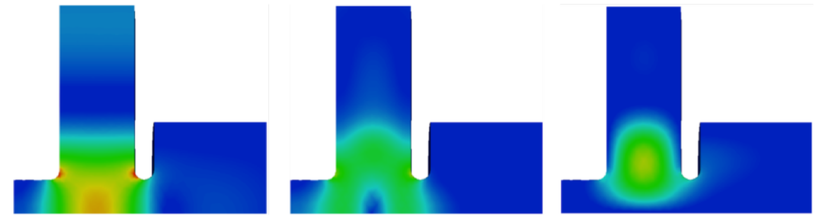
Fast and Reliable Solver for Nonlinear Eigenvalue Problems in Accelerator Cavity Design

Scientific Achievement

Enable the computation of cavity resonant frequencies and damping modes for accelerator cavities with external waveguide coupling

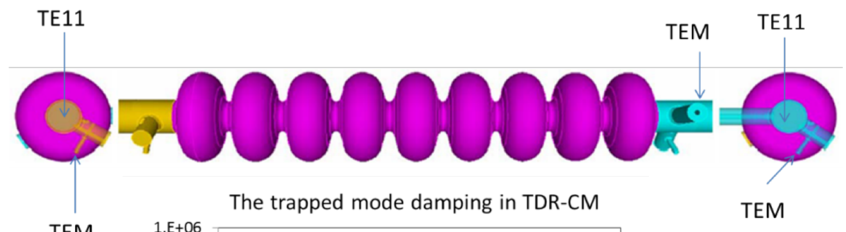
$$\left(K - \lambda^2 M + i \sum_m \sqrt{\lambda^2 - k_m^2}\, W_m^{TE} + i \sum_m \frac{\lambda^2}{\sqrt{\lambda^2 - k_m^2}} W_m^{TM}\right) x = 0$$

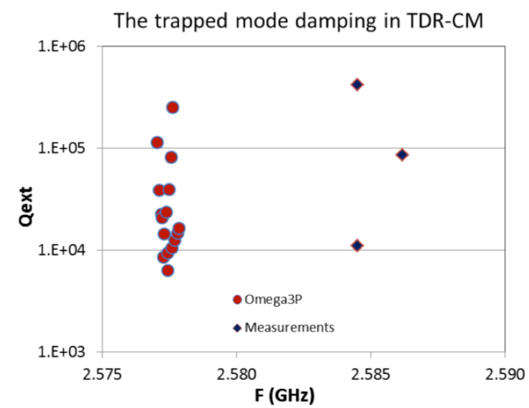


Three computed cavity modes of a pillbox model problem

Significance and Impact

This is the first time accelerator physcists are able to compute trapped modes damped in an ideal eight 9-cell SRF cavity cryomodule





A comparison between computed trapped modes of a LCLS-II cryomodule and experimental measurements shows the external Q values match well.

Research Details

- Use rational approximation to approximate the nonlinear eigenvalue problem by a rational eigenvalue problem.
- Use a special linearization procedure to turn the rational eigenvalue problem into a linear eigenvalue problem with the same eigenvalues.
- Use a compact scheme to represent the linearized operator and eigenvectors so that the dimension of the problem does not increase.

R. Van Beeumen, O. Marques, E.G. Ng, C. Yang, Z. Bai, L. Ge, O. Konoenko, Z. Li, C. Ng, L. Xiao, "Computing Resonant Modes of Accelerator Cavities by Solving Nonlinear Eigenvalue Problems via Rational Approximation", accepted by J. Comp. Phys., 2018.

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