AO Imaging of the Nuclei of Sy2 Galaxies
Indications of an Unexpectedly High Occurrence of Nuclear Rings?

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We analyzed high-resolution near-infrared Ks-band images of the centers of 18 Seyfert 2 galaxies, using adaptive optics with the Large Binocular Telescope (LBT). We used the fully 2-dimensional decomposition algorithm GALFIT to remove radially symmetric components. This enabled us to reveal the stellar nuclear structures underlying the dominant large-scale structure.
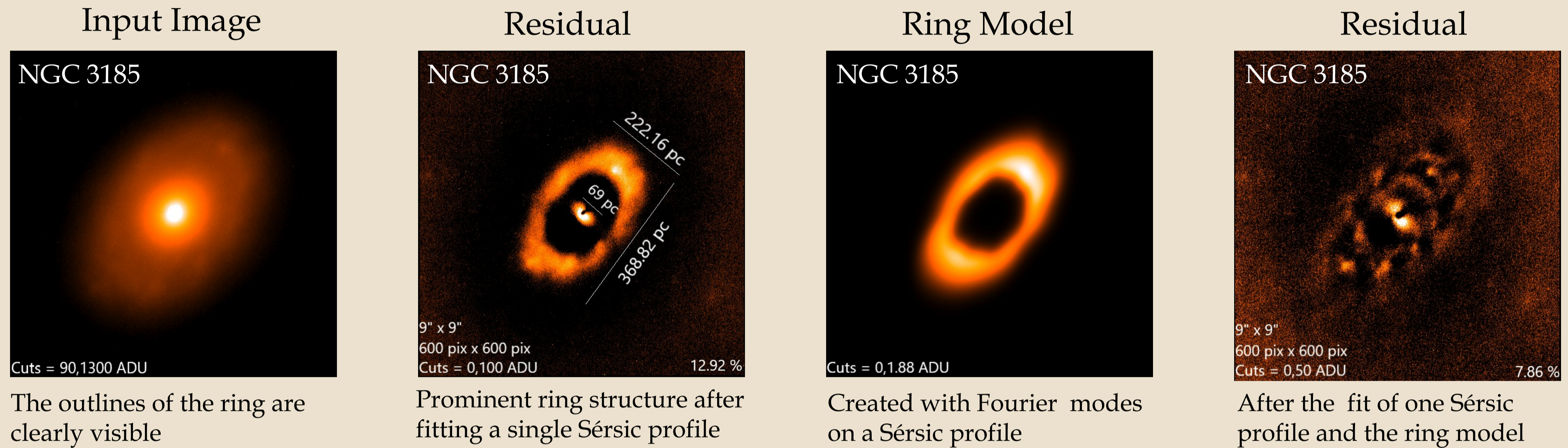
Our Results

- 11/18 targets exhibit ring-like structures. Four of them have a large-scale bar, which could have induced rings through resonant effects.
- The rings vary in radius from 0.15-2 kpc (0.9-10"); five of them are ultra-compact nuclear rings (< 200 pc radius).
- The remaining sources are dominated by bars and/or more complex structures.

