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Galactic rings and secular evolution in barred galaxies

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Abstract. Rings are common in galaxies. Several kinds of rings are known: collisional, polar, and resonance rings, of which the latter is by far most common. Resonance rings are prime tracers of the underlying dynamical structure of disk galaxies, in particular of orbital resonances and of manifolds. Rings are also indicators of angular momentum transport, and this is a key factor in secular evolution (see the various reviews in Falcón-Barroso & Knapen 2012).

Resonance rings come in three flavours, primarily defined by their size, namely nuclear, inner, and outer rings. From studies like those of Buta (1995), Knapen (2005) and Comerón *et al.* (2010, 2013) we know that the radii of nuclear rings range from a few tens of parsec to some 3.5 kpc, while inner rings and outer rings have typical radii of 1.2 and 2.5–3 times the length of the bar. Many host galaxies of rings are barred, but so are most galaxies in general. Some 20% of all rings occur in non-barred galaxies, which implies that rings do not, or hardly, occur preferentially in barred galaxies (Knapen 2005, Comerón *et al.* 2010, 2013). In most non-barred ringed galaxies an oval, a past interaction, or even a prominent spiral pattern lies at the dynamical origin of the ring, but this needs additional scrutiny.

From an inventory of all known *nuclear* rings, Comerón *et al.* (2010) reach the following conclusions. Star-forming nuclear rings occur in $20 \pm 2\%$ of disk galaxies with $-3 < T < 7$; 18/96 occur in disk galaxies without a bar (19%); they are found in S0 to Sd galaxies, peaking in types Sab Sb; when nuclear rings occur in barred galaxies, the ring radius is limited to one quarter of the bar radius; and stronger bars host smaller rings (cf. Knapen 2005).

We are now using the *Spitzer* Survey of Spiral Structure in Galaxies (S^4G; Sheth *et al.* 2010) to expand our survey to inner and outer rings (Comerón *et al.* 2013). We aim to study the relations between ring and host properties – as we did before for nuclear rings. We will use the S^4G sample size and image depth to reach further insight into the secular evolution of galaxies by measuring structural properties of rings, as well as those of components like bars and disks. We will then be able to tackle outstanding questions such as the origin of rings in non-barred galaxies, and how exactly ring properties are determined by the bar.

Keywords. galaxies: evolution, galaxies: formation, galaxies: structure, galaxies: spiral, galaxies: kinematics and dynamics

References

Buta, R. J. 1995, *ApJS*, 96, 39

Comerón, S., Knapen, J. H., Beckman, J. E., Laurikainen, E., Salo, H., Martínez-Valpuesta, I., & Buta, R. J. 2010, *MNRAS*, 402, 2462

Comerón, S., Knapen, J. H., *et al.* 2013, *A&A*, 562, 121

Falcón-Barroso, J. & Knapen, J. H. 2012, Eds., *Secular Evolution in Galaxies* (Cambridge: Cambridge University Press)

Knapen, J. H. 2005, *A&A*, 429, 141

Sheth, K., *et al.* 2010, *PASP*, 122, 1397