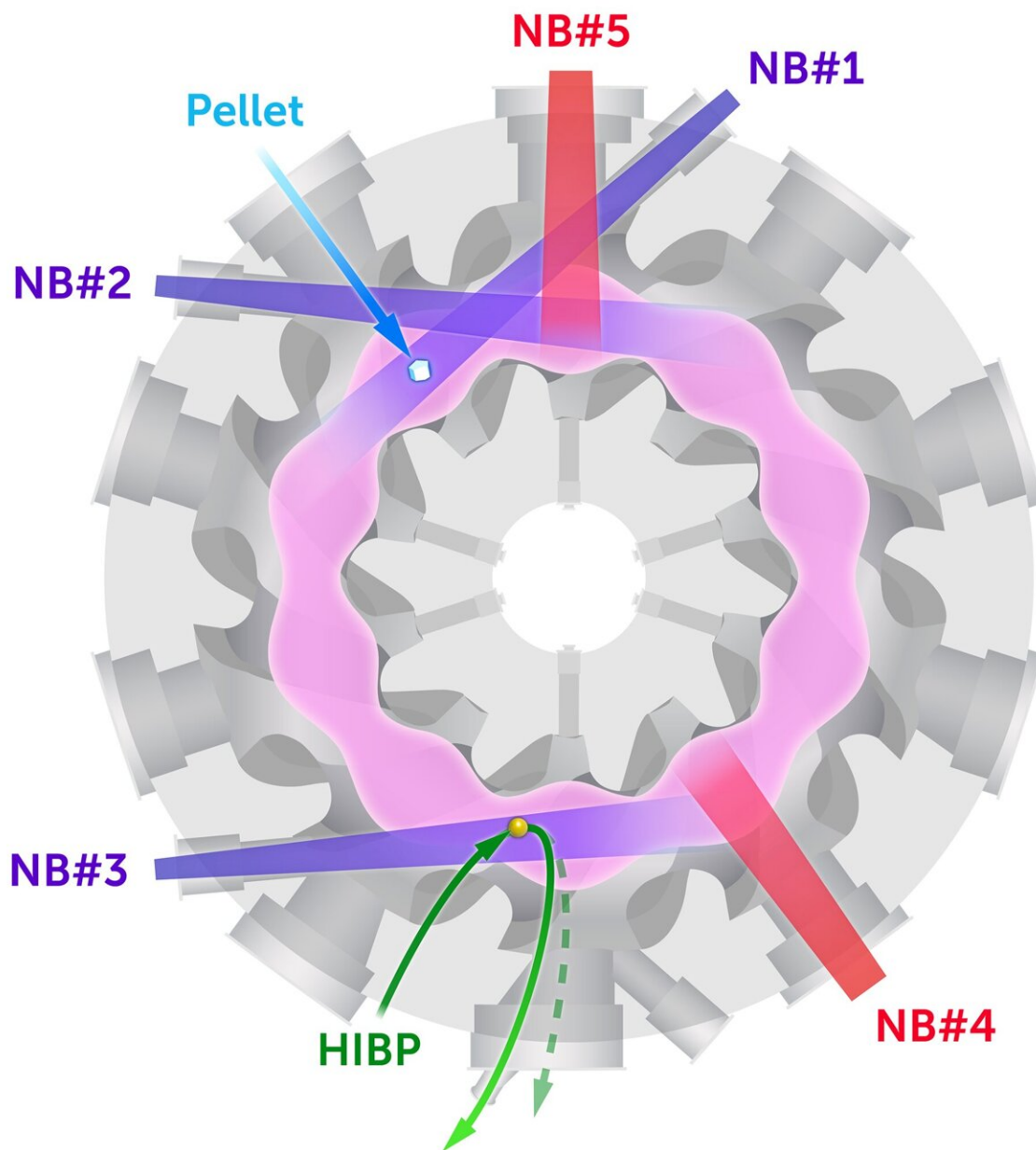


Researchers find potential new method to control plasma density in fusion reactors

June 24 2024



© National Institute for Fusion Science

LHD and neutral beam arrangement. The magnetic field exists in a clockwise direction. Credit: National Institute for Fusion Science

In the realm of fusion research, the control of plasma density, temperature, and heating is crucial for enhancing reactor performance. Effective confinement of plasma particles and heat, especially maintaining high density and temperature at the core where fusion occurs, is essential.

