HST Imaging of Sub-Kiloparsec Scale Structure in Markarian Galaxies

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Abstract.
As part of our HST WF/PC-1 near-IR survey of Markarian galaxies we have identified several non-Seyferts which display peculiar morphologies on sub-kiloparsec scales. These include double nuclei, spiral structures, and twisting isophotes. One explanation is that we are seeing asymmetric disturbances to the gravitational potential which drives gas inflow providing fuel for the nuclear starburst. Alternatively, these features may be tracing the distribution of massive stars produced by the starburst.

INTRODUCTION

Galaxy interactions and mergers are often cited as important mechanisms for inducing bursts of star formation and activity in galactic nuclei. Theoretical studies and numerical simulations of interacting galaxies have shown that large fractions of the system's interstellar medium can be deposited within the central kiloparsec in a few dynamical times (*e.g.* Barnes & Hernquist 1991). To complete this picture, however, additional gravitational torquing is required for the gas to reach the smallest nuclear scales. This can result from bisymmetric disturbances on scales < 1 kpc such as small bars or double nuclei in a merger of two colliding galaxies. By examining the near-nuclear morphology of Markarian galaxies we can determine if such structures are present and their relationship to the star-formation history.

Table. Small-Scale Structure in Markarian Galaxies

Name	cz (km/s)	M^*_{pg} (mag)	Scale* (kpc/″)	Morphology
Mrk 38	10820	−19.8	0.70	Nuclear arm & oval misaligned with main bar.
Mrk 96	6600	−19.2	0.43	Double nucleus.
Mrk 289	12000	−19.5	0.78	Double nucleus, distorted large scale morphology.
Mrk 420	12860	−20.7	0.83	Inner spiral; twisting isophotes.
Mrk 434	9840	−20.1	0.64	Nuclear arm, twisting isophotes.
Mrk 542	7500	−19.5	0.48	Nuclear arm; extended large scale arm.
Mrk 623	12562	−19.6	0.81	Nuclear arm.

* Assumes H_o=75 km $s^{-1}Mpc^{-1}$.

OBSERVATIONS AND RESULTS

We have obtained HST WF/PC-1 "snapshots" (0.043 ″/pix) with F785LP filter, (∼ I band) for 52 Seyfert and 50 non-Seyfert Markarian galaxies. The sample is described in MacKenty (1989). Here we concentrate on the non-Seyferts in the sample. The passband contains virtually no emission lines and therefore produces images which trace stellar and nuclear continuum sources. Each image was deconvolved using the accelerated Lucy algorithm (Lucy 1974).

We present images of 7 sample galaxies which display near-nuclear morphological peculiarities. Results are summarized in the Table. These features are found less than 1 kpc from the nucleus in all cases. Recurrent features are nuclear extensions or "arms" (4), double nuclei (2), twisting isophotes (all?). Similar features are seen in our Seyfert sample (MacKenty *et al.* 1997). We emphasize that these are near-IR continuum images and therefore represent the distribution of starlight and *not* emission line gas.

DISCUSSION

Small-scale, non-axisymmetric structures such as those shown here, can induce the additional gas inflow required to fuel nuclear star formation. (*e.g.* Shlosman, Frank, & Begelman 1989). The two double nuclei objects may be in the late stages of a merger when the most vigorous star formation is likely to occur (Mihos & Hernquist, 1996). The detetction of similar structures in the Seyfert galaxies supports the idea that nuclear activity can be fueled by the same mechanism. Alternatively, since numerical simulations find that secondary bars, which provide the dynamical mechanism for inflow, form not

