Non-local models of perturbative transport

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Perturbative experiments provide valuable time dependent transport information in a relatively controlled setting that can be used to validate and test transport models. In these experiments the transient response of the plasma to externally applied small perturbations, e.g., plasma edge cooling and heating power modulation, is followed in time. In the case of cold pulses, several experiments have shown that perturbations applied at the edge travel to the center on a time scale of a few ms, i.e. much faster than expected on the basis of diffusive time scales compatible with plasma confinement. An open issue in describing these experiments is whether the observed fast pulse propagation is due to non-local transport mechanisms, or if it could be explained on the basis of local transport models. To elucidate this distinction, perturbative experiments involving ICRH power modulation in addition to cold pulses have been conducted in JET for the same plasma [1]. Local transport models have found problematic to reconcile the fast propagation of the cold pulses with the comparatively slower propagation of the ``heat waves" generated by power modulation. Motivated by these studies, we present here a numerical study of heat wave propagation due to modulating sources and cold pulse propagation is the non-local transport model proposed in Ref.[2]. In this model the standard Fourier-Fick's flux-gradient relation is replace by an integro-differential operator of a fractional derivative type. We present a numerical study of the dependence of the pulse speed and the amplitude and phase of heat waves as function of the modulation frequency, the degree of non-locality, the level of asymmetry, and the strength of the fractional diffusivity. Recent comparisons with JET experiments [3] will also be discussed.

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[3] D. del-Castillo-Negrete,,P. Mantica, V. Naulin, and J. Rasmussen, submitted to Nuclear Fusion (2008).