

Movies

Produced by LSU's Astrophysics Theory Group

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Nonaxisymmetric, Self-Gravitating Disks with Uniform Vortensity [1998]

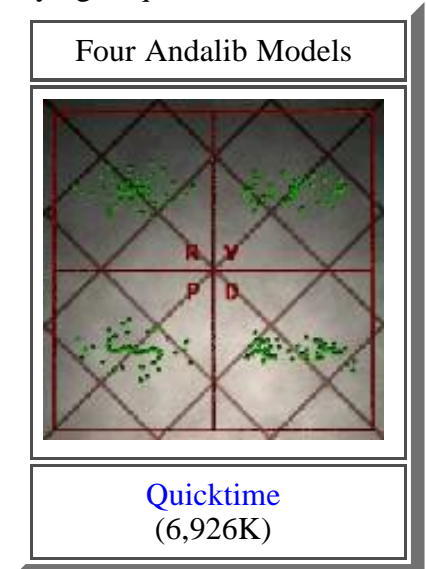


Andalib (1998) has developed a self-consistent-field technique that can be used to construct equilibrium models of infinitesimally thin, self-gravitating gaseous disks with (a) compressible equations of state, (b) nonaxisymmetric structures, and (c) nontrivial internal motions. By demanding that the disks have uniform vortensity (defined as the ratio of vorticity to mass density), Andalib has successfully constructed equilibrium disks with polytropic indices $0 < n < 1.3$ and minor-to-major axis ratios in the range $0.06 < b/a < 0.80$.

In the first frame of the "Prograde" movie shown here, a number of green test particles have been lined up along the major axis of one of Andalib's nonaxisymmetric disk models. Thereafter the particles are followed as they move along equatorial-plane streamlines of the flow, as viewed in a frame of reference that is rotating with the overall pattern speed of the nonaxisymmetric disk configuration. The illustrated flow is entirely prograde and largely differential, but there is a small volume near the center of the configuration that is moving harmonically.

The similarity between the flow in this steady-state configuration -- which has been derived using a self-consistent-field technique -- and the differential flow that has developed naturally from one of our fully three-dimensional, hydrodynamical simulations is striking! (See the accompanying "Equatorial Flow" movie that is presented in our discussion of [Compressible Analogs of Riemann Ellipsoids](#).) Apparently Andalib's model provides a good 2D analog of the 3D "final bar" that forms dynamically as a result of the two-armed, spiral mode instability in rapidly rotating gas clouds.

The animation sequence labeled "Four Andalib Models" illustrates the internal flow of four of Andalib's compressible disks with nonaxisymmetric structures. In addition to the model (P) which also has been displayed in the "Prograde" movie, above, the animation sequence illustrates: one model with fully retrograde internal motions (R); one model with vortices sandwiched between separate regions of prograde and retrograde flow (V); and a common-envelope binary (dumbbell-shaped) configuration (D). Andalib's work demonstrates that model "P" is just one among a series of compressible models with nontrivial internal flows that defines a smooth elliptical-dumbbell-binary sequence. As we have argued in a paper presented at the "Numerical Astrophysics 1998" conference in Tokyo ([Tohline, Cazes, and Cohl 1999](#)), we therefore suspect that the final triaxial configuration that forms as a result of the two-armed,



spiral-mode instability sits on an analogous (3D) sequence and that, if it is cooled slowly, it will evolve along the sequence to a common-envelope binary configuration such as the one illustrated here by model "D".

References

- Andalib, S. (1998), Ph.D. Dissertation, Louisiana State University. *The Sturcture and Stability of Selected, 2D Self-Gravitating Systems*.
- Tohline, J.E., J. E. Cazes, and H. S. Cohl (1999) in Numerical Astrophysics (Proceedings of the International Conference on Numerical Astrophysics 1998), eds. S.M.Miyama, K. Tomishak, and T. Hanawa, pp.155-158.
" *The Formation of Common-Envelope, Pre-Main-Sequence Binary Stars* "

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