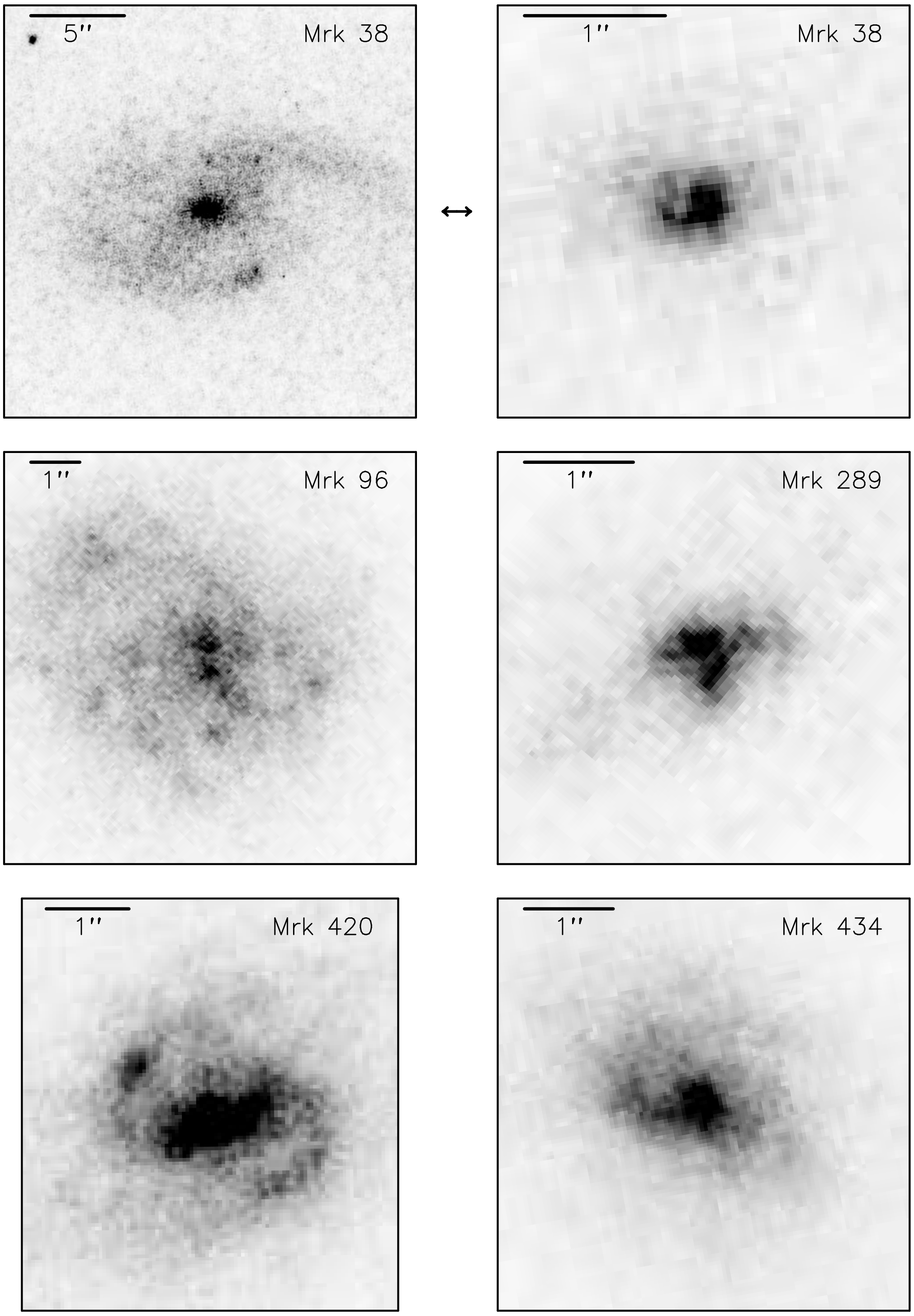

FIGURE 1. Markarian non-Seyfert galaxies with peculiar morphologies on sub-kiloparsec scales.

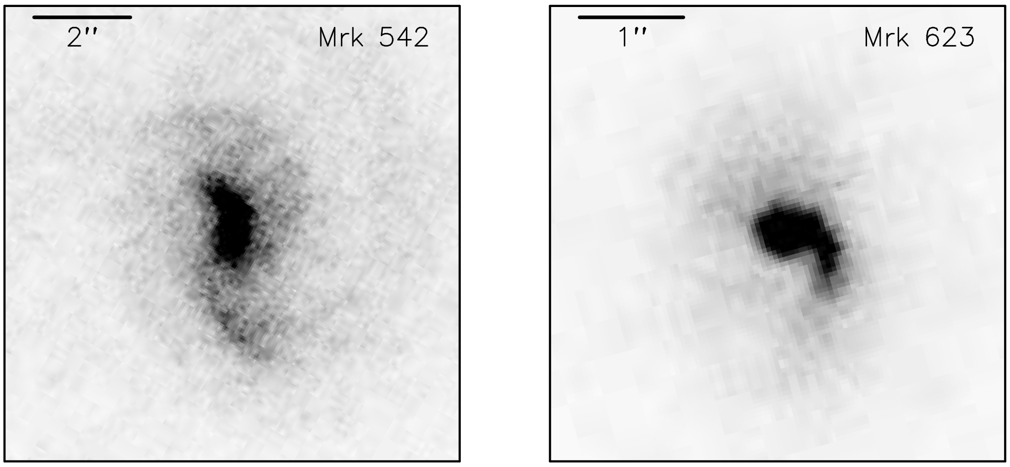

FIGURE 2. Markarian non-Seyfert galaxies with peculiar morphologies on sub-kiloparsec scales.

in the stars but in the gas, the near-IR continuum we observe may come from supergiants produced by star-formation in the gas bar. In this case we are seeing the *effects* rather than the *cause* of the nuclear starburst.

SUMMARY

We present images of Markarian galaxies which display small-scale structure ($<$ 1 kpc) suggesting dynamical mechanisms for producing gas inflow. These features take the form of nuclear arms, double nuclei and isophote twists. It is also possible that these features track massive, evolved stars produced by the starburst rather than the underlying structure of the host galaxy.

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