stellarator news

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Limiter experiments on LHD

The energy confinement time in the Large Helical Device (LHD) is systematically higher than that predicted by the 1995 International Stellarator Scaling (ISS95) [1] and is comparable to values obtained in tokamaks with ELMy H-mode confinement. This improvement is attributed to configuration control and to the formation of a high edge temperature (a pedestal) [2]. The heat transport in the pedestal is smaller than the gyro-Bohm transport [3]. As a result, the pedestal sustains good core confinement similar to thaat observed in the presence of the internal thermal barrier in tokamaks. Although the limiter plate is small, the divertor flux (measured by a Langmuir probe) was reduced by the limiter insertion. Moreover, the pedestal was observed to maintain its width at the edge region bounded by the limiter . No serious degradation of energy confinement time was observed in these experiments.

Plasma discharges in LHD are usually carried out in an open helical divertor configuration. To compare pedestal formation in an open divertor discharge with that in a limiter discharge, and to investigate the dependence of the plasma minor radius on the plasma confinement, a radial movable limiter was installed at the 7.5L lower port of LHD. Figure 1 shows a schematic of the movable limiter along with magnetic flux surfaces for R_{ax} = 3.6 m. The limiter head was made of carbon (IG430U) with high heat conductivity. Plasmas in LHD have an ergodic region surrounding closed magnetic surfaces. The ergodic region is thinnest in the high-field region, near the helical coil, and becomes thicker towards the X-point. To avoid the thick ergodic region and to bound the plasma sharply, the limiter was inserted into the high-field side of the plasma, as shown in Fig. 1. The limiter position is controlled remotely with an accuracy of 0.5 mm.

Figure 2 shows the normalized ion saturation currents in discharges with electron cyclotron heating, as measured with Langmuir probes installed on the divertor plates in various toroidal and poloidal positions. When the limiter was inserted at a normalized radius ρ = 0.8, the flux to the divertor plate fell almost to zero at every position. This

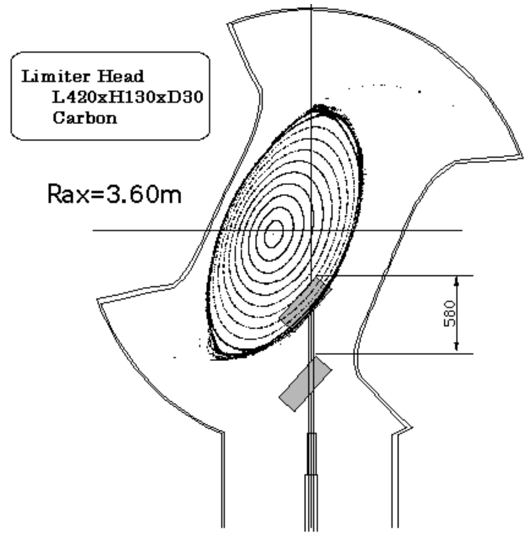

Fig. 1. Schematic of the LHD limiter, which is inserted into the high-field edge region.

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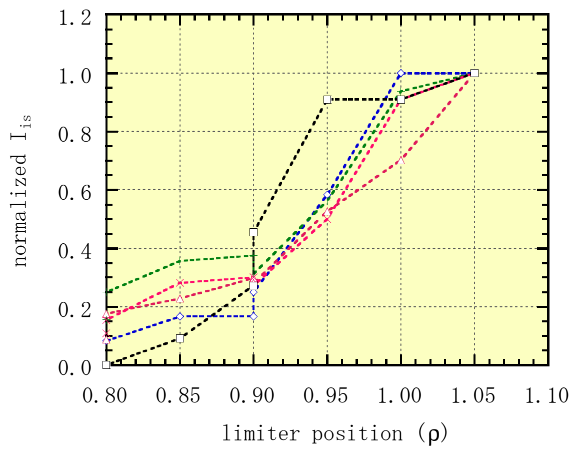

Fig. 2. Dependence of the normalized ion saturation current on the limiter position. The different curves are for the separate Langmuir probe currents.

limiter interrupts the plasma flow to the divertor plate quite effectively.

