Numerical solution of scattering and resonance problems by the pole condition method

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We discuss idea and application of the pole condition method to solve time-harmonic scattering and resonance problems modeled by Helmholtz and Maxwell's equations on unbounded domains. A typical example for an electromagnetic scattering problem is the computation of transmission, reflection and diffraction of light through photo-masks, a typical example for a resonance problem is the computation of modes of optical fibers.

This talk covers the essential aspects of the pole condition approach. First, the entire space is decomposed into an interior domain containing the object of interest and an possibly heterogeneous exterior domain. The basic idea is to consider the Laplace transform of the field in the exterior domain. We characterize the exterior fields by the poles of their Laplace transforms and say that a field satisfies the pole condition if its Laplace transform has no pole in the lower half of the complex plane. Fields satisfying the pole condition are outgoing fields. This enables us to characterize scattered fields based on the pole condition rather than Sommerfeld's radiation condition or the Silver-Müller radiation condition.

Moreover, the combination of finite element methods for the interior problem and the pole condition method for the exterior problem leads in a direct way to a number of new numerical algorithms. These algorithms allow to solve a number of practically relevant problems in 2D and 3D with variable coefficients and infinite obstacles in the exterior domain.