In the Large Helical Device (LHD), challenges persist as the electron [density](#) profile often remains flat or even depressed at the center, complicating efforts to sustain high central density.

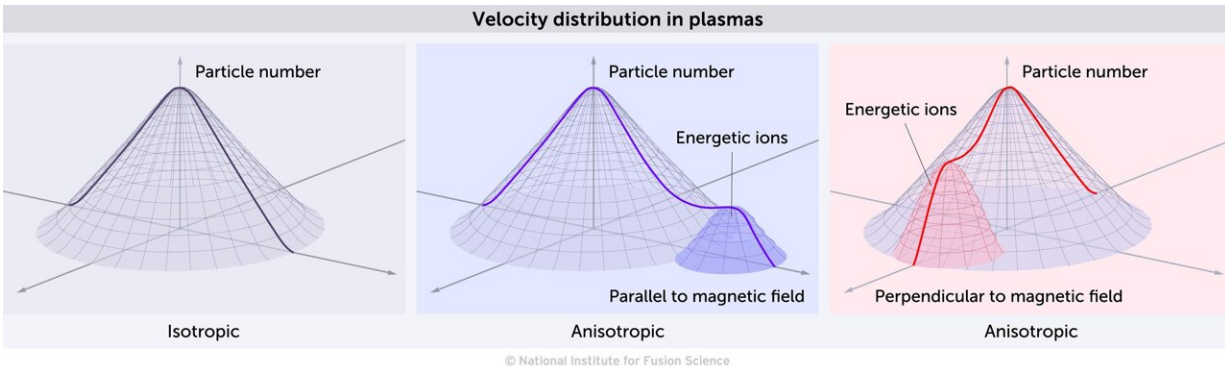
The LHD is equipped with five neutral beam (NB) injectors for [plasma](#) heating. Injectors NB#1 to NB#3, deliver beams tangentially to the [magnetic field](#), while NB#4 and NB#5 inject beams perpendicularly. Despite variations in the power ratio between tangential and perpendicular injections, the ion temperature profile remained unchanged.

Adjustments in the tangential to perpendicular energetic ion ratio alter the velocity distribution from isotropic to anisotropic. The researchers explored how density profile depends on the state of these energetic ions by analyzing the ratio of the stored energies in the perpendicular and parallel components, designated as $E_{n\perp}/E_{n\parallel}$ from the injected beam power of NB#1–NB#5.

Modifying the anisotropy within a range from $E_{n\perp}/E_{n\parallel} = 0.3$ to 0.8 , showed that $E_{n\perp}/E_{n\parallel} > 0.4$ resulted in centrally peaked electron

density profiles.

Subsequently, the density profile of carbon ions was examined by externally injecting carbon and observing the ion behavior. The research is [published](#) in the journal *Physics of Plasmas*.



