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Model reduction of large scale second-order systems with modal damping

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An approach is described for model reduction of second-order systems with types of normal mode damping that include the most common varieties: proportional damping and square-root damping. We show that unlike the general case that requires usage of a second-order Krylov subspace structure, one can build up instead approximating subspaces satisfying all required conditions much more cheaply as direct sums of standard rational Krylov subspaces within much smaller component subspaces. We give a detailed analysis of the distribution of system poles, and then, through descriptive bounds that carry the flavor of classical approximation theory, we are able to exploit the structure of these poles to obtain asymptotically optimal shift selection strategies. Numerical examples are provided to illustrate and support the analysis.