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Stabilization of the SIESTA MHD Equilibrium Code Using Rapid Cholesky Factorization[1] S.P. HIRSHMAN, E.A. D'AZEVEDO, S.K. SEAL, Oak Ridge National Lab — The SIESTA MHD equilibrium code solves the discretized nonlinear MHD force $F \equiv J\text{X}B - \nabla p$ for a 3D plasma which may contain islands and stochastic regions. At each nonlinear evolution step, it solves a set of linearized MHD equations which can be written $r \equiv Ax - b = 0$, where A is the linearized MHD Hessian matrix. When the solution norm $|x|$is small enough, the nonlinear force norm will be close to the linearized force norm $|r| \approx 0$ obtained using preconditioned GMRES. In many cases, this procedure works well and leads to a vanishing nonlinear residual (equilibrium) after several iterations in SIESTA. In some cases, however, $|x|>1$ results and the SIESTA code has to be restarted to obtain nonlinear convergence. In order to make SIESTA more robust and avoid such restarts, we have implemented a new rapid QR factorization of the Hessian which allows us to rapidly and accurately solve the least-squares problem $A^T r = 0$, subject to the condition $|x|<1$. This avoids large contributions to the nonlinear force terms and in general makes the convergence sequence of SIESTA much more stable. The innovative rapid QR method is based on a pairwise row factorization of the tri-diagonal Hessian. It provides a complete Cholesky factorization while preserving the memory allocation of A.

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