Positive invariance and strong stability preservation of SVD and POD for time-stepping methods

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Model reduction is necessary for solving time-dependent problems with millions or billion state variables per time-step, which is the case e.g. when solving large-scale environmental or industrial applications. The proper orthogonal decomposition (POD) and its variants have been used by several solutions. The POD consists of offline generation of snapshots and the singular value decomposition (SVD) is used for defining projections to a low-rank space. SVD gives the L2-optimal projector. It is not obvious what will POD do with the invariance preservation properties (e.g. positivity, total variation diminishing, strong stability).
In this talk, we present an invariance-preserving theorem for the POD time-stepping. We prove that if the snapshot matrix is generated from invariance-preserving data, then the projected flow does preserve the invariance property whenever the initial state is within a smaller invariance set and the singular values decrease at least at a prescribed rate. For this theorem we shall prove an invariance preservation property of the low-rank approximations by the SVD.

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