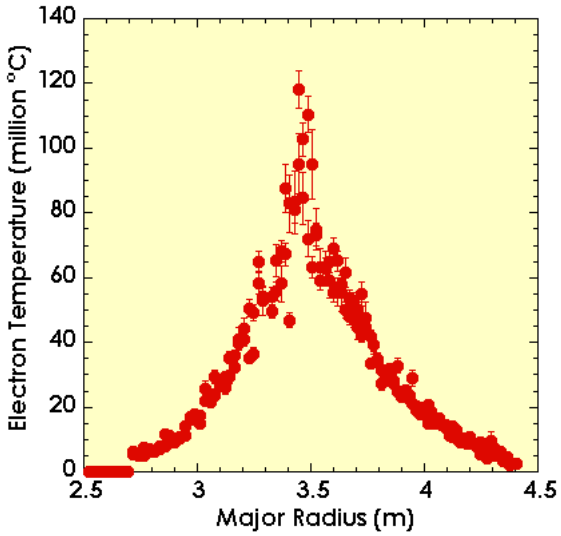
Achievement of a High Electron Temperature of 100 Million Degrees Celsius in Large Helical Device Stimulates Perspective of Helical Fusion Reactor

Achievement of a high-temperature plasma is crucial for stellerators / helical systems. A theory predicts that a radial electric field of the plasma would suppress an enhanced loss of the high-temperature plasma, leading to a rise in the plasma temperature. The helical system has a high potential of the steady-state operation required inevitably for the fusion power plant, in contrast to the tokamaks which are basically in a pulsed operation. (Much effort is now concentrated on the steady-state operation of the tokamaks.) Therefore, it is very important to demonstrate a high-temperature plasma relevant to the fusion reactor in a large-scaled helical machine.

Recently, in the Large Helical Device (LHD), which is a world-largest superconducting helical system operated by National Institute for Fusion Science, Japan, 100 million degrees Celsius of the electron temperature has been achieved. The plasma electrons are heated by intense microwave focused strongly on the magnetic axis of the torus. The electron temperature profile shows a centrally peaked profile with a steep gradient, which suggests the suppression of the electron heat loss. In the case of superposition of the focused microwave on the beam-heated plasma, we observe a special shape of the electron temperature profile, just like so-called internal transport barrier (ITB) in tokamaks, which suppresses the electron heat flow locally inside the plasma. The radial electric field is observed in the central region, and is confirmed to reduce the electron heat diffusivity inside the barrier. As for the ion temperature, high-power neutral-beam heating has realized 58 million degrees Celsius of the ion temperature.

The achievement of high temperature plasmas with suppression of the heat loss by the radial electric field in the LHD is significant to prospects for the helical fusion reactor. The observation of the ITB-like electron temperature profile similar to that in tokamaks also contributes to further understanding of high-temperature plasma physics.



High electron temperature exceeding 100 million degrees Celsius is achieved in centrally focused microwave plasmas. It is observed a centrally peaked profile with a steep gradient, which suggests the suppression of the electron heat loss.

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