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# Photometry and Kinematics of the Ringed Barred Galaxy NGC 3081

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**Abstract.** We present a preliminary analysis of $B$- and $I$-band CCD images and Rutgers imaging Fabry–Perot H$\alpha$ interferometry of the galaxy NGC 3081. We find that the outer $R_1$ and inner ring are both intrinsically oval. We derive a bar pattern speed from the velocity field.

## 1. Introduction

Statistics in the Catalog of Southern Ringed Galaxies (Buta 1995 = CSRG) demonstrate that inner and outer ring shapes are inherently oval, supporting results of ringed galaxy simulations (Schwarz 1984; Byrd et al. 1994). HI studies and simulations have shown that barred galaxies have characteristic twisting isovelocity contours within the bar radius, indicating bar-driven non-circular motion (eg. Bosma, these proceedings; Lindblad et al., these proceedings; and references therein). We examine these properties for a particular galaxy, NGC 3081. NGC 3081 is a classic four-ring barred galaxy — having nuclear, inner, and outer $R_1$ & $R_2'$ rings, and both primary and secondary bars (it also happens to be a Type 2 Seyfert). Its inner ring ranks as one of the highest contrast features of its type.

## 2. Surface Photometry

We observed NGC 3081 on 1992 March 30 and 1995 March 1 in $B$ and $I_C$ filters with a Tek1K CCD on the CTIO 1.5 m telescope, under similar seeing conditions.

Ellipses were fit to image isophotes using standard GASP routines, with the ellipticity, major axis position angle, and ellipse center coordinates allowed to vary. Figure 1 shows results of these ellipse fits. The photometric inclination is $i = 31°$, and the line of nodes position angle is $\phi_n = 88°$; however, these are the averages over ellipses which may be affected by the halos of several field stars lying directly in front of the $R_2'$ ring. After deprojection, the inner ring would have an axis ratio of $q = 0.74$ and would be aligned nearly parallel to the bar, and the outer $R_1$ ring would have $q \approx 0.83$ and would be aligned nearly

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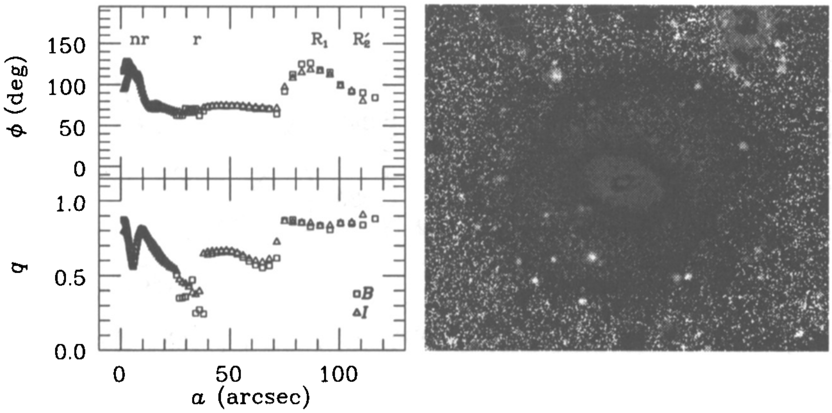


Figure 1. NGC 3081 photometry. Left: results of ellipse fits to isophotes in the $B$- and $I$-band images; the lower panel is the minor/major axis ratio; the upper panel is the ellipse major axis position angle on the sky. Right: the $B-I$ color index map, with blue features ($\mu_B - \mu_I \approx 1.5$) dark and red features ($\mu_B - \mu_I \approx 2.5$) light.

perpendicular to the bar — consistent with statistical results in the CSRG for such features. Figure 1 also shows the $B-I$ color index map from the combined CCD data. All four rings are clearly visible in the figure. The $R_2'$ pseudoring feature, discovered in this study, makes NGC 3081 a previously unrecognized example of the combination $R_1R_2'$ morphology defined in the CSRG.

## 3. Kinematics

We also observed NGC 3081 on 1992 March 27 in H$\alpha$ with the Rutgers imaging Fabry–Perot interferometer on the CTIO 4 m telescope.

Figure 2 shows velocity profiles along the photometric major and minor axes. Significant rotation in the minor axis profile indicates that the photometric position angle is not quite the galaxy's true position angle. There is clearly non-circular motion in the nuclear region. Figure 2 also shows the mean velocity *vs.* position angle diagram for the inner ring (defined in projection as an elliptical annulus with $a = 33'' \pm 5''$, $\phi = 71°$, and $q = 0.66$). Note that the systemic velocity is lower than the nuclear velocity by almost 20 km s$^{-1}$. Pure circular rotation fails to fit these data well; we have fit a uniformly precessing ellipse model (Chevalier and Furenlid 1978) which significantly improves the fit. Unfortunately, using the photometric orientation parameters in the model results in a nearly non-precessing ellipse. If we force the ring to be associated with the inner 4:1 resonance, a situation found in many test-particle simulations (Byrd et al. 1994, and references therein), then the kinematic line of nodes would be 96° and the required pattern speed would be $\Omega_p = 4.78 \pm 0.11$ km s$^{-1}$ arcsec$^{-1}$ or $30 \pm 1$ km s$^{-1}$ kpc$^{-1}$ for a distance of 32.5 Mpc. This is only a preliminary estimate and more sophisticated models should be able to improve on it. We are currently unsure of the exact orientation of NGC 3081.

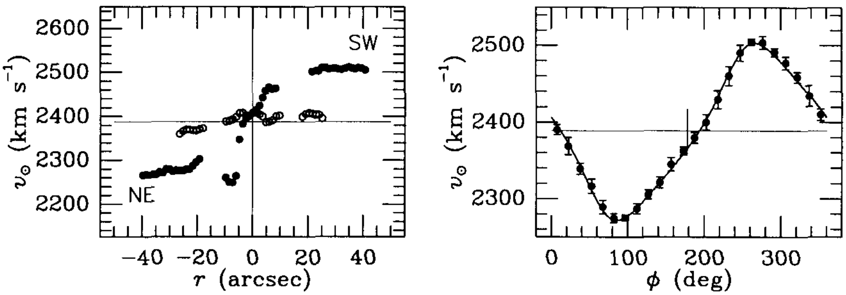


Figure 2. NGC 3081 kinematics. Left: velocity profiles along the photometric major (filled) and minor (open) axes. Typical errors are $< 10$ km s$^{-1}$. The horizontal and vertical lines indicate the systemic velocity, 2389 km s$^{-1}$, and the position of the photometric nucleus, respectively. Right: the velocity–position angle diagram of the inner ring, with the solid curve showing the best–fit uniformly precessing ellipse model using the photometric orientation. The horizontal and vertical lines indicate the systemic velocity, and the position angle of the minor axis (178°), respectively. All points are means, and error bars are standard deviations.

## 4. Conclusions

NGC 3081 is an excellent example of a ringed barred galaxy. The photometric observations provide strong evidence for non-circular shapes of the ring features. An estimate of the pattern speed has been made from an "orbit" model of the inner ring kinematics, which demonstrate non-circular motions in H$\alpha$. A more detailed analysis and interpretation of our data will be presented later.

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