Coordinated Galaxy Growth from Nuclear to Global Scales: Analysis of an Unusually Resonant S0 Galaxy and Its Companion

Tara A. Scarborough and Sheila J. Kannappan
University of Texas at Austin and University of North Carolina

Abstract:
We present an unusual S0 galaxy with narrow, luminous, bright blue inner and outer resonance rings along with a strong bar and likely intrinsic outer-disks elongation. Its dwarf companion at ΔX=30 kpc and ΔY=30 km/s is also bright blue. We investigate the possibility of nested nuclear resonance structure and/or LLAGN activity. We perform stellar population analysis and ugriz photometry and VIRUS IFU spectroscopy to test the hypothesis of coeval interaction-triggered starbursts in both systems across a wide range of scales. The rare combination of multiple blue rings and possible nuclear activity in the primary galaxy may reflect a short-lived evolutionary state that is key to understanding coordinated bulge, disk, and black hole growth, possibly as part of a transformation from a classical S0 to a pseudobulge S0 or later type galaxy.

Background:
Drawn from a recently identified class of E/S0s with colors typical of spirals at the same mass (Kannappan, Pilchak, and Baker 2007), this unusual galaxy may be consistent with disk and pseudobulge growth in a bursty, triggered mode that may depend on companion interactions. Most virally described as a 'racetrack' galaxy, our target is neither spiral nor typical S0. We believe that it is the only known system with narrow, intense blue rings at both the inner 4:1 and outer Lindblad resonances (private communication B. Bulta, 2006, J. Komendy 2006). This could be either a short lived state experienced by many galaxies or a unique paradigm. We propose that observed structures represent a phase that is not uncommon because the structures match canonical resonances. We suggest that this state may be unstable because we see possible breakup in the inner resonance ring and the outer ring's likely intrinsic elongation makes it vulnerable to shear. This ring formation and destruction process may contribute to the growth of the pseudobulge and outer disk. We note that the stellar velocity dispersion (125km/s, SDSS database) places the galaxy on the dynamically hot end of the SDSS. Growth on scales of the disk and pseudobulge, triggered by the same interaction event. We also consider whether further nested nuclear structure may be present given the apparent nuclear elongation at low SDSS resolution. We consider whether the spatial distributions of star formation and of young and old stellar populations support the scenario of disk and pseudobulge (re)building.

Here we investigate whether this system reflects the direct onset of coupled growth on scales of the disk and pseudobulge, triggered by the same interaction event. We also consider whether further nested nuclear structure may be present given the apparent nuclear elongation at low SDSS resolution. We consider whether the spatial distributions of star formation and of young and old stellar populations support the scenario of disk and pseudobulge (re)building.

Conclusions:
We believe that our target is the only known system with narrow, intense blue rings at both the inner 4:1 and outer Lindblad resonances. The galaxy may be an anomaly, but with the companion interaction evidence, this could actually be a short-lived state that is not rare. The ages of the starbursts in the inner and outer ring and the companion are all consistent with an interaction occurring a few hundred Myr ago. The proximity of the primary and companion (30kpc) is consistent with an interaction occurring a few hundred Myr ago assuming a velocity ~100km/s.

New VIRUS-P data will allow for more accurate analysis of the stellar populations.

Nuclear emission line ratios may provide evidence of nuclear activity, more work on this is needed.

This system may reflect a process of linked pseudobulge and disk growth involving interaction induced star formation.

References:

We are grateful for Jason Adams and the VIRUS-P team who helped reduce data and provided funding to travel to McDonald Observatory. Also a special thanks to Ben Wilkins and Shane pigeon for their scientific feedback. Andrew Baker coined the phrase "lackbulge" galaxy.

This research was partially supported by an NSF Astronomy & Astrophysics Postdoctoral Fellowship to S.K. under award AST-0402347.