

SAWTOOTH PHENOMENA FOLLOWING PELLETT INJECTION IN TEXTOR-94

J. Hobirk, K.H. Finken, H.R. Koslowski, A. Krämer-Flecken, G. Mank

*Institut für Plasmaphysik, Forschungszentrum Jülich GmbH, EURATOM Association,
Trilateral Euregio Cluster, D-52425 Jülich, Germany*

Sawteeth are a well known phenomenon in tokamak discharges. They are existing in nearly all kind of discharges if a flux surface with a safety factor $q = 1$ is present in the plasma. Most models assume they are a MHD instability with poloidal and toroidal mode numbers $m=1$ and $n=1$. A sawtooth consist in general of two parts, first a relatively slow rise phase (some milliseconds up to several 100 milliseconds) where the plasma profiles (electron density and temperature) steepen and a fast crash phase (some 100 μs) which leads to flattening of the profiles. A survey on experimental observations can be found in [1].

Pellet injection can modify this activity, well known is a transient or even complete suppression of the sawteeth. The stabilisation of sawteeth can lead to impurity accumulation and/or mode activity.

The influence of pellet injection on the sawtooth oscillations has been investigated in TEXTOR-94 for ohmic and neutral beam heated discharges at various electron densities. Main diagnostics in these experiments were the electron density measurements with a 9-channel HCN-interferometer, the determination of the electron temperature profiles using ECE radiometers, measurements of the visible bremsstrahlung to determine Z_{eff} and the determination of the q-profile utilizing the Faraday rotation measurement.

In the experiments at TEXTOR-94 two different cases can be distinguished:

1. the pellets are small ($5 \cdot 10^{18} - 2 \cdot 10^{19}$ particles) and the plasma (typically $1 - 2 \cdot 10^{20}$ particles) has a small density or strong auxiliary heating is applied. In this case the sawtooth activity is not influenced. An example is shown in Fig. 1 for an ohmic discharge. The time traces of the line integrated electron density and the electron temperature in the plasma center and at the plasma edge are plotted. The sawtooth activity continuous throughout the displayed time interval. The effect of the pellet is only seen in a moderate increase of the electron density.
2. Larger pellets influence the sawtooth activity in different ways. They can suppress or modify transiently the sawtooth activity or can trigger a complete suppression for the rest of the discharge. An example of complete suppression is shown in Fig. 2.

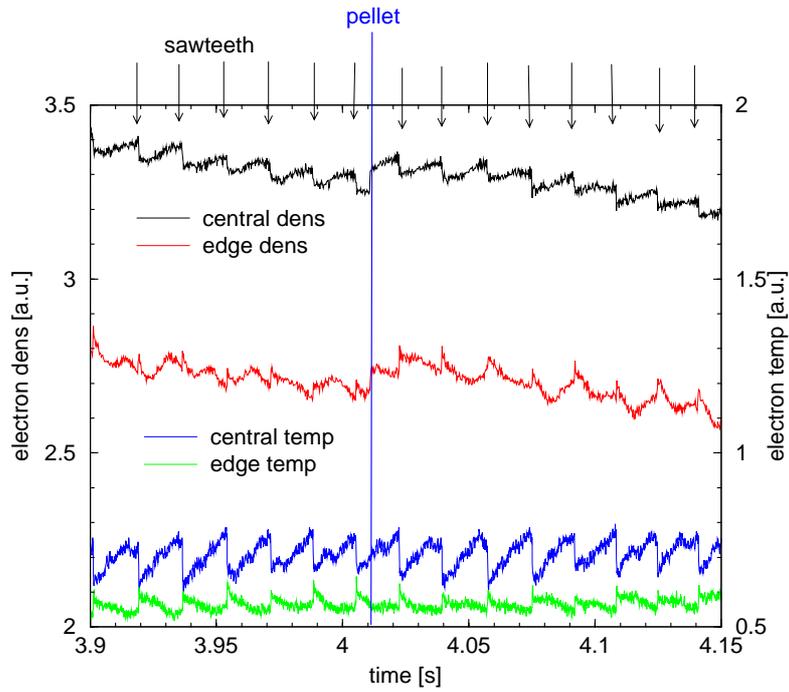


Figure 1. Time trace of density and temperature in an ohmic heated discharge with pellet injection without influence on sawteeth

