Kinetic Equilibrium Reconstruction and Stability Analysis of KSTAR Plasmas Supporting Disruption Event Characterization and Forecasting

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ABSTRACT

- Equilibria with the required accuracy and fidelity are produced as input for a suite of stability analyses, including ideal MHD stability (DCON) and resistive MHD (resistive DCON), which can then be used to determine correlations with experimental plasma stability.
- Present kinetic equilibrium reconstructions include Thomson scattering (TS) data, charge exchange spectroscopy (CES) data, motional Stark effect data, external magnetics, shaping field current data, and inclusion of vacuum vessel and passive plate currents.

BACKGROUND

- Disruption prediction and avoidance is a high-priority challenge for tokamaks to sustain long pulse and high performance plasmas that are critical for ITER and next-step devices for fusion generation. Disruption-free, continuous operation of high performance plasmas over long pulse is a main goal of modern superconducting tokamak devices such as the Korea Superconducting Tokamak Advanced Research (KSTAR) facility.
- Stability analyses comprise an important part of the disruption event characterization and forecasting (DECAF) framework presently expanding in capability to characterize and forecast plasma disruptions in tokamaks.
- High fidelity kinetic equilibrium reconstructions are an essential requirement for accurate determination of the plasma stability and disruption prediction analyses to support the goal of continuous, disruption-free operation.

CHALLENGES/CONCLUSION

- Only equilibria with low convergence error can provide a good radial Grad-Shafranov error in the stability analysis with high fidelity. The present kinetic equilibria with MSE can obtain at best convergence error as good as 10^{-13} and an average convergence error close to 10^{-10}.
- Linear ideal and resistive stability calculations are examined for these kinetic equilibrium with MSE, and they are sensitive to reconstructed profile polynomial order, plasma pressure profile, safety factor q and q_{min}.
- The achieved kinetic equilibria with low convergence error can provide reliable input parameters to stability calculations and the disruption event characterization and forecasting (DECAF) code.