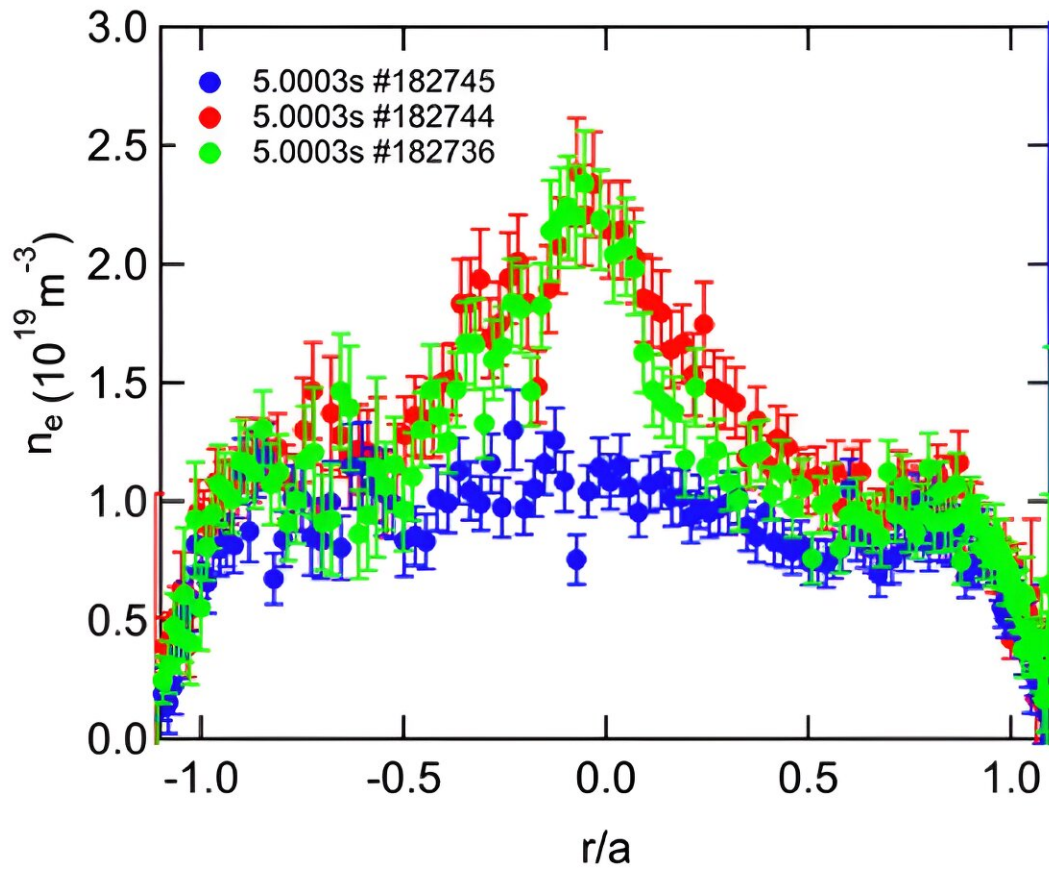
(a), (b), and (c). Velocity distribution in plasmas. Credit: National Institute for Fusion Science

The [profile](#) was centrally depressed in the conventional experimental range of $E_{n\perp}/E_{n\parallel} \perp/E_{n\parallel} > 0.4$.

