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Fractional models for heat propagation. Applications in fusion plasma physics

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Abstract: After a short review of basic information on fractional calculus, the fractional diffusion and heat equations are derived. It is shown that these fractional models involve memory effects (through the fractional time derivative) and non-local spatial effects (through fractional spatial derivatives). The practical importance of the theoretical enlargement is also discussed.
In order to show the usefulness of fractional models we focus on the description of heat propagation during thermo-controlled nuclear reactions. These reactions occur in experiments made in tokamaks (toroidal devices) in order to get energy through nuclear fusion. In this particular case the heat propagation is correlated with the existence of a 3D magnetic field which is strongly anisotropic. Some analytical considerations are made for models involving simple magnetic fields and specific numerical methods are used for solving complex situations. The obtained results point out the dependence of heat propagation on the ideal (unperturbed magnetic field) and on its perturbations.