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Identification of the Poloidal Mode Number in Tokamak Plasma

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Mirnov coils are installed along the inside of the vacuum vessel to identify the mode number of the plasma instabilities in the KSTAR tokamak. The toroidal mode number is easily identified by the toroidal array of Mirnov coils but there is ambiguity in the identification of poloidal mode number by the poloidal array of Mirnov coils. Sometimes a strange phase shift is observed that the instability propagates backward only in certain poloidal angles. There is an important difference in the configuration between the toroidal and poloidal arrays. The toroidal array is aligned in parallel with the tangential line to the plasma flux surface. However the poloidal array is aligned usually with the poloidal cross section of the vacuum vessel instead of the poloidal cross section of the plasma for the ease of the installation. This misalignment is the main cause of the ambiguity in the identification of poloidal mode number. The effects of the misalignment are quantitatively analyzed by calculating the pickup of the magnetic field due to the current filaments on the rational q surface of circular shaped plasma as shown in Fig. 1. The Mirnov coil tilted by the angle of θ from the tangential line is most sensitive to the current filament shifted by the angle of $\Delta\emptyset$. The shifted angle of $\Delta\emptyset$ is analytically calculated.

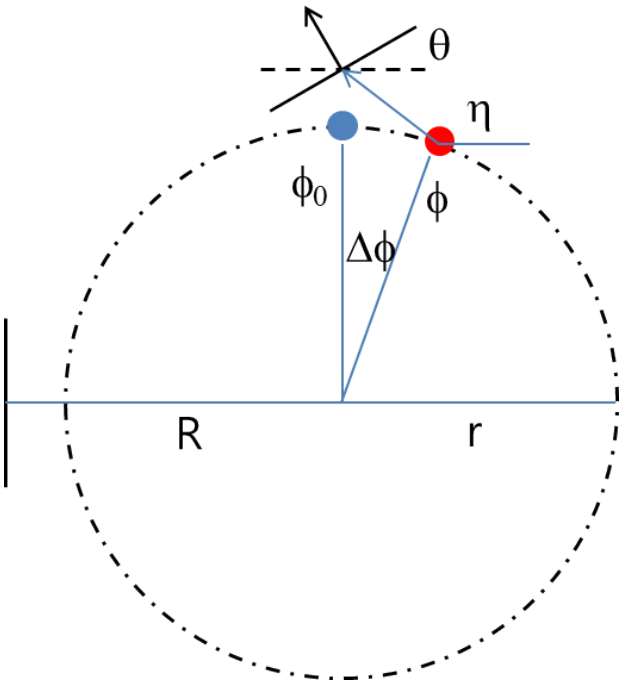

Figure 1. The magnetic field pickup by a Mirnov coil tilted from the tangential line.

For the case of noncircular shaped plasma, the response of Mirnov coil is numerically simulated to estimate the effects of the misalignment. For the realistic simulation, the field line equation is solved for the given equilibrium flux surface to find the poloidal distribution of the instability on a rational q surface. Through the simulations, it is shown that the maximum response due to a current filament occurs at an angle different from the geometrical angle of the Mirnov coil. This effective angle should be used to get the correct poloidal mode number.

The mode number can be visually determined by plotting the phase diagram of all the Mirnov coils like Fig. 2 (a). An alternative method is devised based on wavelet transform. From the wavelet transform coefficients of a dominant frequency, the phase difference between adjacent coils can be calculated. By accumulating the phase difference, the mode number is automatically obtained. The result is shown in Fig. 2 (b).

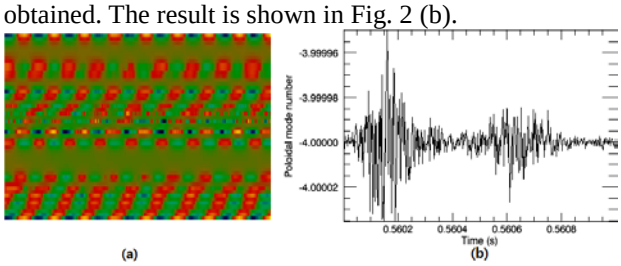

Figure 2. (a) Visual identification of mode number by plotting the phase diagram. (b) Automatic identification of mode number by using wavelet coefficients.

Based on this method, the time evolution of poloidal mode number is observed for the various plasmas in the KSTAR tokamak.