Topic number 5

Challenges in the modelling of reactive plasmas: limitations and opportunities in global modelling

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The use of global models in various forms is commonplace in the low temperature plasma community in large part because of their computational simplicity, which leads to short solution times and relative ease of interpretation. However, the penalties paid for a short solution time are often the loss of spatial and temporal information on the system of interest. In some applications, these variations could be considered negligible, but in others, they are crucial in defining the properties of the plasma. In this contribution, a perspective will be given on the limitations of global models, mainly from the point of view of temporal and spatial averaging. Specific examples of global models developed to circumvent these limitations will be presented along with a further perspective on the opportunities presented by such approaches for the field of global modelling, particularly with a view to improving comparisons with experimental measurements.

1. Introduction

Global models are often the first step undertaken by researchers aiming to understand complex variations in plasma properties under the change of a given external parameter. The low degree of computational complexity involved in these models allows for studies of systems inclusive of complex gas mixtures and reaction mechanisms, which are significantly more difficult using higher dimensional models. The lack of spatial dimensions and analytical complexity additionally simplifies the analysis of the results of the model allowing complex phenomena to be identified even in models inclusive of large reaction mechanisms.

2. Overcoming spatial and temporal averaging

The spatially and temporally averaged assumptions inherent in the most basic global model approaches present clear limitations when applied to many experimental systems, meaning that comparisons between global models and experimental results are often difficult. However, several works have demonstrated that it is possible to extend the basic global model approach to more complicated experimental systems while maintaining computational simplicity provided that the dominant physical properties of these systems are understood [1, 2, 3].

This contribution will discuss examples where the assumptions of spatial and temporal homogeneity inherent in global models limit the understanding of important phenomena in certain physical systems and how these limitations can be overcome while maintaining computational simplicity [4].

A further perspective will be given as to the opportunities presented to the field of global modelling by such approaches. Particular emphasis will be given to how these approaches may improve comparisons between global models and experimental results for systems that cannot be reasonably viewed to be spatially or temporally homogenous.

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