Infinite Elements for exterior Helmholtz resonance problems based on a frequency dependent complex scaling

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Complex scaling is a popular method for treating scattering and resonance problems in open domains. Thereby the unbounded domain is decomposed into a bounded interior and an unbounded exterior part. Subsequently, complex scaling is applied to the exterior domain to obtain exponentially decreasing solutions. Afterwards the complex scaled exterior is usually truncated and discretized using finite elements. To avoid truncation and obtain a better approximation we use infinite elements, which are based on Hardy space infinite Elements ([2]).
For solving scattering problems it is common to use frequency dependent scaling functions, whereas for treating resonance problems usually frequency independent scalings are applied to conserve the linearity of the resulting eigenvalue problem. Unfortunately a frequency independent complex scaling works well only for a very narrow range of frequencies and the approximation depends heavily on the specific choice of the scaling function. To overcome this we use frequency dependent scaling functions for resonance problems as well, which leads to polynomial eigenvalue problems ([1]). The latter can be treated with no siginificant extra effort compared to linear problems by using a version of the shift-and-invert Arnoldi algorithm.

References.

[1] Nannen, L., Wess, M. (2018), *Computing scattering resonances using perfectly matched layers with frequency dependent scaling functions,* BIT Numerical Mathematics.

[2] Hohage, T., Nannen, L. (2009), *Hardy space infinite elements for scattering and resonance problems,* SIAM J. Numer. Anal. 47.