ACKNOWLEDGEMENTS

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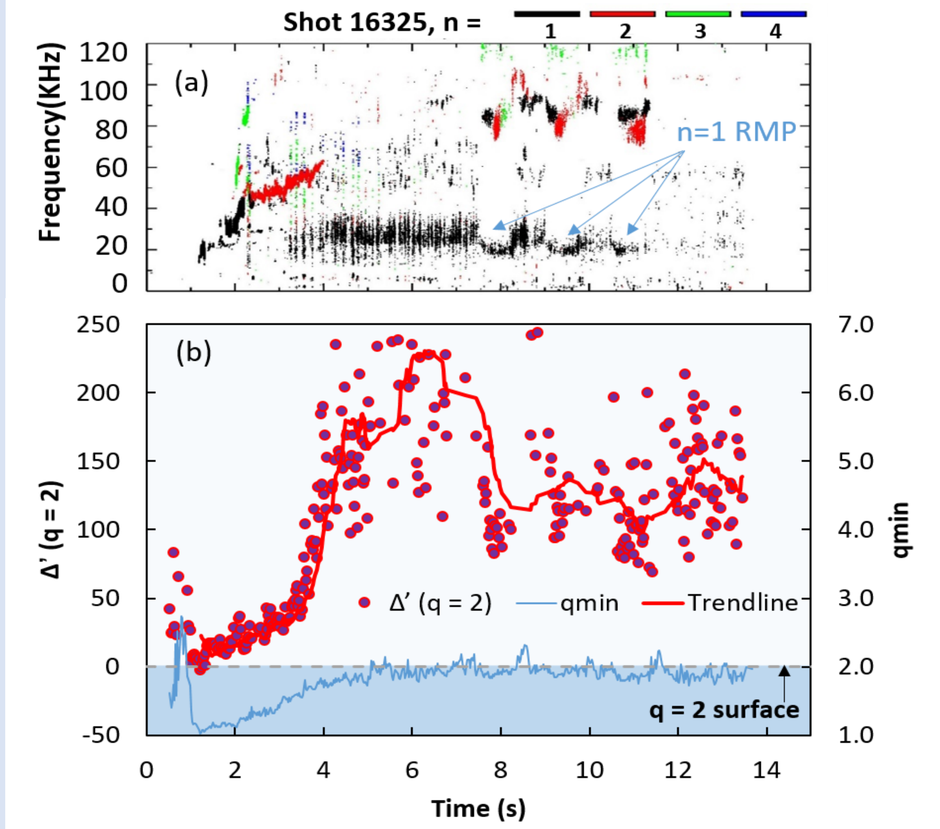
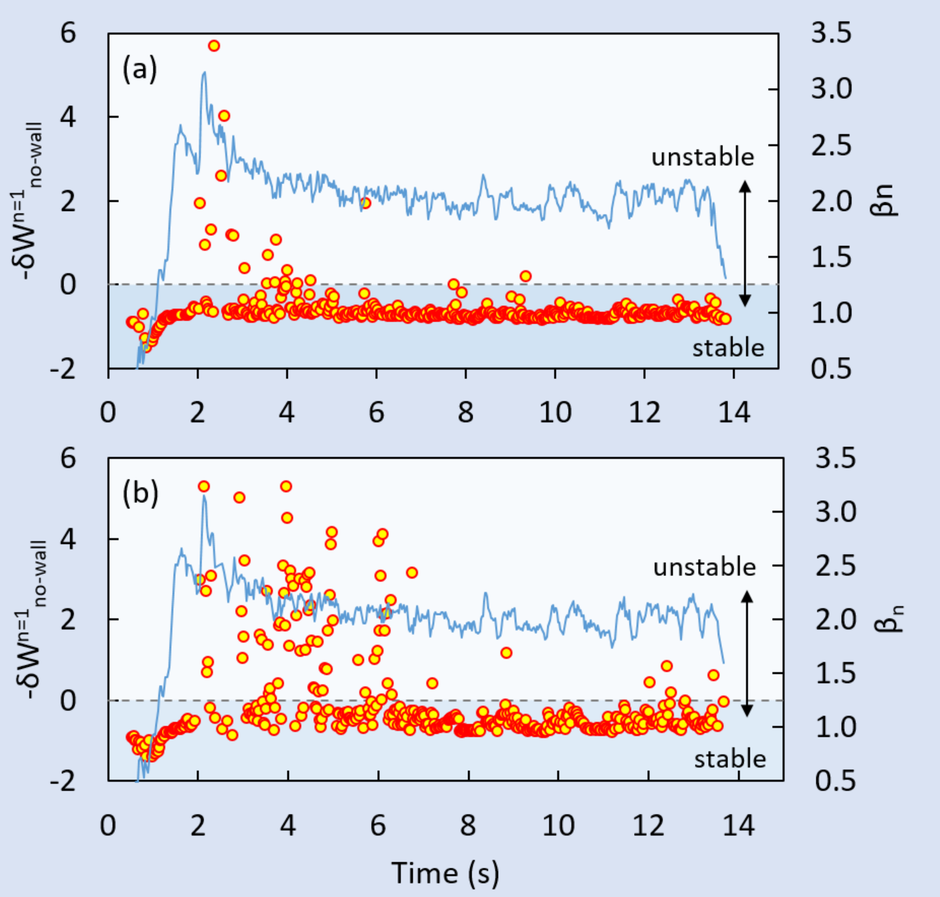
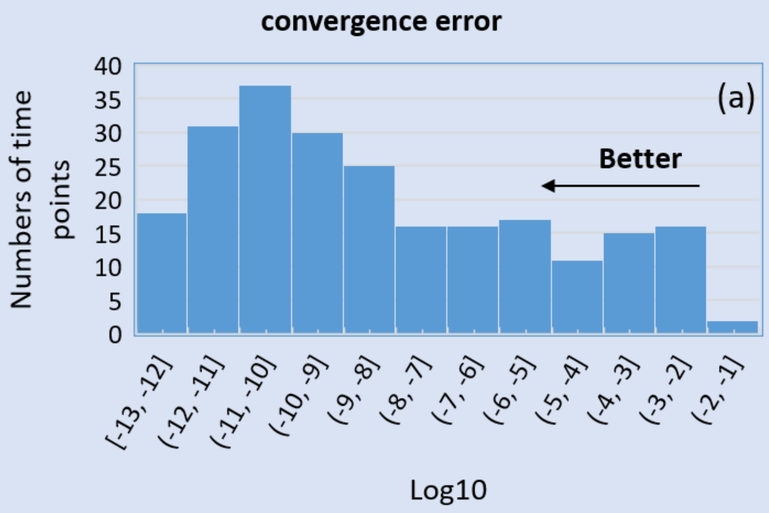
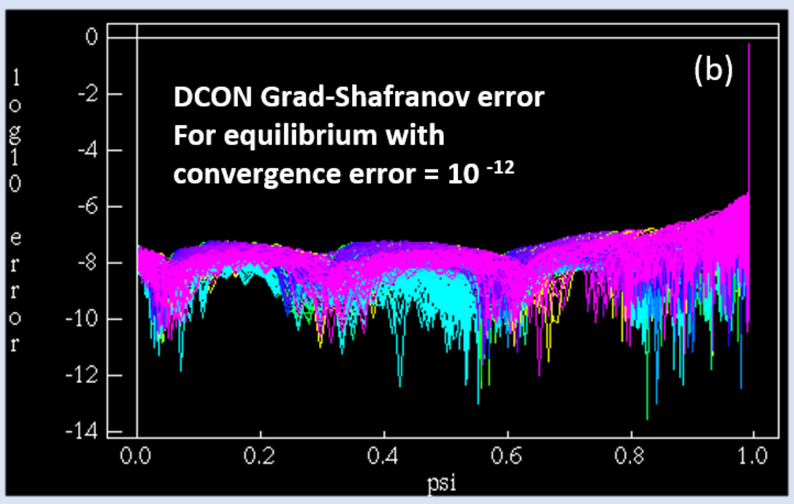


