

# FLORA Equilibrium and Stability Code Archive

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## FLORA Equilibrium and Stability Code Archive

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FLORA solves, in a 2-D domain (radial and axial dimensions) with a specified azimuthal Fourier mode, for the linearized stability of a long, thin, axisymmetric plasma equilibrium in an applied magnetic field. Before the stability equation is solved, FLORA solves a set of simple equations for pressure balance that specify the equilibrium magnetic field and plasma pressure in the long-thin limit given a simplified description of the magnetic coils. It uses an initial-value method for the linear stability problem in which an equilibrium is given an initial perturbation to its magnetic field, and the temporal behavior of the perturbation is followed. The perturbation has been Fourier expanded in the azimuthal coordinate; each azimuthal mode must be examined separately. The complex partial differential equation of motion for the perturbed radial displacement of the field lines is solved as a coupled system of two real p.d.e.'s and the solution consists of two parts, the real part and the imaginary part. The system is solved by bringing the coupling terms in each equation to the right side and using an iterative technique.

The formulation of FLORA was documented in [1], and examples of its use were published in [1], [2], [3], and [4]. A user's manual is available in [5]. The plasma equilibrium is required to be axisymmetric and long-thin (paraxial). Finite pressure is allowed, and the stability equation includes both finite-Larmor-radius effects, e.g., diamagnetic effects, and ExB rotation. There is an option to include a "rigid" energetic electron population whose diamagnetism affects the equilibrium curvature.

The original version of FLORA was written in FORTRAN77 in the early 1980s and was subsequently ported to the BASIS system [6] and then finally into PYTHON in 2025.

The FLORA archive contains source code listings and, for selected examples, code inputs and output plots (Appendix A). The archive is publicly available in <https://github.com/LLNL/FLORA>

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## References

[1] Cohen, B.I., Freis, R.P. and Newcomb, W.A., Interchange, Rotational and Ballooning Stability of Long-Thin Axisymmetric Systems with Finite Orbit Effects, Phys. Fluids 29, 1558 (1986).

- [2] Caponi, M.Z., Cohen, B.I., and Freis, R.P., Stabilization of Flute Modes by Finite Larmor Radius and Surface Effects, *Phys. Fluids* 30, 1410 (1987).
- [3] Dobrott, D., Kendrick, S., Freis, R.P., and Cohen, B.I., Magnetohydrodynamic Stability of Hot-Electron Stabilized Tandem Mirrors, *Phys. Fluids* 30, 2149 (1987).
- [4] Post, R. F., T. K. Fowler, R. Bulmer, J. Byers, D. Hua, and L. Tung. "Axisymmetric tandem mirrors: stabilization and confinement studies." *Fusion science and technology* 47, no. 1T (2005): 49-58.
- [5] R.P. Freis and B.I. Cohen, Users Manual for the FLORA Equilibrium and Stability Code, UCID-20400 (April 1985).
- [6] BASIS System, Lawrence Livermore National Laboratory, (November 13, 2007), UCRL-MA-118543.

#### Appendix: Superset of files in FLORA archive

In addition to copies of Refs [1-4] above, the FLORA archive contains source code listings and input/output files. The archived files were organized into the following blocks by R. P. Freis. The acronyms and nomenclature are due to R. P. Freis.

1. Original FLORA XFLCII listings (2) – one correct and consistent, the other inconsistent
2. XFLCII examples and results – linear stability studies of rigid rotor equilibrium, several cases with parameter variations
3. FLORA5 examples – 2 linearly stable cases
4. Rigid Rotor PF linear stability examples (19 cases)
5. FLORE QT – quick test FLORA listing with corrected diagnostics and “gravity” as a surrogate for magnetic curvature
6. FLOREQT examples (16 cases, not all “good”)
7. FLOREQT Flute stability examples (17 cases) – some stable and some linearly unstable.
8. FLOREQT examples NF (6 cases, not all good)
9. FLOREQT examples NOSF61 – flute modes
10. FLOR OSC code listing and examples (2 linear stable cases)
11. FLOR TEX code listing and MHD stability examples (3)
12. FLOR TM 4, 5 and 6 codes listings, tandem mirror linear stability
13. EDISK 65 examples (6) – electron ring/disk stabilizing mirror runs using FLOR TM6
14. FLORTL8 code listing – no low-beta expansion used in equilibrium
15. XFLTK8 examples – ROT 36, 37
16. Energy diagnostic test series with electron ring/disk – FLR 1-21
17. FLRROT code listing
18. FLRROT examples – XFLROT series (~20 cases)
19. XFLDP examples (6 cases) patterned after earlier work by L D Pearlstein, DON PRO series
20. XFLM6 TANH PRO examples (5 cases)
21. FLR52 example for SAI (Don Dobrott) (1 case) – under-resolved in z

22. FLRM10 code listing (with error), FLRM11 code listing (corrected)
23. FLRD12 code listing and run series for Don Dobrott, SAIC