J. Plasma Fusion Res. SERIES, Vol.1 (1998) 281–282

# MHD Activity in Torus System and Helical Field

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(Received: 30 September 1997/Accepted: 25 January 1998)

## Abstract

This paper presents an experimental studying on the disruptive instability occurring in the Iran-tokamak 1 (IR-T1) in comparison with stellarator experiments, particularly CLEO machine. It is found that, the fluctuations of the poloidal mode numbers $m=2$ and 3 at the rational surfaces $q=2$ and 3 are responsible for most of global magnetohydrodynamic (MHD) activities in low shear stellarators and tokamaks.

## Keywords:

disruptive instability, Mirnov oscillation, low shear stellarator, IR-T1 tokamak, CLEO stellarator, helical field

## 1. Introduction

The understanding of the collapse phenomena in toroidal plasmas is an essential subject, because such events determine the boundaries of the plasma parameters and the stationary operation. One of the possible candidate of the mechanisms that causes the collapse is the Mirnov instability. If the rotational transform at the boundary of low shear stellarator plasmas, such as CLEO[1] and W7-AS [2,3], with and without a net toroidal current approaches low rational values (1/2 and 1/3), Mirnov data indicate the presence of modes with the expected poloidal harmonic m. Moreover, in tokamaks, the disruptive instability is often preceded by strong Mirnov oscillation (usually $m/n=2/1$ or $3/1$) in the outer regions of the plasma[4]. In the present work we have studied characteristics and the control of such fluctuation for improving the confinement. Also, these results are compared with CLEO experimental results. In the edge rotational transform regime $\iota_a \leq 0.5$ such as $\ell=3$ CLEO[1] and IR-T1 tokamak, there is a $q=2$ rational surface, which is the pre-condition of the growth of $m/n=2/1$ mode. Here $m(n)$ is the poloidal (toroidal) mode number. Diagnostics and operational region with and without $\ell/n=2/1$ and $\ell/n=3/1$ helical fields of the IR-T1 tokamak have already been presented [5,6].

## 2. Experiments and Results

A typical hard disruption on the IR-T1 tokamak is shown in Fig. 1, where toroidal field $B_\phi \cong (0.5-0.7)$ tesla and mean electron density $\bar{n}_e \cong 1.1\times10^{13}$ cm$^{-3}$.

Several characteristic features of the disruptive instability are identified as follows: (a) the major decrease of plasma current after vertex close to 12.2 ms, (b) a series of negative spikes on the loop voltage, (c) inward motion of plasma due to instability as is seen on horizontal displacement signal, (d) interaction between plasma and limiter which is evident by pulsed increases in the emission of the CIII-impurity line ($\lambda=4644$Å; 2S3S–2S3P), (e) rapid growth of dominant $m/n=2/1$ mode from $\approx 6$ ms before the disruption and (f) sudden drop in electron cyclotron emission (ECE) indicating rapid decrease in electron temperature. The ECE radiation shows sawtooth-like oscillations before the disruption and decays with the development of the $m/n=2/1$ mode in the plateau phase. The disruption is also recognized by sudden drop in the central soft X-ray radiation. Time evolution of the safety factor at the plasma edge is shown in Fig. 1(g). During current

