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New Physical Applications and Extensions to the GATO Ideal MHD Stability Code

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The GATO code has historically been successful in predicting global low n stability limits in tokamaks and has been an invaluable tool for understanding and interpreting MHD activity in DIII–D. Recent enhancements and improvements in the speed, numerical resolution, and accuracy now allow the code to address previously difficult or even impossible cases requiring high resolution such as intermediate n ($5 \lesssim n \lesssim 10$), ballooning-like, and highly localized ELM-like instabilities. Improved radial resolution is achieved by a combination of strong nonuniform packing of flux surfaces and increases in speed and memory requirements which permit larger meshes. Increased poloidal resolution is obtained by extracting the local ballooning phase factor through the transformation $\tilde{\xi} = \xi e^{-inq\chi}$, where χ is the straight field line poloidal angle and q is the safety factor, and solving for the more slowly varying $\tilde{\xi}(\psi,\chi)$ instead of $\xi(\psi,\chi)$. New applications include identification of intermediate n highly edge localized ELM instabilities in DIII–D discharges. The code has also been coupled to several other codes in order to increase its utility as an interpretive and predictive tool. Coupling to the VACUUM and VALEN codes, for example, allows calculation of wall image currents and prediction of Mirnov loop data for experimental equilibria, and coupling to a new diagnostic code allows direct comparison of ideal mode structures with internal density and temperature fluctuation diagnostics in DIII–D, and led to the identification of the Resistive Wall Mode in DIII–D wall stabilization experiments. Modifications and improvements have also made routine application of the code to non-tokamak equilibria, such as the ST, Spheromak, RFP, and FRC, possible: the code was used in the design of the LLNL SSPX experiment and to identify stable, very high β ($\beta \sim 60\%$) fully bootstrapped ST equilibria. Continued benchmarking with other ideal stability codes, specifically PEST, KINX, DCON, and MARGZD for a wide variety of cases has revealed a better understanding of the numerical convergence properties of Finite Hybrid Elements in general, and greatly enhances the credibility of the code predictions.

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