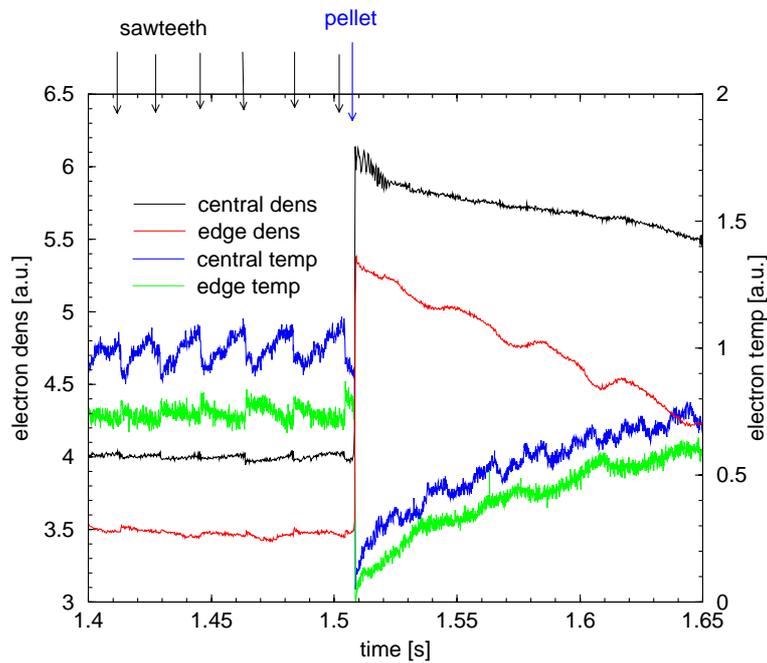


Figure 2. Time trace of density and temperature in an ohmic heated discharge with suppression of sawteeth

A pellet with a number of particles approximately equal the number of particles in the plasma is injected at $t = 1.51s$. The sawtooth activity which is present before the pellet, stops immediately and does not recover for the rest of the discharge. Investigations of several discharges have shown that the modification of sawteeth depends more on the plasma parameters

than on the pellet. The pellet size or penetration depth are found to have only minor influence on the modification of the sawtooth oscillations. The electron density and temperature of the target plasma have been identified to be the most important quantities for the subsequent stabilisation of sawteeth. An evaluation of the duration of the transient sawtooth-free period after the pellet yields a decrease (i. e. a shorter interval) with increasing central electron temperature, and an increase with electron density. The large scatter in the available data implies that there are additional dependencies. A strong influence of Z_{eff} seems likely.

The transient suppression of sawteeth directly after pellet injection can not be attributed to a change of the current distribution on a very short time scale. Polarimetric measurements have shown that no sudden change in the current profile takes place if a pellet is injected. A rise of q above one can be excluded to cause the disappearance of the sawteeth. In cases where due to the pellet impurity accumulation occurs, the safety factor q increases on a resistive time scale (several 100ms) and finally sawteeth are completely stabilised because no $q = 1$ surface exists in the plasma. This leads to the conclusion that another mechanism of sawtooth stabilisation is necessary to explain the observed behaviour.

A new observation on TEXTOR-94 is that the first sawtooth after injection of a pellet can be clearly visible on the electron temperature signal but not on the line integrated electron density (Fig. 3).

