Experimental Study of Plasma Confinement on EAST

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Abstract

Long pulse plasma (pulse duration up to 60 s) with double null divertor configuration has been successfully achieved by LHCD in the EAST recently. The injected LHW power is up to 1.2 MW at 2.45 GHz. The energy confinement of LHCD discharges is studied experimentally. It is observed that the highest energy confinement time is about 120 ms at plasma current of 0.5 MA during LHCD. The result is in good agreement with the ITER-89 scaling law for L-mode plasma. The confinement of ohmic heating plasma matches the neo-Alcator scaling law on EAST.

1. Introduction

The first plasma was obtained in the Experimental Advanced Superconducting Tokamak (EAST) in 2006. Single-null and double null diverted plasmas were achieved successfully on EAST tokamak in 2007 [1-4]. Lower hybrid wave (LHW) experiment has been oriented for steady-state operation on EAST [5-10]. The LHCD experiment has been conducted on the EAST tokamak since 2008. The highest injected power of LHW is 1.2 MW at 2.45 GHz. The longest pulse duration was achieved up to 60 s by LHCD on EAST. The confinement of LHCD plasmas and ohmic discharges are studied experimentally in this paper. H-mode plasma is expected by the synergy of ICRF heating (4 MW at 30-110 MHz) and LHCD (1.5 MW at 2.45 GHz) on EAST tokamak recently.

2. Experimental setup

EAST is the first full superconducting tokamak with advanced configuration in the world [1, 2]. Its purpose is to establish a scientific and technological basis for the next generation of tokamak reactors. The EAST toroidal field system comprises 16 D-shaped toroidal field coils; the superconducting coils can create and maintain a toroidal magnetic field, B_T, of up to 3.5 T in steady state. The key components of EAST are 14 superconducting poloidal field (PF) coils, current leads and superconducting bus-lines, vacuum vessel, thermal shields, cryostat, divertor and in-vessel components. It had a major radius of R = 1.75 m, a minor radius of a = 0.4 m and an aspect ratio of 4.25. In 2006, the first wall was made of full stainless steel with a Mo limiter, which

was horizontally moveable on the low field side. A full graphite wall with active water cooling system has been installed since 2008 in the EAST as shown in Fig.1 (a). A stable double null configuration was employed as shown in Fig.1 (b) in LHCD experiments successfully.

3. Experimental results

Figure 2 shows experimental energy confinement time of LHCD plasma with the ITER-89 scaling law. It is observed that the highest energy confinement time is about 120 ms at plasma current of 0.5 MA during LHCD. Fig.3 shows H factors for different density. The energy confinement level shows a typical L-mode plasma confinement in Fig.3. When the density is lower at 0.8-1.5 x 10^{19} m^{-3}, higher LHW coupling and higher LHCD efficiency is often observed on EAST experimentally. Figure 4 shows experimental energy confinement time of ohmic heating plasma. The confinement of ohmic heating plasma is agreed with the neo-Alcator scaling law on EAST. It is compared between the plasma energy of LHCD plasma and that of ohmic plasma in Fig.5. A stable double null configuration was applied for plasma control as shown in Fig.1 (b) in LHCD discharges. Fig.6 shows that a full non-inductive current drive discharge is achieved by LHCD. The injected LHW power is 1.2 MW at 2.45 GHz. Fig.7 (a) shows a long pulse discharge of 32 s on EAST. The CCD camera shows a very stable double null configuration (see Fig.7 (b)). The main parameters in long pulse LHCD discharges are: Ip = 250 kA, Bt = 2.25 T, <ne> = 1x10^{19} m^{-3}, and maximum discharge duration time is 60 s as shown in Fig.8.

