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Least-Square Weighted Residual Methods for Solution of Global Model Equations

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Global models have become a popular tool for estimating volume-averaged plasma parameters such as number densities of plasma components, or electron temperature in partially-ionized plasmas of practical interest (with possibly thousands of chemical species and hundreds of thousands of chemical reaction paths in the discharge). Due to the usage of a volume-averaged approximation, global models do not contain any information regarding spatial distributions. In addition, they rely on the assumption of uniform power deposition and uniform electron temperature. In this work, we present a verification of a novel formulation of global model equations that allows us to predict plasma parameters not only qualitatively (as is the case in conventional global models) but also quantitatively. In this model we choose a rational functional representation with undetermined coefficients to represent various plasma properties. We then use least-square weighted residual methods to determine these coefficients in a way that minimizes the L^2 norm of the residual of 1D multi-fluid equations. This allows us to get optimal fitting parameters for all plasma components. In this work we focus on verification of the method by comparing our simulation results with analytical solutions of simplified fluid equations. Due to its use of prescribed functional representations, this model is computationally less expensive than models which compute solutions of fluid equations. As well, it allows us to retain chemical complexity without unduly increasing simulation times. Another important advantage of the presented method is that it can be applied for more complicated cases, such as flows in nozzles or multi-chamber discharges, for which global models are not yet available.

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