Movies
Produced by LSU's Astrophysics Theory Group

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Two-Armed, Spiral-Mode Instability
[1997 - 1999]

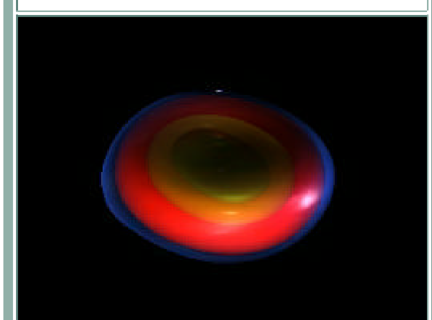
Some time ago, using three different 3D hydrodynamic simulation tools, Durisen *et al.* (1986) followed the development to nonlinear amplitudes of a two-armed, spiral-mode instability that arises naturally in rapidly rotating, self-gravitating systems. The particular initial model that was examined had an n = 3/2 polytropic equation of state, an n' = 0 angular momentum distribution, and an initial ratio of rotational to gravitational potential energy T/|W| = 0.33. The simulation tools that were used at the time were relatively crude, compared to tools that are available today.

Model A

Quicktime
(5,907K)

Employing a significantly improved finite-difference simulation code and improved spatial resolution (128^3 grid zones), we have repeated this simulation (Cazes 1999, Cazes & Tohline 1999). This has been done, in part, to check the validity of the earlier work and, in part, to permit us to conduct a much more thorough analysis of the end-state configuration. The movie labeled **Model A** was produced from this more recent simulation and shows the nonlinear development of the two-armed, spiral-mode instability in an initial model having an n = 3/2 polytropic equation of state, an n' = 0 angular momentum distribution, and a ratio of rotational to gravitational potential energy T/|W| = 0.30. The evolution is shown in the inertial reference frame and covers 46 dynamical times (20 central rotation periods) as defined by the properties of the initial model. Each frame of the Model A movie displays four nested isodensity contours at 80%, 40%, 4% and 0.4% of the maximum density. Via the trailing spiral structure, gravitational torques are able to effectively redistribute angular momentum on a dynamical time scale; a relatively small amount of material is shed into an equatorial disk (this disk material is not visible in the Model A movie because the disk material all has a mass density less than 0.4% of the maximum density); and the central object (containing most of the initial object's mass) settles down into a new equilibrium configuration.

Model B



Quicktime
(10.8M)

For comparison, we also have studied the development of the same type of two-armed (bar-mode), spiral instability in a model having an n = 3/2 polytropic equation of state and an initial T/|W| = 0.28, but with an angular momentum distribution specified to produce a uniform vortensity profile in the initial model, where vortensity is defined to be the ratio of vorticity to mass density (Cazes 1999, Cazes & Tohline 1999). The movie labeled here as Model B shows this evolution from an inertial reference frame and covers approximately 32 dynamical times as defined by the mean density of the initial model. The instability in this model has less of a pronounced spiral character, but ultimately results in the formation of a new triaxial equilibrium configuration with properties that are similar to the end-state of the Model A evolution.

As illustrated and discussed elsewhere we are convinced that the dynamically stable triaxial configurations that have been formed through both of these model simulations are compressible analogs of Riemann S-type ellipsoids. As such, they can provide important clues to our understanding of the evolution of protostellar gas clouds and the possible fission of such clouds into binary star systems; long-lived gaseous bars in galaxies; and compact stellar structures that may appear as continuous sources of gravitational radiation.

References

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