4. Summary

The confinement of ohmic heating plasma and LHCD discharges are studied experimentally on EAST. The highest energy confinement time is about 250 ms in ohmic discharges. The highest energy confinement time is about 120 ms at plasma current of 0.5 MA in LHCD plasmas. The main parameters in long pulse LHCD discharges were: Ip = 250 kA, Bt = 2.25 T, <ne> = 1x10^{19} m^{-3}, and maximum discharge duration time was achieved up to 60 s. The highest injected power of LHCD is 1.2 MW at 2.45 GHz with double null configuration. H-mode plasma is expected by the synergy of ICRF heating (4 MW at 30-110 MHz) and LHCD (1.5 MW at 2.45 GHz) on EAST in 2010.

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References:

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Caption of figures:

Fig.1 (a) The active water-cooling graphite wall on EAST

Fig.1 (b) Double null divertor configuration for LHCD (shot No. 14291 @ 4.981s)

Fig.2 Energy confinement time vs ITER89 scale law in LHCD discharges

Fig.3 H_{89} factor for different density in LHCD discharges

Fig.4 Confinement of ohmic discharges in the EAST tokamak

Fig.5 Study of stored energy for LHCD and ohmic discharges

Fig.6 LHCD plasma (1.2 MW at 2.45 GHz) with DN divertor configuration

Fig.7 (a) LHCD plasma (t = 32 s) with double null configuration

Fig.7 (b) Evolution of CCD camera during LHCD for shot No.13603

Fig.8 Long pulse LHCD plasma (t = 60 s) on EAST

Figures:

Fig.1 (a)

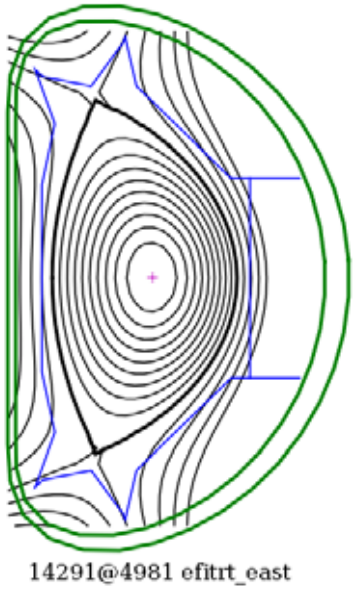

Fig.1 (b)

