# Effect of Lithium on MHD Activity in FTU

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## 1. Introduction

The effect of lithization of vacuum vessel on MHD instabilities is an important issue in view of improving plasma performance by stabilization of MHD activity in future tokamaks. This investigation could also provide information concerning plasma-wall interaction and edge plasma phenomena in presence of lithium. Previous observations indicated a decrease of intensity of the m=2, n=1 tearing mode on FTU [1,2] and ELM's on NSTX [3] in lithized discharges. In this work, we compare discharges with and without lithium using the FTU Liquid Lithium Limiter [4], based on a capillary porous system, which deposits a Li film on the wall during discharges (lithization). The MHD activity is detected by a set of pick-up coils placed inside the FTU vacuum vessel. The paper is organized as follow, in the next section we shows previous data of FTU discussing the needed of further systematic analysis, in the third section we present and discuss new data, and finally we present conclusion and perspective in the fourth part.

## 2. Motivation and method of analysis

Previous analysis of discharges at B = 6T, I = 500 KA , $n_e = 0.65\ 10^{20}\ m^{-3}$ showed a decrease of intensity of a tearing mode activity at about 8 – 9 kHz in discharges after lithization [1]. A typical example of this phenomenology can be seen in the upper part of Fig. 1 (a,b). We also observed a reduction of MHD activity in sets of consecutive discharges during days when then the LLL has been inserted in the plasma scrape-off of FTU, that assure a comparison of with discharges with the same wall conditions [2].

In general MHD activity in TOKAMAK device can be influenced by a great variety of causes and occasional occurrences including impurity transport, heat transport, the camera wall conditions, radiative events; moreover, we aspect lithium is not able to influence all types of MHD modes and with any cleaning conditions of wall. In order to extend the analysis and to get a characterization without ambiguity of the lithium effect on MHD activity we have selected lithium-free discharges with a specific cause and high occurrence of MHD activity, then we have compared them with similar discharges after lithization within a few days. We have characterized the effect of lithium looking at occurrence and intensity of MHD activity. The degree of lithization of the vacuum vessel has been also considered.

## 3. Experimental observations

First of all, we have repeated the discharges at $B_T = 6T$, $I_p = 500$ KA, $n_e = 0.65\ 10^{20}\ m^{-3}$ to get information on MHD behavior with the actual wall conditions. The result is summarized in Fig. 1. With previous wall condition, the presence of a tearing mode in an old lithium-free discharge (a) due to impurity is reduced after lithization (b). With the current wall conditions, we observe no appreciable MHD activity in lithium-free discharge (c) because of cleaner wall conditions and no variation after litizathion (d).

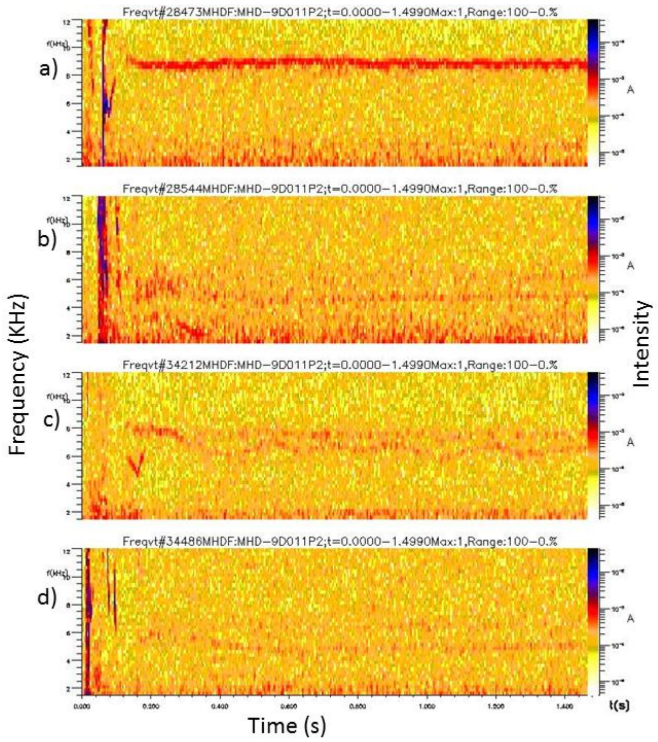


**Figure 1** Fast Fourier Trasformer Spectrogram of Mirnov coils signal for discharges with $B_T$=6T , $I_P$=500 KA, $n_e$=0.65 $10^{20}$ $m^{-3}$ shows the presence of a tearing mode in an previous lithium-free discharges (a) reduced after lithization (b). Within the current cleaner wall conditions no appreciable MHD activity is present in lithium-free discharges (c) and after lithization (d).