Discussion

- The sample is unbiased, selected based on observability at the telescope, but has an S/N ratio 10 times higher than that in earlier studies. The results are robust, as confirmed by our analysis of HST data for these sources.
- Surprisingly, over 50% of our galaxies have ring-like structures, which is considerably higher than what has been found in earlier studies (10%). About 20% of non-active galaxies show nuclear rings.
- There is a clear lack of small rings in Sy 2 galaxies (histogram left). Earlier studies have typically used 1-dimensional analysis through ellipse fitting and analysis of the surface brightness profiles. Redoing the analysis using GALFIT or other 2-dimensional methods may possibly reveal the missing population.
- The nuclear rings in both - active and non-active galaxies - are found in the same region within a galaxy and are more likely to be triggered by non-axisymmetric potentials along the ILR than by the active nucleus (see histogram on the right).
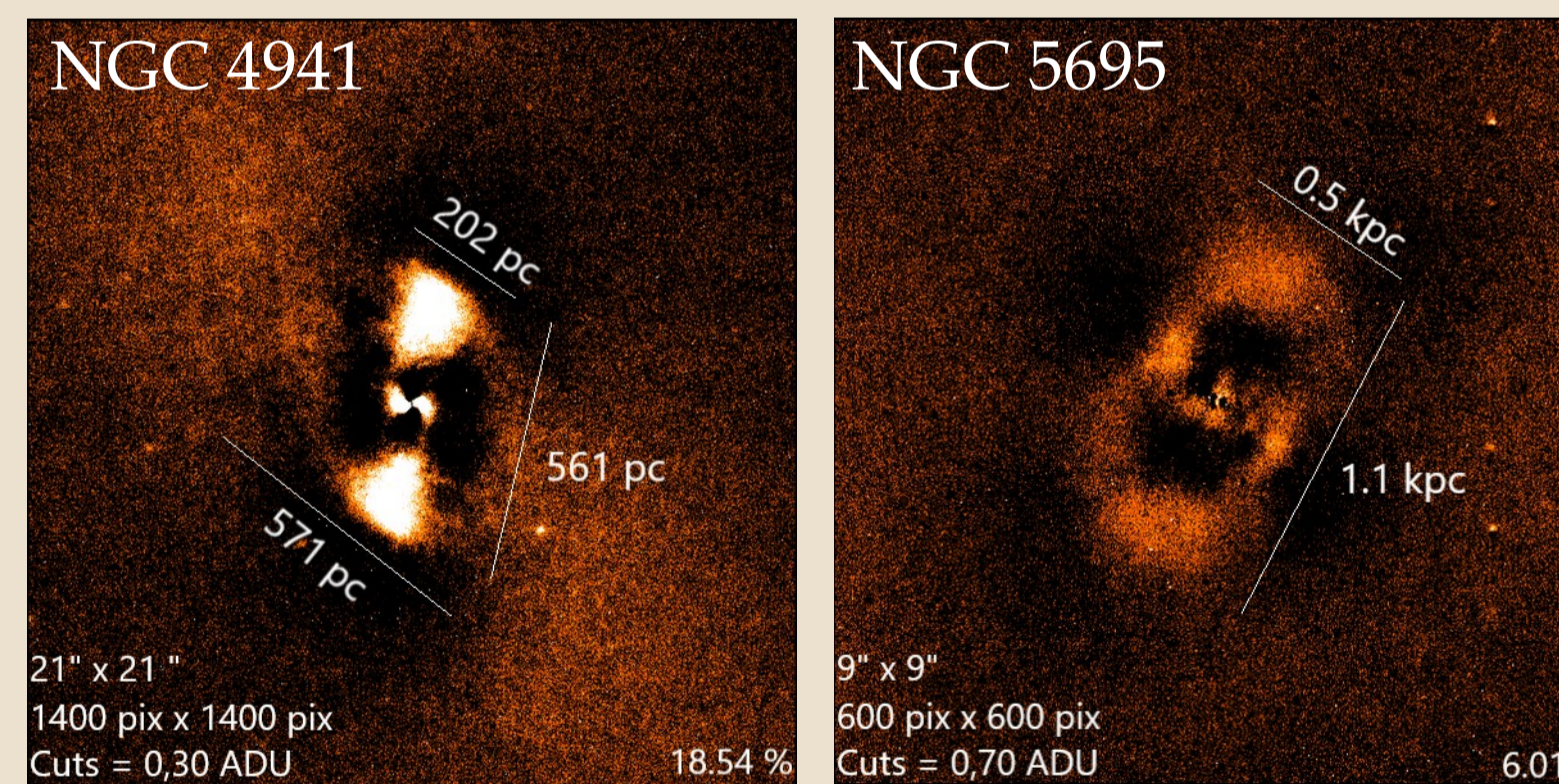
The formation of nuclear rings does not depend on whether there is an active source in the center or not (at least for low-luminosity AGN). This is understandable, as the lifetime of a ring (1-3 Gyr) is considerably longer than that of an active nucleus.