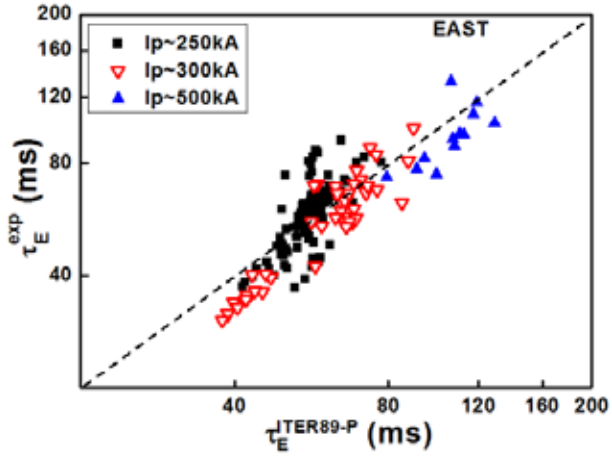

Fig.2

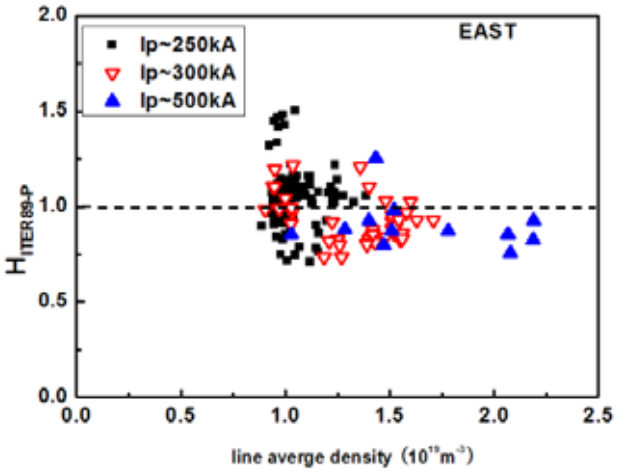

Fig.3

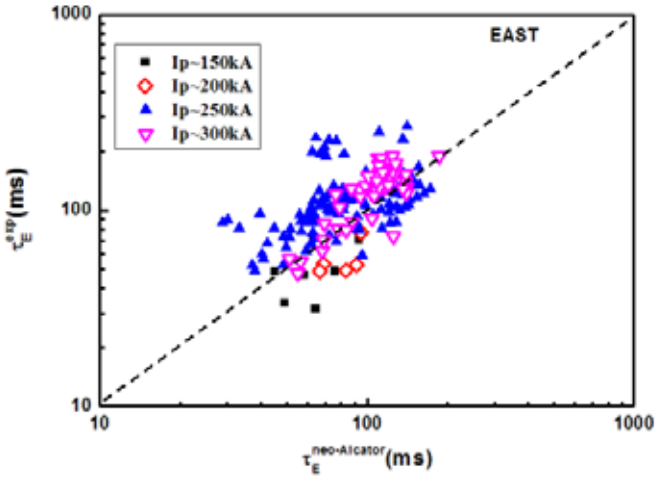
EAST
Ip~150kA
Ip~200kA
Ip~250kA
Ip~300kA
1000
100
10
10
100
1000
τ_E^{fit}(ms)
$\tau_E^{neo\text{-}Alcator}$(ms)

Fig.4

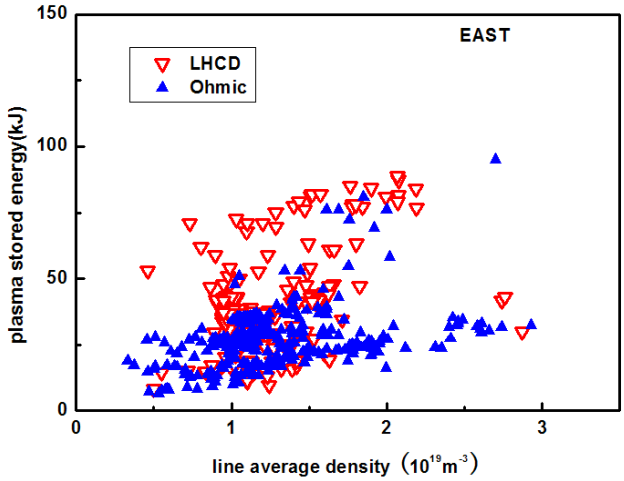
EAST
LHCD
Ohmic
150
100
50
0
0
1
2
3
plasma stored energy(kJ)
line average density ($10^{19}m^{-3}$)