Afterwards we have selected two sets of discharges without lithium and MHD occurrence near 100%. The first includes discharges with $B_T = 2.5$ T, $I_p = 400$ KA and flat top density at $n_e = 0.65\ 10^{20}\ m^{-3}$ which a tearing mode which appears always at 7 kHz during the whole discharge. The second set includes discharges with $B_T = 7.2$ T, $I_p = 700$ KA and electron density ramped up to 3.0 $10^{20}\ m^{-3}$ to approach the density limit. The density ramp systematically destabilizes a tearing mode at 6-8 KHz leading a disruption. In Fig. 2 we show the spectrograms for some discharges regarding the first set. We observe no variation of MHD occurrence and no appreciable attenuation of MHD intensity with both low and high degree of lithization, just a decrease of 10-15% with high degree of litization is observed.

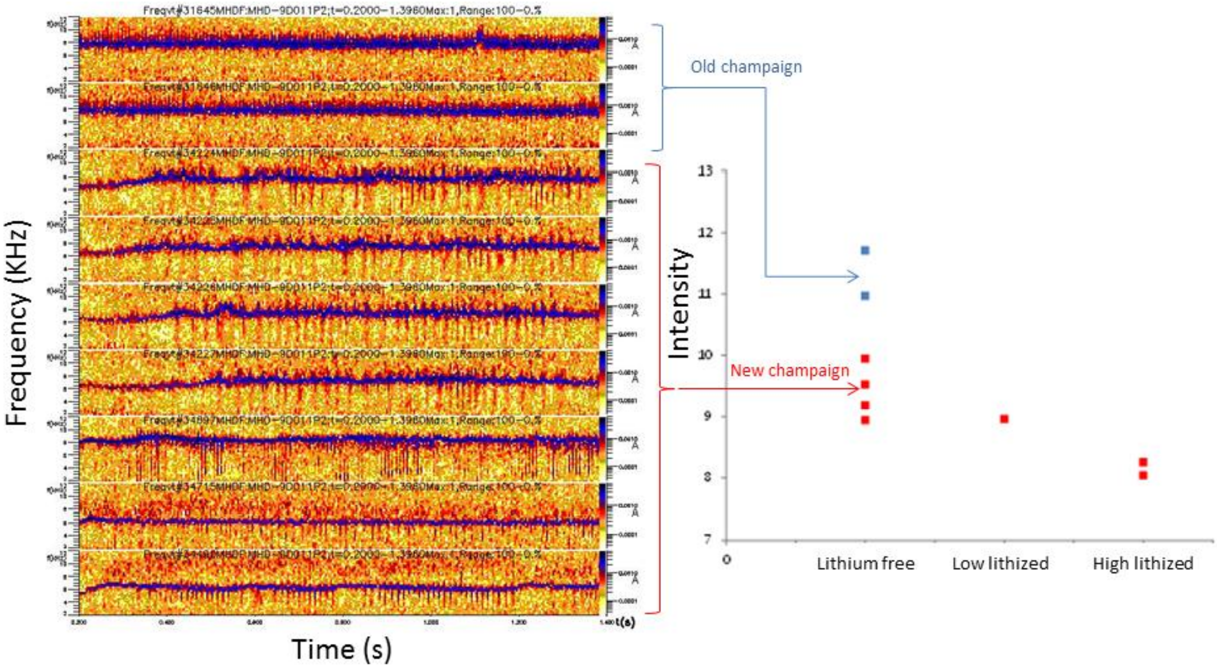


**Figure 2** MHD Activity in discharge at $B_T$=2.5 T, $I_p$ = 400 KA and $n_e$ =0.65 $10^{20}$ The first two refer to discharges of an old campaign, the others to discharges of the previous campaign with different degree of lithization (left). The intensity of a tearing mode activity at about 7 KHz is weakly reduced in discharges with high degree of lithization (right).

