A triaxial model for the bulge of NGC 4697

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There is now mounting evidence that the intrinsic shape of elliptical galaxies and bulges of disk galaxies may generally be triaxial. There are different signatures of non–axisymmetric structures observed: velocity gradients along the minor axis (e.g. Davies & Birkinshaw 1986), twisting of the isophotes (e.g. Williams & Schwarzschild 1979) and misalignment between bulge and disk major axes (e.g. Bertola, Vietri & Zeilinger 1991). Therefore, a framework of reliable algorithms for the dynamical modelling of such triaxial potentials is needed.

Of all triaxial potentials, Stäckel potentials have the advantage that all orbits are regular. Moreover, the three integrals of the motion are simple quadratic functions of the velocities. Therefore one can construct simple components, representing families of stars, which are in (not necessarily self–consistent) equilibrium in a Stäckel potential.

Very flattened elliptical galaxies were selected as observational prerequisite for such models. In the past most of the effort was concentrated on round "bona–fide" ellipticals, and there are no explicit dynamical models for flattened ellipticals. If kinetic energy (pressure or rotational) is responsible for their flattenings, their most advantageous viewing angle is one that is very nearly edge-on, since in that direction the large kinetic energy will appear as motion along the line-of-sight, which is detectable.

The E6 galaxy NGC 4697 is considered to be one of the "prototypes" of non–rotationally supported systems. The observations were carried out at the ESO 3.5-m NTT with EMMI in the Red Medium Spectroscopy Mode using a FA 2048×2048 CCD (15 μm pixelsize). Long–slit Spectra with a spectral resolution of 20 km/s were obtained along the optical major axis, 45° intermediate axis and at an offset of $5''$ parallel to the major axis. The calibrated spectra were rebinned to have $S/N > 30$ in the centre and 15 in the outer parts. The spectra were analyzed with the Fourier Quotient technique yielding radial velocities and velocity dispersions as a function of radius.

Unlike the spherical case, we must make a number of assumptions when modelling triaxial galaxies from their projected quantities: First of all, there are no direct indicators for the determination if the viewing angles, such as a gaseous disk (as in NGC 5077). Surface photometry of NGC 4697 reveals however a stellar disk, seen almost edge–on (being the most favourable inclination for detection). Hence, we place the z-axis in the plane of the sky. There is no obvious choice for the orientation of the x-axis. We arbitrarily place it in the plane of the sky. Further, we assume a Kuzmin–Kutuzov potential for simplicity. Using ellipsoidal coordinates with axis ratios of $a/b = 1.1$, $b/c = 1.5$, and a scale length $b + c = 1.75$ kpc, we

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were able to produce a projected surface density which is a surprisingly good fit to the photometry.

The dynamical model has components of Abel type (Dejonghe & Laurent 1991), and has a distribution function $F(E, I_2, I_3) = F(E + wI_2 + uI_3)$, where E, I_2 and I_3 are the Stäckel integrals of the motion. In order to produce rotation, we added new components which are constant on similar planes in phase space, but are restricted to the region in phase space occupied by short axis tubes. The calculations for the moments (mass density, mean rotation and velocity dispersion) are only approximate at this point.

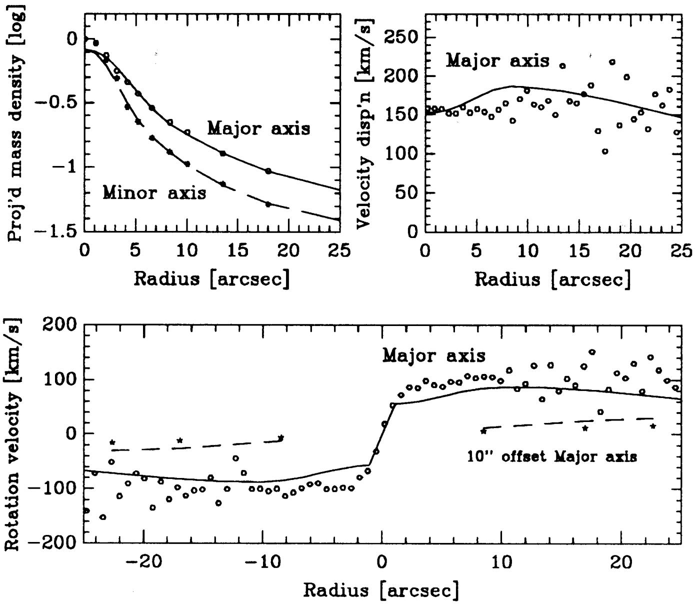

Fig. 1. Projected mass density (top left), projected velocity dispersion (top right) and rotation velocity (bottom). Lines (solid and dashed) show the model.

As is clear from the figure, the model produces an excellent fit to the photometry. The velocity dispersion too is fitted within the observational error (suggested by the spread of the data points). Clearly no hidden matter is needed on these scales. The rotational velocity is, if anything, a bit low. In the model, the different kinds of short axis tubes are populated fairly evenly. This suggest that there is more structure in the short axis orbit population, with more emphasis on circular orbits.

References

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