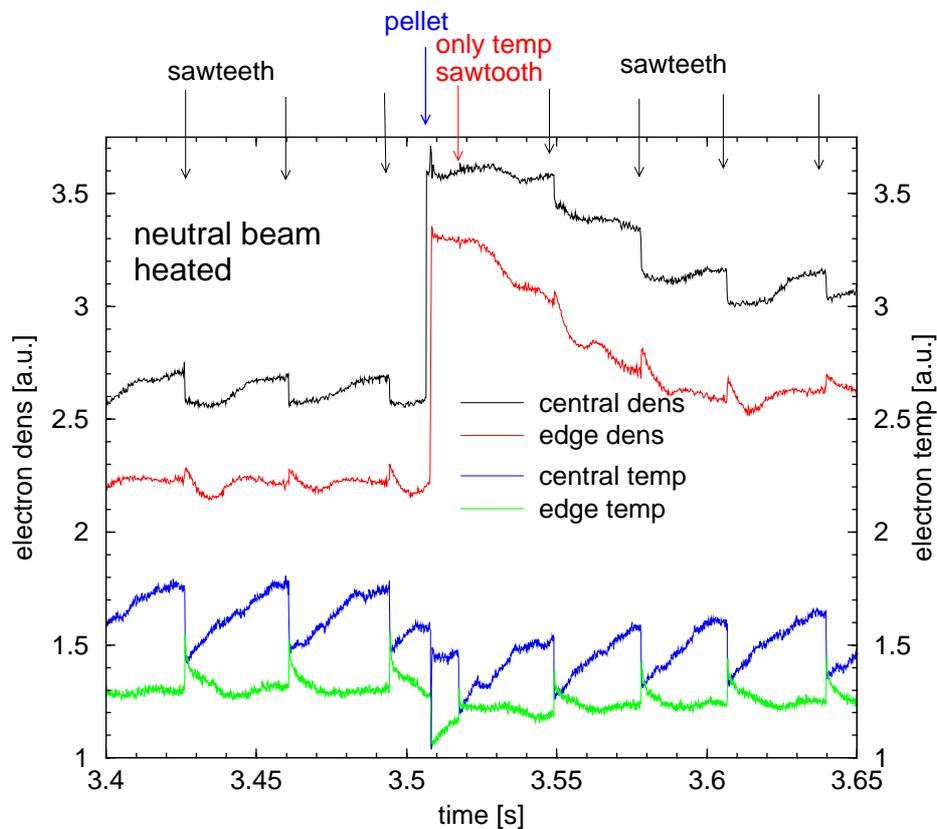


Figure 3. Time trace of central and edge electron density (line integrated) and temperature in a neutral beam heated discharge

This is found in ohmic heated and neutral beam heated discharges. An effect of line integration in the density traces can be excluded. The electron density and temperature profiles of a similar case in an ohmic heated plasma are plotted in Fig. 4.

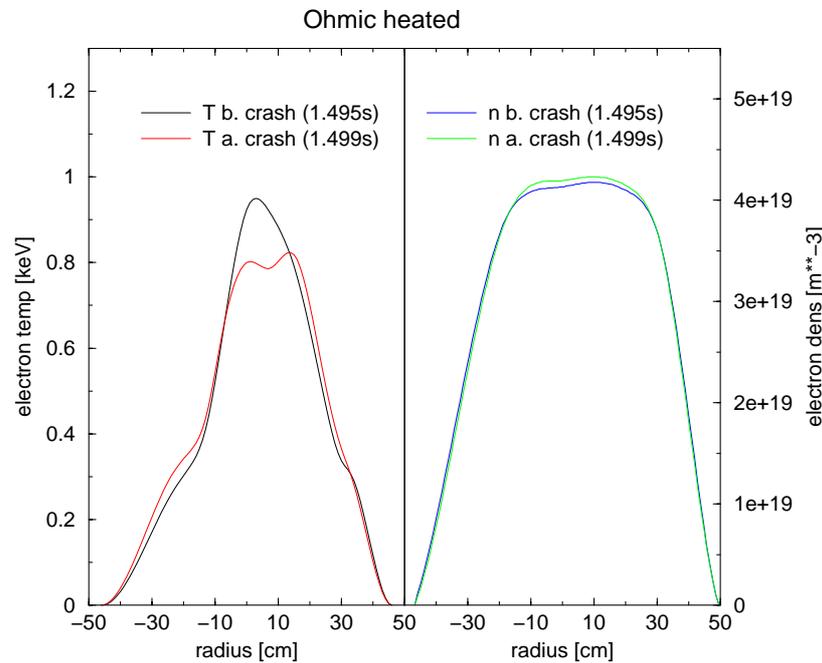


Figure 4. Electron temperature and density profiles before the crash of the first sawtooth after pellet injection in an ohmic heated plasma

The central electron density even increases due to profile steepening caused by pellet injection. In contrast to normal plasma conditions the first sawtooth occurs in the presence of a peaked electron profile and a flat electron density profile. Both profiles are decoupled due to the modifications by the pellet on the plasma. Nevertheless a strong anomalous transport of plasma energy from the center to the edge causes the reduction of the central electron temperature without a netto transport of particles.

To summarize, investigations of the influence of pellets on the sawtooth activity in ohmic and neutral beam heated discharges showed that above a certain pellet size transient or even complete stabilisation of sawteeth occurs. The parameters of the target plasmas have a larger influence sawtooth suppression than the size or penetration depth of the pellet. The pellet can produce plasma conditions where the transport of energy and particles are decoupled.

References

- [1] B.N. Kuvshinov and P.V. Savrukhn: Internal disruptions in tokamaks. *Sov. J. Plasma Phys.* **16** (5), 353 (1990)