# Modenumber signs from magnetic measurement

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# 1 Experimental setup on ASDEX, magnetic probe positions

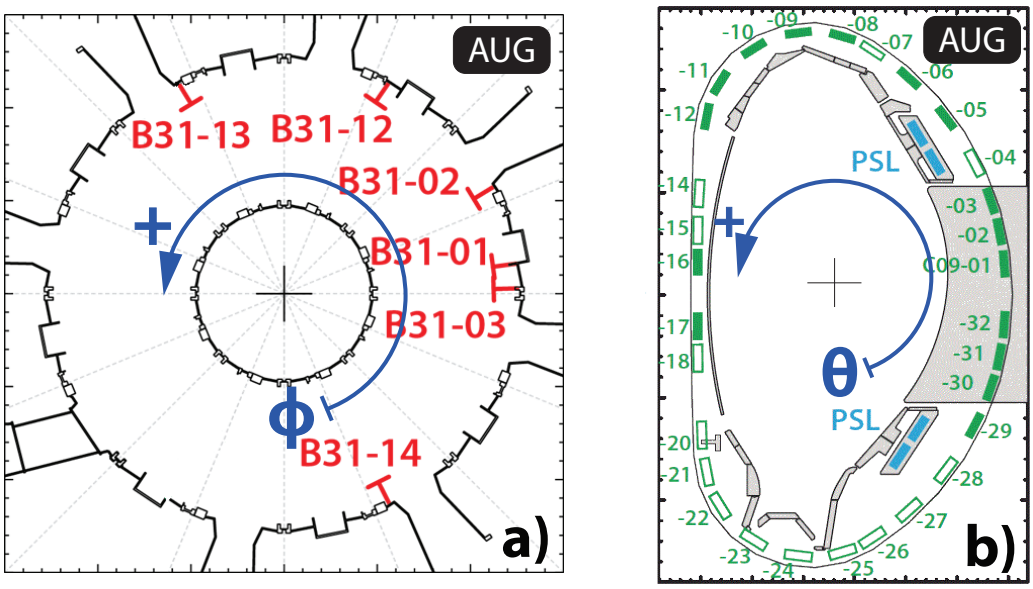


Figure 1: Magnetic probe (**a)** toroidal ballooning array and **b)** poloidal Mirnov array) positions on ASDEX Upgrade.

Both in toroidal- and poloidal crossections the coordinates of the probes follow counter clockwise (CCW) setting, which is marked with blue line on figure 1. Therefore the position is increasing that way (mod $2\pi$).

# 2 Signal processing methodology of NTI Wavelet Tools

In contiuous time-frequency transformations we suppose that the investigated physical processes, phenomena can be decomposed to a sum of $\Psi$ harmonic waves described with the following equation:

$$\Psi(\rho, \theta^*, \phi, t) = A(\rho, \theta^*) \cdot e^{i(m\theta^* + n\phi - \omega t)} \ , \tag{1}$$

where $A(\rho, \theta^*)$ is the amplitude of the wave, or radial eigenfunction. It only depends on the $\rho$ minor radius, and the $\theta^*$ coordinate which is related with the $\theta$ poloidal direction. The phase of the wave is linear both in $\theta^*$ and $\phi$, and the proportionality factors are the $m$ poloidal and $n$ toroidal mode numbers, which describe the spatial structure of the plasma wave.

Supposing a pure sinusoidal wave with (n,m) mode numbers phase difference between different positions can be extracted from crosstransforms as follows:

$$\Delta\varphi_{kl}^{meas}(t, \omega) = arg\Big(Tf_k^*(t, \omega) Tf_l(t, \omega)\Big). \tag{2}$$

To investigate wave propagation directions, let there be two different probes with $\phi_1 = 0$ and $\phi_2 = \frac{\pi}{4}$ (same poloidal position), and a wave propagating in CCW direction with $|n| = 1$. Therefore the wavefunction at two different position:

$$\Psi_1(\rho_0, \theta_0^*, 0, t) \propto \quad \exp[i(-\omega t)] \tag{3}$$

$$\Psi_2(\rho_0, \theta_0^*, \frac{\pi}{4}, t) \propto \quad \exp[i(-\omega t + \frac{\pi}{4})] \tag{4}$$

which toroidal position difference is $\Delta\phi = \frac{\pi}{4}$, and the phase difference is $-\frac{\pi}{4}$ (checked with test signals, see on figure 2).

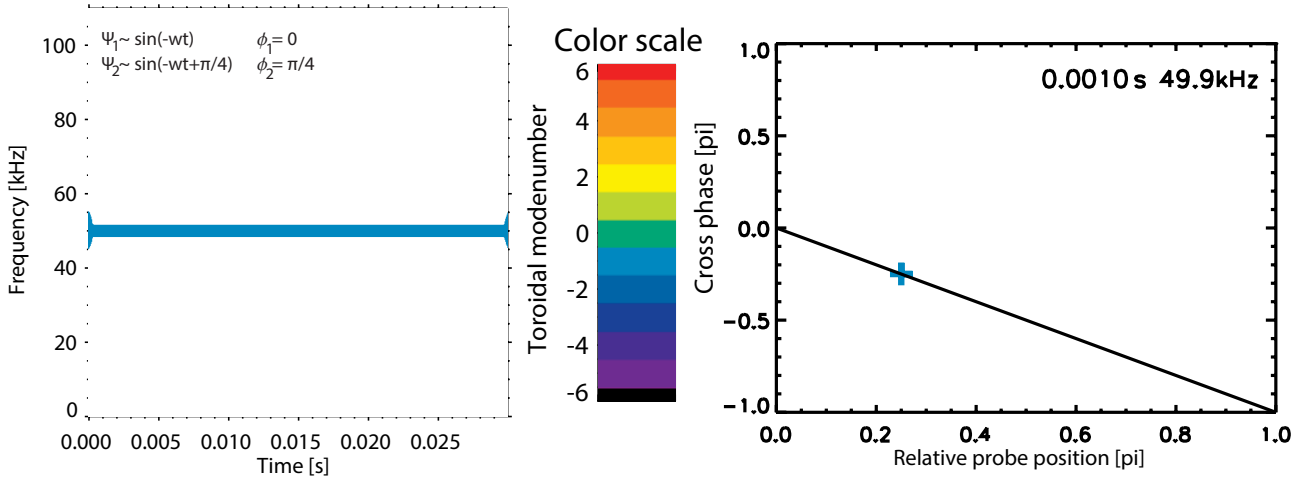


Figure 2: Best fitting toroidal modenumbers, for artificial signal with 50 kHz constant frequency.

# 3 Directions of physical processes

| | | | | | Modenumber sign from NTIWT | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | + | | - | |
| | | | | | Diamagnetic direction | | | |
| | | | | | poloidal | toroidal | poloidal | toroidal |
| **AUG** | **B tor.** | + | **I plas.** | + | electron | electron | ion | ion |
| | | | | - | electron | ion | ion | electron |
| | | - | | + | ion | electron | electron | ion |
| | | | | - | ion | ion | electron | electron |

Table 1: This table contains the main directions of the named experiments (both machine coordinate system and **TYPICAL** relevant physical quantities, marked with green) in order to determine that a modenumber calculated with NTI Wavelet Tools means what actual direction. + sign means counter clockwise (CCW), - sign means clockwise (CW).