What do we measure in NBI modulation experiments?

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In tokamaks, a modulation of the tangential neutral beam injection (NBI) is routinely used to investigate toroidal momentum transport. The momentum transport coefficients (diffusion, convection and sometimes residual stress) are inferred from the response of the toroidal velocity profile to the momentum source modulation. The experiments are usually designed to achieve a small modulation of the toroidal rotation (typically by 5-20%) so that the transport equation can be linearised around the steady-state values. In practice, as NBI is not only a momentum source but also an energy source, it is difficult to avoid modulating the temperature profile by some 2-5%. Assuming a Bohm or gyro-Bohm dependence of the heat diffusivity on the temperature and a Prandtl number around unity, the 2-5% temperature modulation would result in a 2-5% momentum diffusivity modulation. This modulation is often assumed to be negligible in the analysis.

The purpose of the present work is to test quantitatively this assumption and address how much the momentum flux dependence on the plasma temperature (and temperature gradient) affects the reconstruction of the momentum transport coefficients. It is to be noted that a modulation of the transport coefficients caused by the source is not excluded per se in modulation analyses and can be taken into account by considering off-diagonal terms in the transport matrix relating the fluxes to the plasma parameters (see for instance [1]). However, to our knowledge, this effect has not been investigated in depth in the case of perturbative momentum transport studies and could possibly affect the interpretation of the measurements. To address this point, a very basic study is carried out:

1) The transport coefficients and the source modulation are assumed to be perfectly known and the corresponding profiles evolution (rotation and temperature) is computed numerically
2) standard inversion methods are used to retrieve the transport coefficients from the modulated data, taking into account or ignoring the modulation of the transport coefficients
3) the inferred transport coefficients are compared to the assumed ones and the impact of the temperature dependence quantified