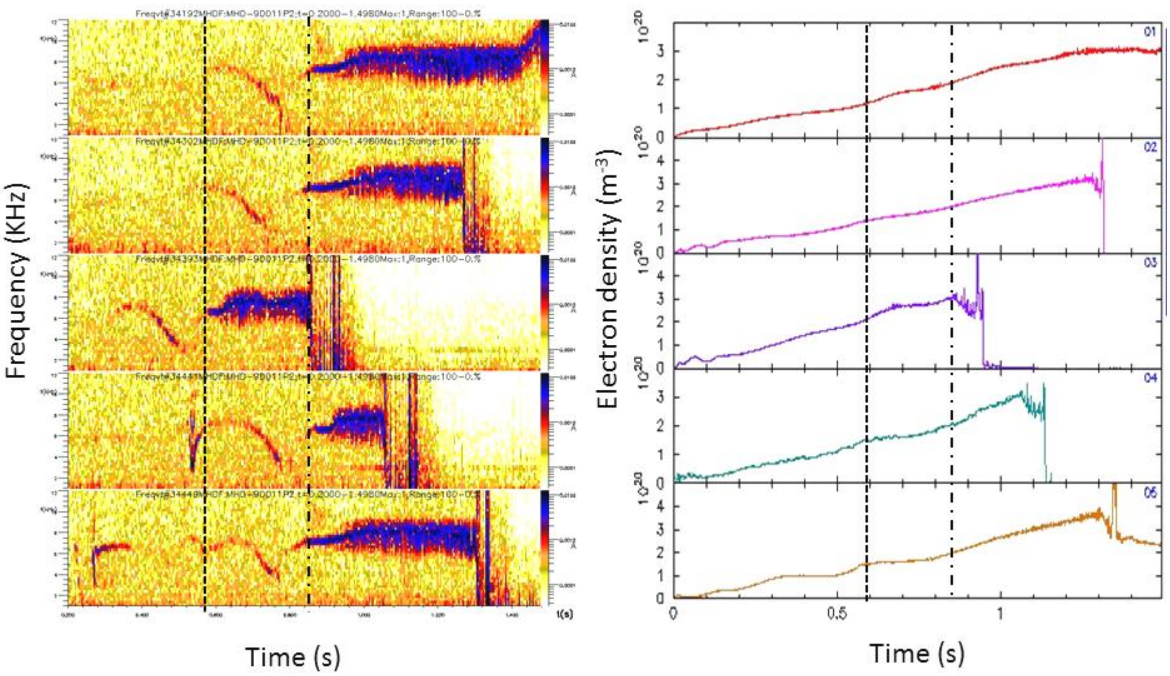


**Figure 3** MHD activity in discharges at $B_T$ = 7.2 T, $I_p$ = 700 KA approaching the density limit, (left) and correspondent density ramps (right). No appreciable modification of MHD activity are observed in discharge with and without lithium, in all discharges MHD modes start at $n_e \cong 2.0\ 10^{20}\ m^{-3}$ and disruptions occur at $n_e \cong$ 2.9-3.0 $10^{20}\ m^{-3}$.

In Fig. 3 we show the spectrograms of some discharges regarding the second set. The first two refer to discharge without lithium, the others to discharge with different degree of lithization (left part). Also in this case, no appreciable modification of MHD activity is observed, in all discharges MHD modes start at $n_e \cong 2.0\ 10^{20}\ m^{-3}$ and disruptions occur at $n_e \cong 2.9\text{-}3.0\ 10^{20}\ m^{-3}$.

## 4. Interpretation, conclusion and perspectives

The effect of lithium on MHD activity should be related to the modification induced on temperature and density profile in the edge plasma region and its influence on the plasma current profile affecting the formation and the growth of MHD activity. Recycling of light elements from camera wall (mainly carbon and oxygen) produces modification on temperature and density profile at edge due to increasing radiation. For this reason, with not clean vessel, MHD influenced by high recycling of light elements can be mitigated by lithization which well-known reduces the particle recycling and therefore radiation [4]. This mitigation is evident in the case of disruptions for density limits, in this case the occurrence of disruptions has been strongly reduced in discharges with lithium [5].

In this work, we have analyzed the case of tearing mode induced by critical magnetic configuration and tearing mode induced by approaching density limit in the case of clean vessel conditions. In clean conditions, MHD is purely induced by other causes and lithium weakly reduces recycling of light elements, for these reasons we have observed no appreciable attenuation of MHD activity after lithization.

Further investigation are in progress taking into account destabilization of MHD modes by pellet injection and by ECRH. In addition, for the future, we are using a different approach to investigate MHD activity induced by presence of lithium in the vacuum vessel, selecting a set of discharges with high occurrence of MHD modes after lithization to be compared with similar discharges without lithium.

References:

1. BOTRUGNO, A. et al. AIP Conf. Proc. March 12, 2008, Vol **988**, pp 38
2. TUDISCO, O., et al. Fus. Eng. Des. Vol.**85**, Issue 6, 2010, p. 902-909.
3. MAINGI, R., et al.36th EPS Conference on Plasma Phys. Sofia, June 29 - July 3, 2009, ECA Vol.**33E**, p. 2.175
4. MAZZITELLI, G. et al., Nucl. Fusion **51** (2011) 073006
5. MAZZITELLI, G et al., The 2nd International Symposium on Lithium Applications for Fusion devices, April 27-29, 2011, Princeton.