Figure 3 compares radial electron density and temperature profiles for an open divertor discharge (labeled "w/o limiter") and a limiter discharge ("with limiter"). The electron temperature profiles are measured with a multichannel YAG Thomson scattering system [4] along the major radius at the horizontally elongated position, and the electron density profiles are derived from the results of a multichannel FIR laser interferometer [5] measurement using Abel inversion at the vertically elongated position. To compare results in different positions, a flux coordinate ρ is used as a radial indication. Arrows in this figure show the equivalent limiter position. The electron temperature was well bounded by the limiter. However, the plasma density expanded past the limiter, as shown in Fig. 3. A similar phenomenon was observed in the open divertor discharge. The plasma density is maintained into the ergodic region ($\rho > 1.0$) as shown in Fig. 3. A clear change of the electron temperature gradient can be seen at $\rho \sim 0.85$ in the divertor discharge and $\rho \sim 0.6$ in the limiter discharge. A high temperature gradient is maintained in both discharge conditions.

Figure 4 shows dependences of the central electron temperature T_{e0}, electron temperature at pedestal knee position T_e^{ped}, line-averaged electron density $\langle n_e \rangle$, pedestal width $\Delta\rho_{ped}$, and temperature gradient at pedestal $T_e^{ped}/\Delta\rho_{ped}$ on various limiter positions. Here, the position $\rho = 1.2$ corresponds to the limiter position farthest from the plasma, the lowest position in Fig. 1. Because the electron temperature at the pedestal knee position and the pedestal width are kept constant at every limiter position, the temperature gradient at pedestal is kept high.

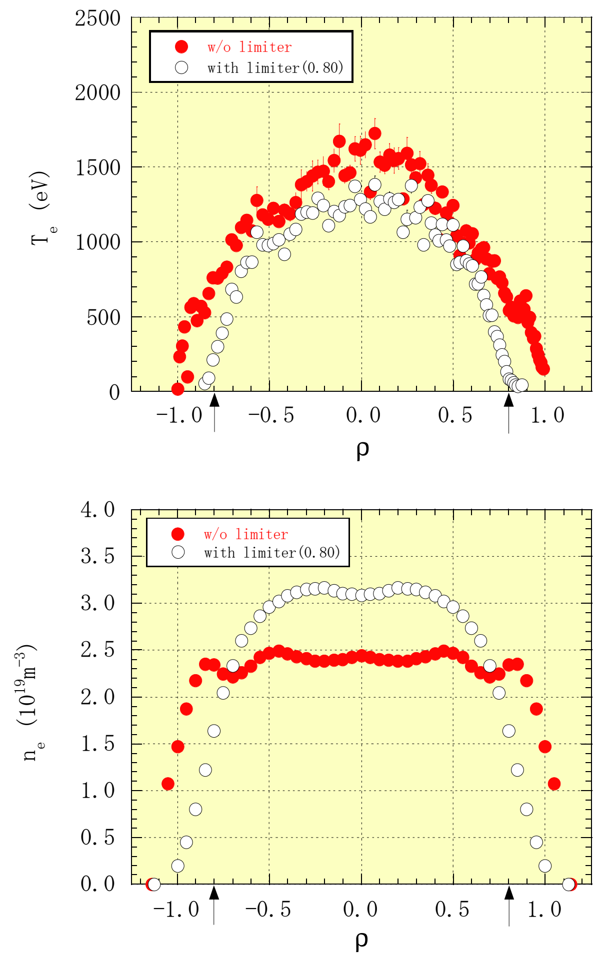

Fig. 3. Electron temperature (top) and density (bottom) profiles with and without a limiter. The equivalent limiter position is indicated by the arrows.

The formation of the pedestal configuration led to good energy confinement in divertor discharges [3]. Since pedestal formation is also observed in limiter discharges, good energy confinement is also expected in limiter discharges. Figure 5 shows the energy confinement time normalized with the ISS95 scaling in various limiter positions. An enhancement factor of 1.1 ± 0.3 from ISS95 scaling was observed at every limiter position, and no serious degradation of the energy confinement time was observed.