Fig.5

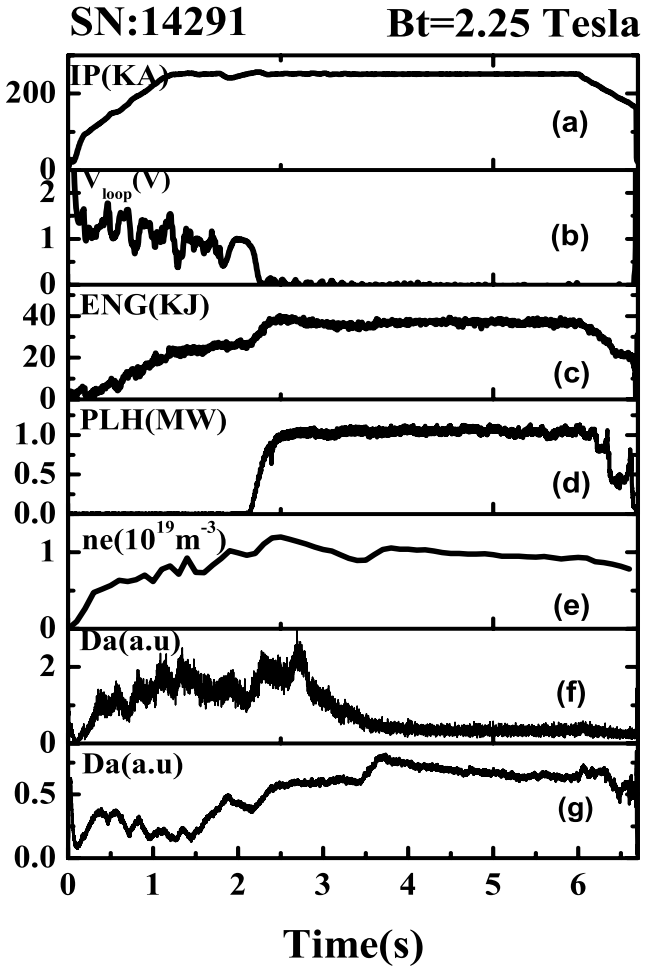
SN:14291
Bt=2.25 Tesla
IP(KA)
(a)
V_{loop}(V)
(b)
ENG(KJ)
(c)
PLH(MW)
(d)
ne(10^{19} m^{-3})
(e)
Da(a.u)
(f)
Da(a.u)
(g)
Time(s)

Fig.6

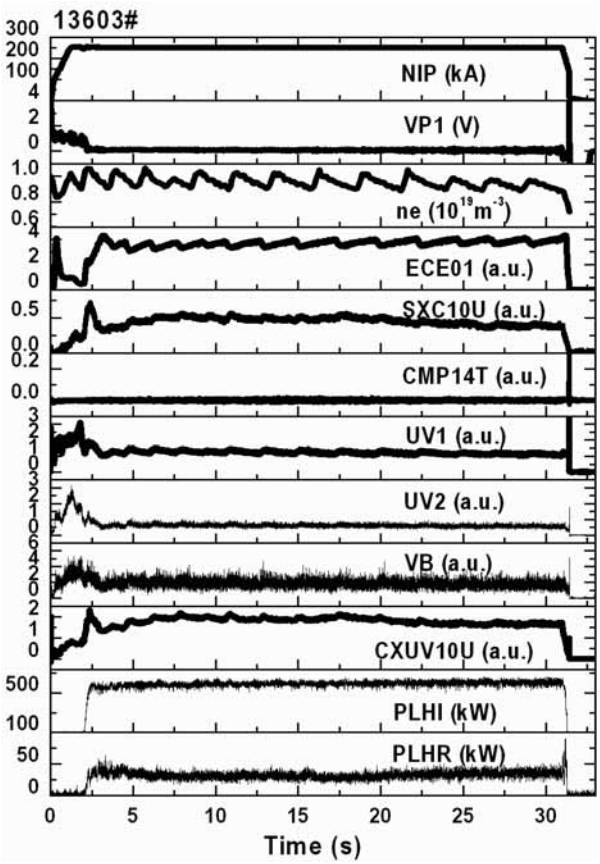
13603#
NIP (kA)
VP1 (V)
ne ($10^{19}m^{-3}$)
ECE01 (a.u.)
SXC10U (a.u.)
CMP14T (a.u.)
UV1 (a.u.)
UV2 (a.u.)
VB (a.u.)
CXUV10U (a.u.)
PLHI (kW)
PLHR (kW)
Time (s)

Fig7 (a)