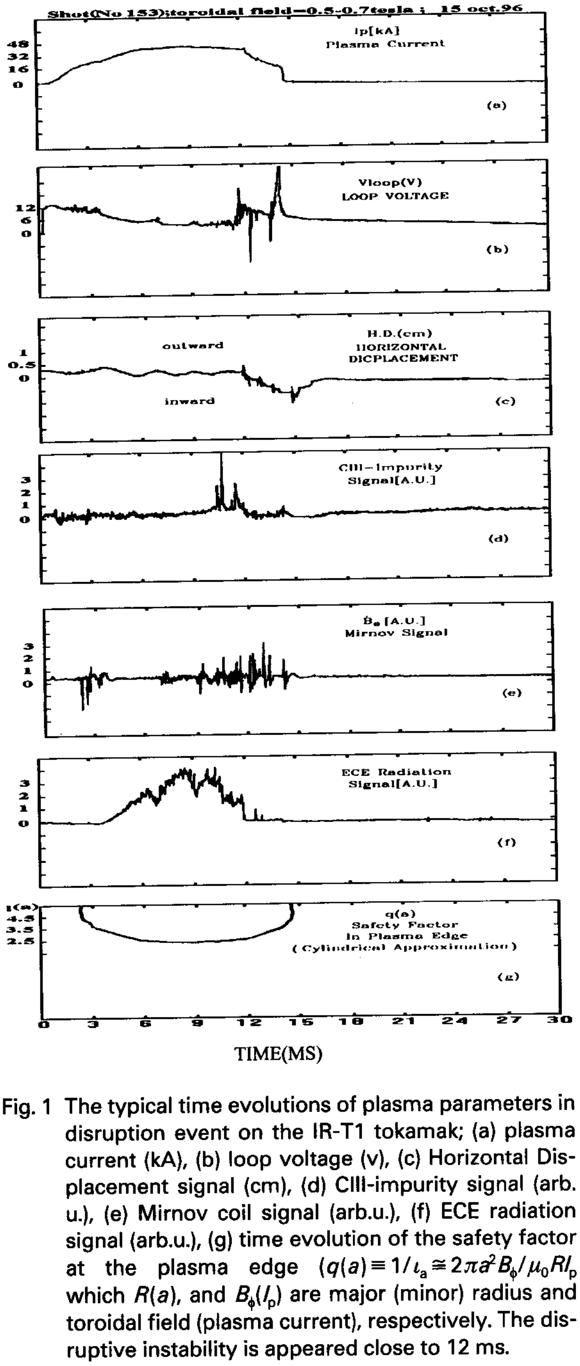


Fig. 1 The typical time evolutions of plasma parameters in disruption event on the IR-T1 tokamak; (a) plasma current (kA), (b) loop voltage (v), (c) Horizontal Displacement signal (cm), (d) CIII-impurity signal (arb. u.), (e) Mirnov coil signal (arb.u.), (f) ECE radiation signal (arb.u.), (g) time evolution of the safety factor at the plasma edge ($q(a) \equiv 1/\iota_a \cong 2\pi a^2 B_\phi/\mu_0 R I_p$ which $R(a)$, and $B_\phi(I_p)$ are major (minor) radius and toroidal field (plasma current), respectively. The disruptive instability is appeared close to 12 ms.

ramp-up, there is dominant $m/n=3/1$ mode, as shown in Fig. 1(e).

MHD behaviours observed in the IR-T1 tokamak show some similarity to the results presented by Atkinson *et al.* [1] on the CLEO stellarator. Some common results from CLEO and IR-T1 experiments are: (a) large fluctuations on loop voltage; growth of $m/n=2/1$ mode, (b) low level fluctuations on loop voltage; growth of $m/n=3/1$ mode and (c) current limit at the value of $\iota_a \cong 0.4$ with major disruption, extensive $m/n=2/1$ island near the edge of the plasma.

Results from stellarator experiments, particularly WVII [7], indicate that disruption – free operation is possible even with substantial ohmic heating currents. The analysis concerns the effect of $\ell/n=2/1$ helical field (HF) on ideal and resistive tearing modes. These results are not too different from the pure tokamak. In IR-T1 experiments, the weak $\ell/n=2/1$ HF could produce magnetic islands near the $q=2$ resonant surface so that the distribution of the current density would be flattened. It is found that when the amplitude of the HF is about $(0.2-1\%)I_p$, the development of the $m/n=2/1$ mode is delayed [5]. It is effective for improving the quality of the discharge by reducing of light impurities radiation and suppressing the disruption[6].

## 3. Conclusion

In the IR-T1 machine similar to the low shear CLEO Stellarator, operation at the highest currents is only possible at lower values of edge rotational transform ($\iota_a < 0.4$) where the effects of the $m/n=2/1$ magnetic perturbation is less serious. Also, experimental results suggest that the addition of a relatively small amount of helical field to the basic torus configuration should be capable of suppressing disruptive instabilities.

## Acknowledgments

The authors wish to thank the entire HT-6B Group for installation of the IR-T1, particularly professor J. Xie for helpful discussion concerning this tokamak.

## References

[1] D.W. Atkinson *et al.*, *Plasma Physics and Controlled Nuclear Fusion Research*, 1980 (*Proc. 8th Int. Conf.* Brussels, 1980) Vol.1, IAEA, Vienna, p.161 (1981).

[2] M. Anton *et al.*, in these Proceedings, p.259 (1998).

[3] M. Fujiwara, *Proc. Asian Science Seminar*, Hefei, China, p.40 (1996).

[4] W.M. Manheimer and C.N. Lashmore-Davies, MHD and Microinstabilities in Confined Plasma, (IOP Publisher, UK), (1989).

[5] J. Chen *et al.*, Nuclear Fusion **30**, 2271 (1990).

[6] M. Ghoranneviss, M. Masnavi *et al.*, J. Scientia Iranica, Vol.4, No.2, p.71 (1997).

[7] WVII-A TEAM, Nuclear Fusion **20**, 1093 (1980).