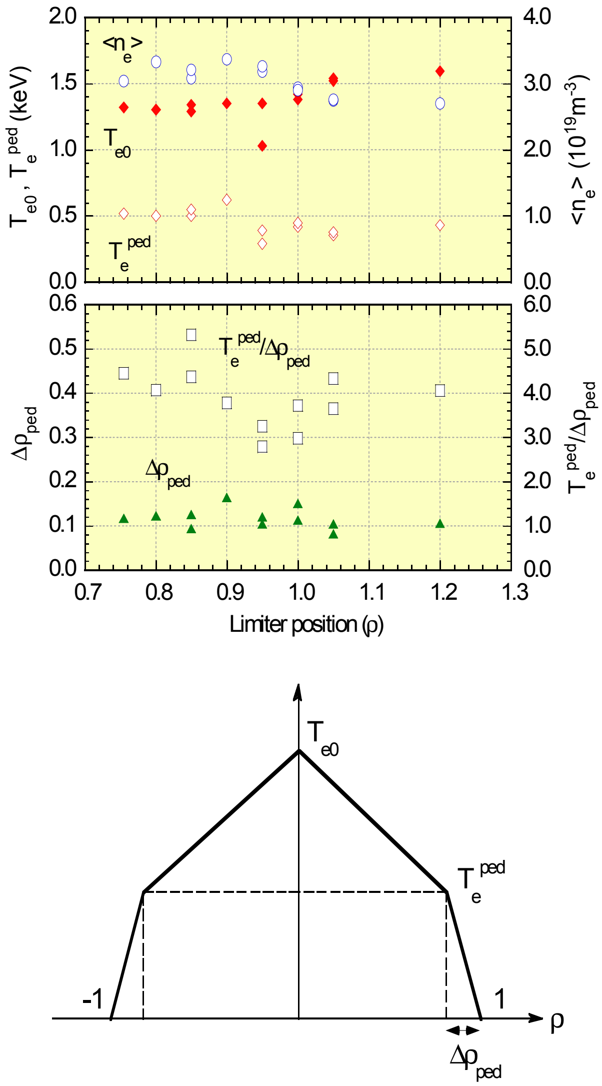

Fig. 4. Dependence of central electron temperature T_{e0}, pedestal electron temperature T_e^{ped}, average electron density $\langle n_e \rangle$, pedestal width $\Delta\rho^{ped}$, and temperature gradient at pedestal $T_e^{ped}/\Delta\rho^{ped}$ on limiter position. Limiter position is expressed in flux coordinates, and ρ = 1.2 means the position farthest from the plasma.

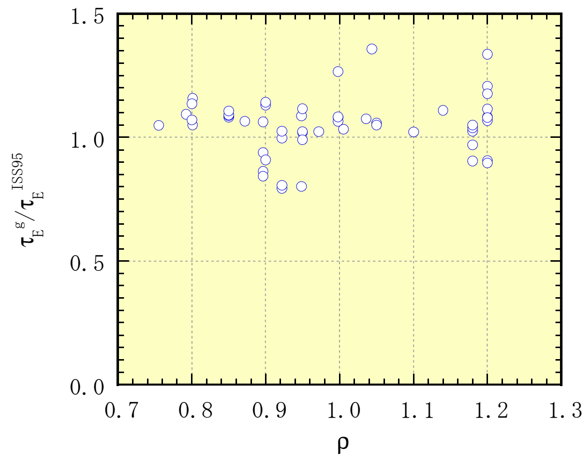

Fig. 5. Comparison of the LHD energy confinement time to the ISS95 scaling.

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People

Thomas Klinger new division head at IPP Greifswald

As of 1 April 2001, Prof. Thomas Klinger is scientific member of the Max-Planck-Institut für Plasmaphysik (IPP) and head of the newly formed division *Experimental Plasma Physics 5*. It is one of the three scientific divisions at IPP Greifswald, together with *Stellarator Theory* (Prof. Jürgen Nührenberg) and *Experimental Plasma Physics 3* (Prof. Friedrich Wagner).

Thomas Klinger obtained his Ph.D. in physics at the University of Kiel. His research has been in the fields of gas discharge and plasma physics with an emphasis on the investigation of nonlinear phenomena, drift wave turbulence in magnetized plasmas, and control of plasma instabilities. As a guest scientist, he worked at the Alfvén Laboratory in Stockholm, at the Centre of Theoretical Physics in Marseilles, at the University of Nancy, and at IPP Garching. In 1999 he was appointed professor of experimental physics at the University of Greifswald, and he was elected director of its institute of physics in 2000.

The research topics of his division will be fluctuations, microinstabilities and global instabilities, and turbulence, as well as plasma edge and divertor physics. The experiments will initially be performed at the Wendelstein VII-AS (W7-AS) stellarator in Garching. For complementary basic research on the dynamic behavior of plasma waves and instabilities, the linear VINETA device is being operated in Greifswald. Another important task for the near future is to develop the various diagnostics for the future W7-X device.

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