Finite element methods for the computation of 3D corner singularities

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For the analysis of the stress distribution at the top of a polyhedral corner or at a crack tip, one typically expands the displacement in terms of the form $kr^{\alpha}u$, where r is the distance to the tip, u is a function of the spherical angles and k is the stress intensity coefficient. The exponent α and the function u do not depend on the loading but only on the geometry and the material parameters. They form an eigenpair of a quadratic operator eigenvalue problem.

Since the eigenvalue problem can in general not be solved analytically, the finite element method is used to solve it approximately. This method is flexible enough, such that also anisotropic or composite materials can be treated. By the finite element approximation, the operator eigenvalue problem is transformed into a quadratic matrix eigenvalue problem with a special structure. It can be reformulated as an eigenvalue problem of a Hamiltonian, a skew-Hamiltonian or a symplectic matrix. There are special Arnoldi and Lanczos algorithms which exploit the structure of the underlying eigenvalue problem. In this talk, we introduce different methods of finite element discretization and present recent numerical results.

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