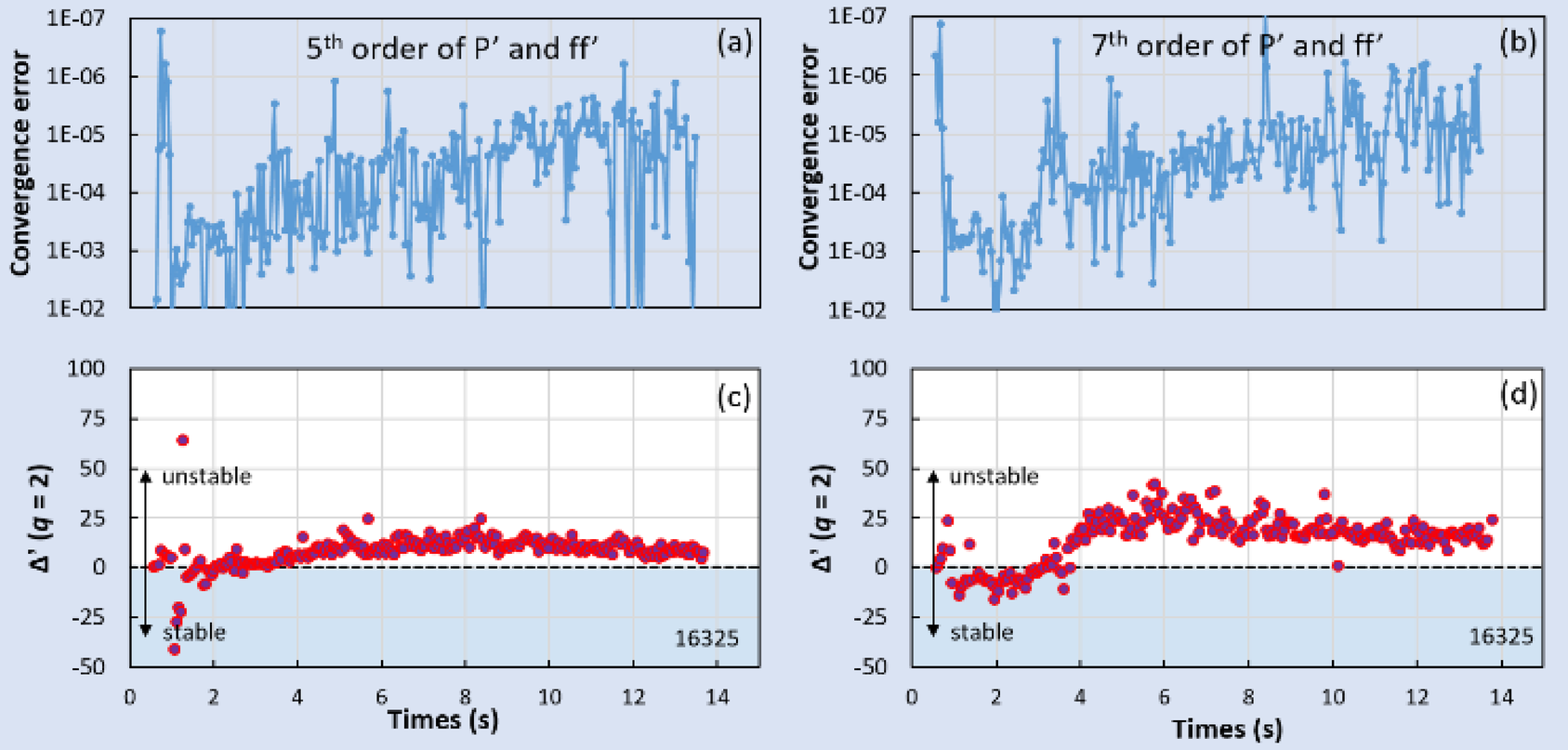
Spectrogram (a), qmin, and resistive Δ' at the q = 2 surface, 20 pt. moving avg trendlines (b) provided by kinetic equilibria with average 10^{-10} convergence error.



DCON calculation with limited q shear model (a) and more shear freedom model (b) for KSTAR 16325







Resistive stability (c,d) results based on two different equilibrium models (a, b) computed in the same full-time of KSTAR discharge 16325.