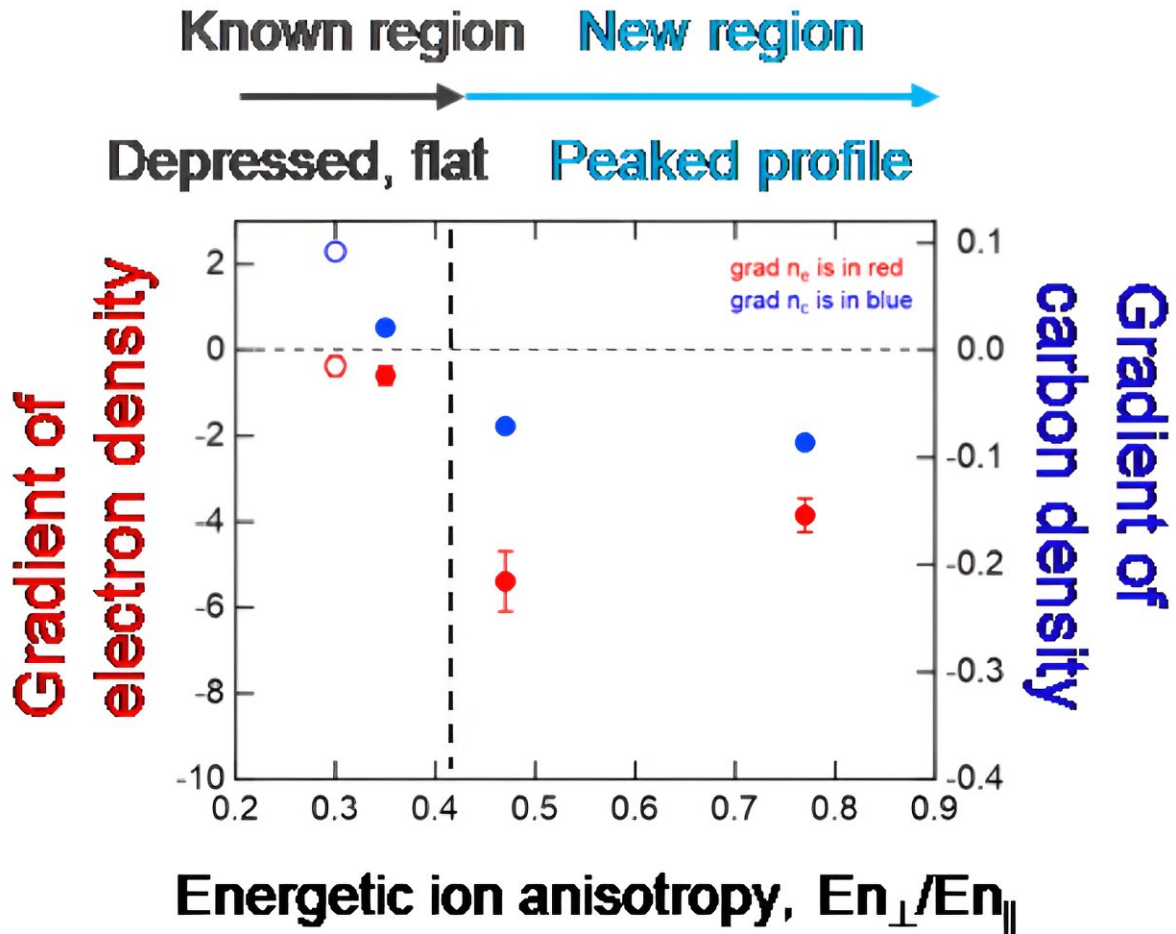
These findings suggest that the plasma inflow/outflow rates change spontaneously with the presence of energetic ions. Further investigations into the effects of energetic ions were conducted using simulation calculations.

Initially, the investigators analyzed the electric field in the radial direction at the plasma core, which simulated -5 kV/m, consistent with measurements from the heavy ion beam probe (HIBP). Although an [electric field](#) of this strength is unlikely to influence particle flow

significantly, further analysis of particle inflow and outflow due to turbulence was conducted. The results suggest that turbulence may influence both peaked and flat density profiles.



Electron density profiles in plasmas. Changing high-energy ion state shows the peaked and flat density profiles. Credit: National Institute for Fusion Science



Relation between electron and impurity density gradients in plasmas and energetic ion anisotropy $E_{n\perp}/E_{n\parallel}$. Credit: National Institute for Fusion Science

Significance of research results and future developments

This discovery elucidates that the direction and volume of particle inflow and outflow within the confinement region of fusion plasma can be effectively regulated by applying the anisotropic nature of energetic ions, thereby keeping the plasma in an optimal state.

According to the researchers, the new physics mechanism behind this must be clarified. The researchers say they will further develop their research to contribute to higher performance of fusion reactor plasmas, downsizing of fusion reactors, improvement of energy output, and control of plasma burning conditions.

More information: M. Nishiura et al, Core density profile control by energetic ion anisotropy in LHD, *Physics of Plasmas* (2024). [DOI: 10.1063/5.0201440](https://doi.org/10.1063/5.0201440)

Provided by National Institutes of Natural Sciences

Citation: Researchers find potential new method to control plasma density in fusion reactors (2024, June 24) retrieved 28 June 2024 from <https://phys.org/news/2024-06-potential-method-plasma-density-fusion.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.