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Basis Generation Techniques for Symplectic Model Order Reduction

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Mathematical models for physical phenomena typically show certain structures if formulated correctly. Hamiltonian systems are an example for such structured systems. They rely on the so-called symplectic structure, which is responsible for the characteristic property to preserve the Hamiltonian function over time. In numerical mathematics, preservation of these structures shows great improvements in stability and accuracy e.g. for numerical integration [1] or model order reduction (MOR) [2].

Our goal is to show how so-called symplectic reduced-order bases can be computed from data, which is relevant for structure-preserving MOR of Hamiltonian systems. To this end, we give a short introduction to symplecticity and Hamiltonian systems. Based thereon, we discuss symplectic basis generation techniques in comparison to the classical Proper Orthogonal Decomposition (also: Principal Component Analysis). Based on a two- and a three-dimensional linear elasticity model, we show how such techniques can be used (a) for classical data compression and reconstruction tasks and (b) for symplectic MOR.

[1] E. Hairer, G. Wanner, and C. Lubich. Geometric Numerical Integration. Springer, Berlin, Heidelberg, 2006. ISBN 978-3-540-30666-5. doi: 10.1007/3-540-30666-8.

[2] L. Peng and K. Mohseni. Symplectic Model Reduction of Hamiltonian Systems. SIAM J. Sci. Comput., 38(1):A1–A27, 2016. doi: 10.1137/140978922.

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