In four galaxies, the ring was so prominent, as shown here for NGC 3185, that it was possible to model the rings with GALFIT
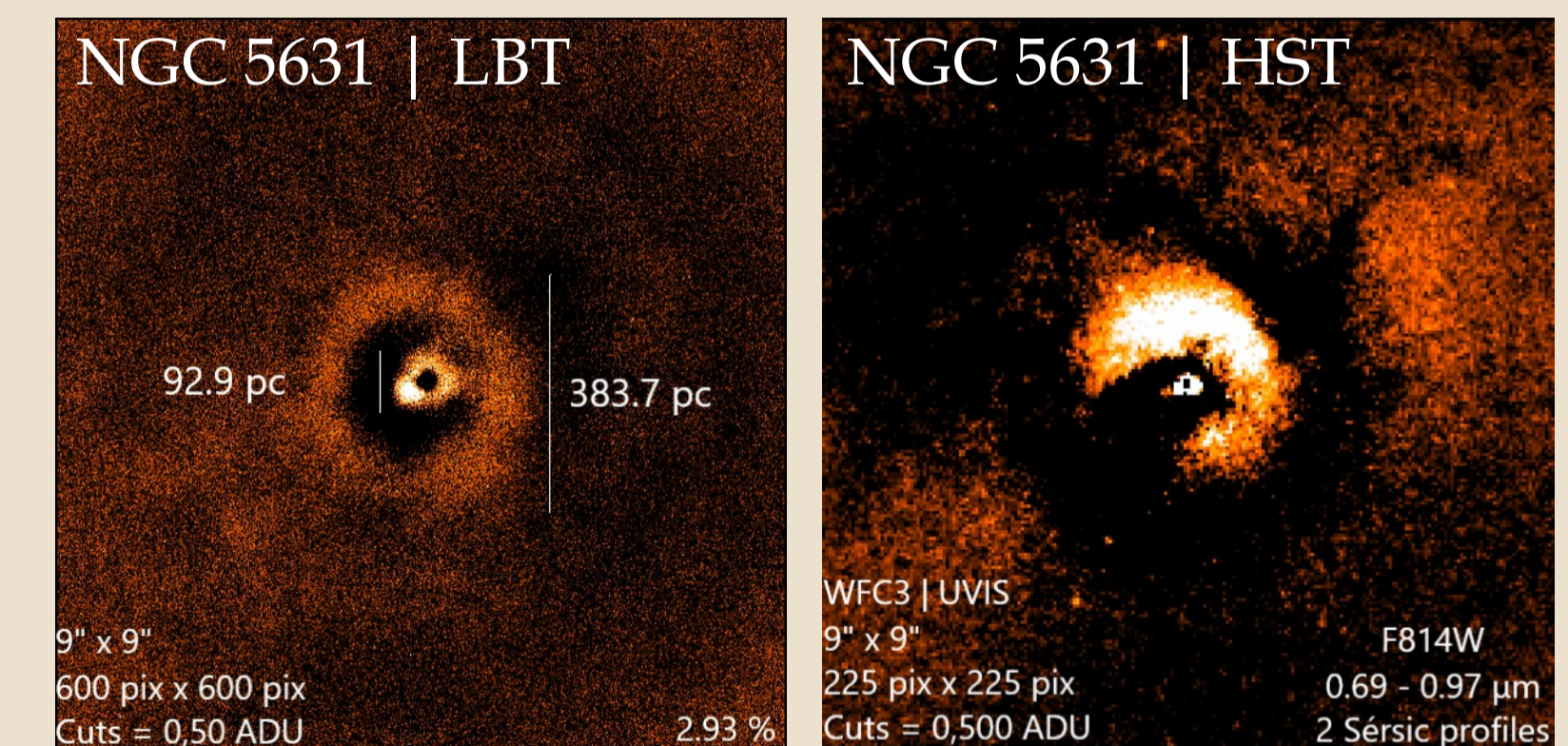
Input Image

NGC 3185

Cuts = 90,1300 ADU

The outlines of the ring are clearly visible

Residual

NGC 3185

222.16 pc
69 pc
368.82 pc

9" x 9"
600 pix x 600 pix
Cuts = 0,100 ADU   12.92 %

Prominent ring structure after fitting a single Sérsic profile

Ring Model

NGC 3185

9" x 9"
Cuts = 0,1.88 ADU

Created with Fourier modes on a Sérsic profile

Residual

NGC 3185

9" x 9"
600 pix x 600 pix
Cuts = 0,50 ADU   7.86 %

After the fit of one Sérsic profile and the ring model

In some galaxies the ring...

...was not the dominant structure

NGC 4941

202 pc
561 pc
571 pc

21" x 21"
1400 pix x 1400 pix
Cuts = 0,30 ADU   18.54 %

NGC 5695

0.5 kpc
1.1 kpc

9" x 9"
600 pix x 600 pix
Cuts = 0,70 ADU   6.01%

The ongoing work involves modeling the dominant structures, such as bars, using Ferrer functions to make the weaker ring structures more visible

... was very compact and unclosed

NGC 5631 | LBT

92.9 pc   383.7 pc

9" x 9"
600 pix x 600 pix
Cuts = 0,50 ADU   2.93 %

NGC 5631 | HST

WFC3 | UVIS
9" x 9"
225 pix x 225 pix
Cuts = 0,500 ADU   F814W
0.69 - 0.97 µm
2 Sérsic profiles

The analysis of the HST snapshot data for most of the objects reveals qualitatively consistent results, as demonstrated by the example of NGC5631

Radii of the rings and their position within the galaxy compared to inactive galaxies

Radii of circumnuclear rings
- non-active galaxies (Comeron 2010)
- Sy 2 (Martini (2003), Aguero (2016))
- our Sy 2

r [kpc]

Ratio of the ring radius over the galaxy radius
- non-active galaxies (Comeron 2010)
- Sy 2 (Martini (2003), Aguero (2016))
- our Sy 2

log (r_ring/r_galaxy)