PoPe verification and model reduction scheme: application to 1D-1V multispecies kinetics

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The growing complexity of numerical tools requires an increased effort to verify the codes and develop a model reduction framework necessary to determine the relevant data to be stored for post-processing and provide an understanding of the physics at hand. We have developed the PoPe scheme[1], **P**rojection **o**n **P**roper **e**lements, to address these challenging issues. A first scope is to quantify the verification performance and have a capability to analyse the shortfalls. Since accuracy of the code is not really needed only for a set of specific test cases but must be determined for any simulation of interest, the PoPe method does not rely on changes in the code. Only adapted implementation of data storing and post –processing is involved. As underlined by the name of the scheme, PoPe can be understood as a projection scheme: projection of the space spanned by the original operators of the model, or that of the reduced model, and projection transverse to these spaces characterised by a residual. The statistical distribution of the projections weights quantifies the projection on the model while the residual is specific of what is not captured by the model, of interest in particular for model reduction.

The PoPe scheme is used for a demanding problem, namely the kinetic response in 1D-1V to an external drive which is of interest to the physics addressed in the Enabling Research project ESKAPE, for the present illustration near SOL acceleration of electrons by Lower Hybrid launchers. The geometrical features of PoPe are illustrated with the verification of the VOICE code used here in the Eulerian version pseudo-spectral both in position and velocity. Completing the verification of VOICE, the projection on a reduced model is used to understand and quantify the properties of the transient to the steady state electric potential response. Open issues related to the statistical analysis of the projection weights and physics of escaping electrons are also addressed.

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[1] T. Cartier-Michaud at al., Physics of Plasmas **23**, 020702 (2016)