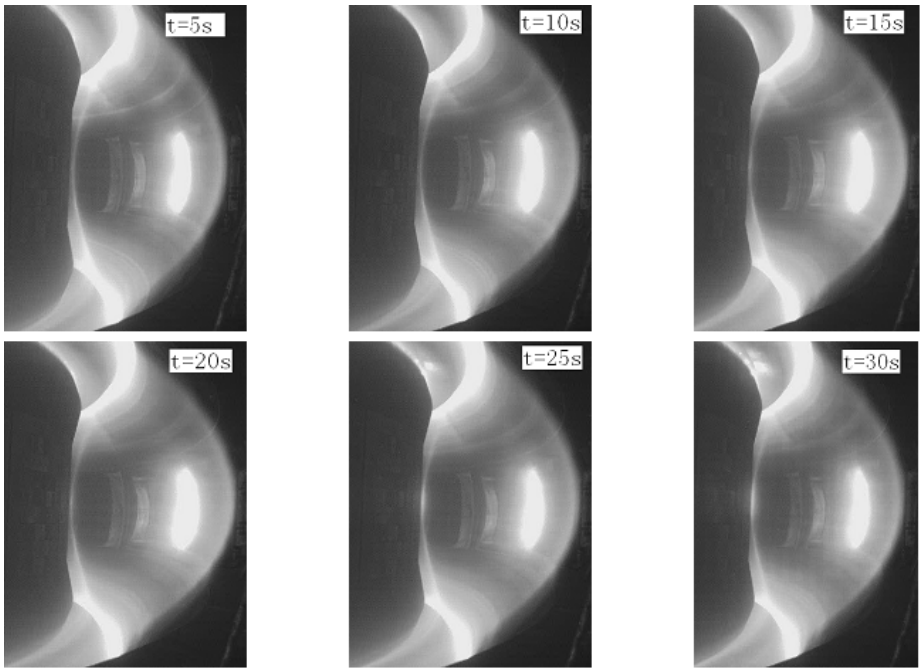
t=5s
t=10s
t=15s
t=20s
t=25s
t=30s

Fig.7 (b)

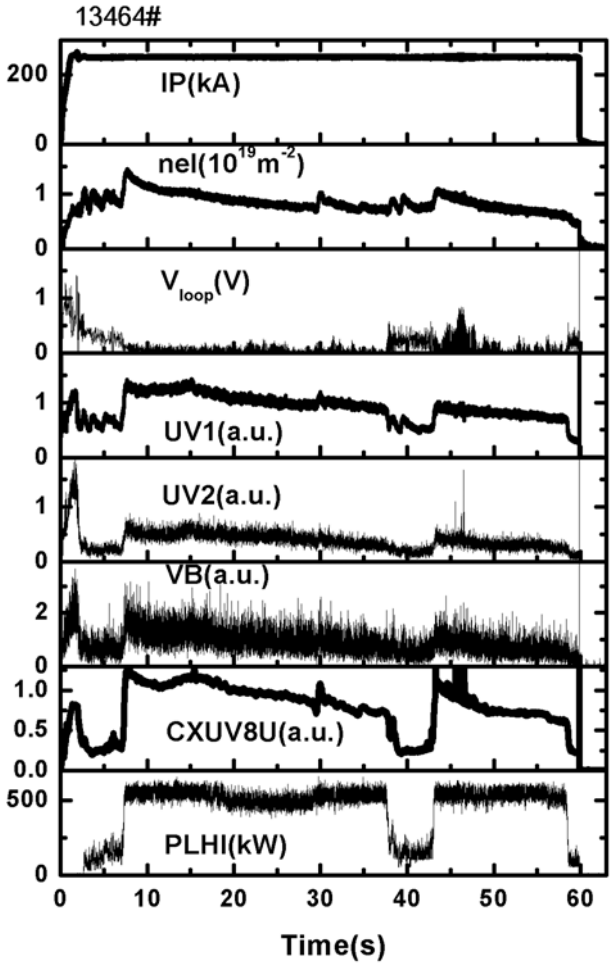
13464#
IP(kA)
nel(10^19 m^-2)
V_loop(V)
UV1(a.u.)
UV2(a.u.)
VB(a.u.)
CXUV8U(a.u.)
PLHI(kW)
Time(s)

Fig.8

(END)