Wavelet analysis of Mirnov coils signals for disruption prediction at JET

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Disruption are often preceded by MHD modes slowing down, growing and locking when the amplitude exceeds a critical value. The fluctuations of the poloidal magnetic field recorded by the Mirnov coils could provide useful markers related to the presence of this kind of instabilities causing disruptions. This paper proposes a time-frequency analysis of the Mirnov signals recorded at JET by the high resolution probes of KC1M diagnostic. The work is a contribution toward the definition of new features characterizing disruptive behaviours to be used as input in a multisignal disruption predictor.

Mirnov coil signals are non-stationary, thus, their spectrum changes with time. Compared to Fourier transform, wavelet transform (WT) is a step forward in the spectral characterization of a time series, since allows to study the temporal evolution of amplitude, frequency over time scales comparable with the wave period. The continuous WT of a discrete time series $\{x[i]\}$ is defined as the convolution product of $\{x[i]\}$ with a scaled ($t \rightarrow t/s$) and shifted ($t \rightarrow t - \tau$) version of a mother wavelet $\psi(t)$. The windowing is intrinsic in the wavelet and it depends on scale s. The smaller s, the more compressed the wavelet is, so it can catch rapidly changing details in the signal.

The database taken into account in this work consists of 116 non disruptive and 78 disruptive pulses. The Mirnov signals are acquired at the frequency of 2MHz and resampled at 20kHz. Then, the wavelet coefficients are evaluated on a mobile window as in a real time application. The results of a preliminary analysis performed on a single probe show that, for all non disruptive pulses, several high scale (low frequency) coefficients stay smaller than an optimized value, whereas for 86% of the analysed disruptive shots they exceed this value more than 10ms before the disruption time. Thus, this technique seems promising to anticipate the alarm of a multisignal predictor in case of rotating precursors to locked mode. In the final paper, an analysis of more signals from several Mirnov coils will identify the presence of locked modes or other instabilities in order to interpret the results. The study will be extended integrating the information given by different wavelet coefficients.