# PERIODIC ORBITS IN THREE–ARMED GALAXIES

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## 1. Introduction and Models

Although interarm features in the Population I disk of spiral galaxies frequently give an impression of a three-fold symmetry (Patsis *et al.*, 1997), true three-armed spiral structures in the old stellar disk are seldomly seen. Such systems are of special interest since they display unique conditions which favor the growth of m=3 modes. The face-on spiral NGC 7137 shows a clear three-armed pattern on K-band images and was used as a prototype for the potential of these systems.

A K-band map of NGC 7137 was decomposed in axisymmetric components and a synthetic rotation curve was generated [see (Grosbøl and Patsis, 1998)]. The maximum rotational velocity was taken to be ≈150 km $sec^{-1}$corresponding to the mean value given by (Rubin *et al.*, 1982) for this type of galaxy.

The potential used by (Contopoulos and Grosbøl, 1986) was adopted for the dynamic models substituting the m=2 perturbation with a three-armed spiral. The rotation curve associated to the axisymmetric potential was fitted to the synthetic curve. The spiral pattern had a pitch angle of $-33.2°$ while the pattern speed $\Omega_p$ was set to 31.7 km $sec^{-1}$ $kpc^{-1}$corresponding to the 6:1 resonance being at the end of the strong symmetric spiral. Two sets of models were calculated namely: a weak spiral with a relative radial force perturbation $f_r = 1.5\%$, and a strong spiral ($f_r = 9.0\%$) to show non-linear effects.

## 2. Periodic orbits

The central family of periodic orbits were found for each model. The stability index $\alpha$ is shown on Fig. 1a where also the location of resonances are indicated. The orbits are all stable (i.e. $|\alpha| < 1$) and display the typical variation as function of energy expressed as the radius $r_c$ in an axisymmetric model. The central family of periodic orbits splits at the resonances 3:1, 6:1, 9:1 etc. similar to the behavior for two-armed spiral models at the resonances 2:1, 4:1 and 6:1.

The actual periodic orbits for the strong spiral case are plotted in Fig. 1b where also locations of the spiral potential minima are shown. It is clear from this figure that the orbits develop cusps at the main resonances (i.e. 3:1, 6:1, 9:1 etc.) and that their orientations shift (e.g. by 60° at 3:1 and 30° at 6:1). Further, the response is only in phase with the perturbation in the region between 3:1 and 6:1 [see



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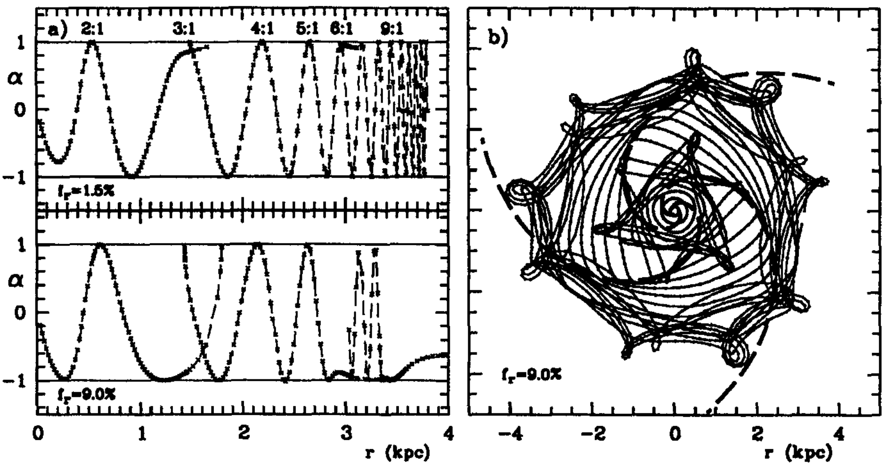


Fig. 1. **a)** Stability index $\alpha$ for the weak and strong spiral models as function of energy expressed as $r_c$. **b)** Central family of periodic orbits for the strong spiral model. The dashed lines show the locations of the spiral potential minima.

(Contopoulos and Grosbøl, 1988) for the two-armed case]. This suggests that self-consistent models of strong three-armed spirals can be constructed only between the 3:1 and 6:1 resonances while weak spiral perturbation can exist outside this region. It confirms the general conclusions of (Contopoulos and Grosbøl, 1988) in the case of three-armed spiral galaxies where the 3:1 and 6:1 resonances replace the 2:1 and 4:1 resonances as the most important.

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