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POLARIZATION IN THE RADIO GALAXY 3C 109—AN OBSCURED QUASAR

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ABSTRACT

The broad-line radio galaxy 3C 109 is one of the most highly polarized active galaxies known, outside of the "blazars." We present data from a newly commissioned spectropolarimeter on the Hale 5 m telescope which convincingly demonstrate that the continuum and broad-line region are polarized by transmission through aligned dust grains within the host galaxy of 3C 109 itself. The wavelength dependence of the polarization is well fitted by a combination of two Serkowski laws, one representing polarization within our own Galaxy and the other representing polarization at the redshift of 3C 109. The large Balmer decrement of the broad lines also indicates the presence of reddening by dust. The narrow emission lines, such as [O III] $\lambda\lambda$4959, 5007, are relatively unpolarized; the implications for the location of the dust are discussed. When dereddened by the implied minimum amount of intervening dust, the continuum becomes very blue ($\alpha = 1.0 \pm 0.3$, where $f_\nu \propto \nu^\alpha$). This is comparable to (2 σ higher than) the bluest slopes seen in other quasars, $\alpha \approx 0.5$. It almost certainly indicates that the dust grains in 3C 109 have a high polarizing ability, at least as great as the highest seen in our own interstellar medium.

When extinction by the intervening dust is taken into account, the absolute V-magnitude of 3C 109 becomes -26.6 or brighter, placing it well into the "quasar" luminosity range. Although classified as an N galaxy by several authors, if the nucleus were seen unobscured, the surrounding galaxy would be invisible on ground-based images, and we would classify the object as a quasar. The radio spectrum and morphology suggest that the radio jets are fairly close to the plane of the sky. These results generally support the view that many radio galaxies may be quasars with their jets pointed away from our direct line of sight.

Subject headings: dust, extinction — galaxies: individual (3C 109) — galaxies: nuclei — instrumentation: polarimeters — polarization — radio continuum: galaxies

1. INTRODUCTION

Much recent work in the field of active galactic nuclei (AGNs) has concentrated on understanding the effects of aspect dependence on our classification schemes and interpretation of the AGN phenomenon. For example, it is now generally accepted that the phenomena seen in many continuum-dominated, highly variable AGNs are the result of our line of sight passing close to the axis of a relativistic, and hence Doppler-boosted, jet. Other evidence for relativistic beaming has been used to argue for aspect-dependent effects in radio galaxies and quasars, and the term "unification" has become popular (e.g., Barthel 1989). Unification implies that radio galaxies and quasars are to a great extent similar populations of AGNs, but our classification of a particular object depends on our view of it, rather than on some fundamental property of the object itself.

Another form of aspect dependence is obscuration. Spectropolarimetry has been used to show that several Seyfert 2 galaxies actually harbor Seyfert 1 nuclei, apparently hidden from direct view by obscuring tori of high optical depth (Antonucci & Miller 1985; Miller & Goodrich 1990; Miller, Goodrich, & Mathews 1991). The broad-line regions (BLRs) are seen in these objects via scattered, hence polarized, light. A similar effect may exist among radio galaxies, as discussed by Antonucci & Barvainis (1990).

We have commissioned a new spectropolarimeter at Palomar Observatory and are using it to study the question of obscuration in radio galaxies, and the possible unification of radio galaxies and radio-loud quasars. In this contribution we study the high-polarization broad-line radio galaxy 3C 109.

Yee & Oke (1978) presented a low-resolution spectrum of 3C 109 and noted the large Balmer decrement in their data. Subsequently Rudy et al. (1984) published filter polarimetry and gave a critical discussion of the possible polarigenic mechanisms in 3C 109. They concluded that the high polarization was constant across the broad Hα emission feature and was consistent with the large degree of reddening implied by the large Balmer decrement. They further suggest that the narrow [O III] emission lines should be less highly reddened, and less highly polarized, as the [O III]/Hβ line ratio appears to be larger than normal.

We present spectropolarimetry of 3C 109 which strengthens the picture of polarization by dust transmission in the host galaxy of 3C 109. We also discuss possible explanations for the discrepancy between high continuum polarization and apparently low continuum reddening, as well as the implications for aspect dependence in radio galaxies in general.

2. OBSERVATIONS

Spectropolarimetry of 3C 109 was obtained on two different nights using the new spectropolarimeter attached to the double spectrograph on the Hale 5 m reflector of Palomar Observatory (Oke & Gunn 1982). The polarimetry optics are described in more detail in Goodrich (1991). In brief, they consist of a rotateable achromatic half-wave plate above the spectrograph slit, and a calcite beam-splitting prism below the slit. The beam splitter places two spectra on the detector, which was an 800 × 800 pixel Texas Instruments CCD. Four positions of the waveplate are used to calculate the two linear Stokes parameters Q and U (Miller, Robinson, & Goodrich 1988). The total

TABLE 1

OBSERVATION LOG

DATE (UT)	EXPOSURE (minutes)	λ RANGE Blue	Red
1990 Nov 13	60	3423–5140	5280–10,111
1991 Jan 13	80	3427–5142	5279–10,117

flux spectrum, in integrated light, is also calculated. The slit width was 2″.

On the red side of the double spectrograph we used a 158 line mm^{-1} grating covering the wavelength range 5280 Å to 1.01 μm at a dispersion of 6.1 Å pixel^{-1}. The spectral resolution was ~3 pixels. The wavelength scale was determined using spectra of neon, argon, and helium calibration lamps, and the zero point was determined from measurements of the [O I] λλ6300, 6363 night-sky emission lines in the 3C 109 spectra themselves. Relative velocities are accurate to ~30 km s^{-1}, although absolute velocities may be somewhat more uncertain. With the blue camera we used a 316 line mm^{-1} grating covering 3425–5140 Å at a dispersion of 2.16 Å pixel^{-1}. Again the spectral resolution was ~3 pixels. The wavelength scale was determined using calibration spectra of mercury and helium, with the zero point determined from the night-sky line Hg I λ4358.

The absolute flux scales for both red and blue spectra were obtained by observations of standard stars in Stone (1977), with the extensions into the near-infrared of Massey & Gronwall (1990). Polarization efficiency and position angle correction curves were calculated by observing bright stars through an HNP′B Polaroid and a thin-film polarizing cube which works from 6000 Å to 1 μm. The zero point of the p.a. correction curve was determined from observations of known high-polarization stars during the 1990 November run. During 1991 January we used HD 251204 to determine the zero point of the p.a. correction; however, this star was later found to be variable, and we could not use the original zero point. Instead we circumvented this problem by matching the mean p.a. of 3C 109 to that obtained in the 1990 November run. More details of the data reduction are found in Miller et al. (1988) and Goodrich (1991). Table 1 summarizes the observations.

A note on how polarizations are calculated and manipulated should be made here. Since $P = \sqrt{Q^2 + U^2}$ is a positive-definite quantity, it is often replaced by a "debiased" quantity, involving not only Q and U but also their uncertainties. As Miller et al. (1988) show, however, the error distribution of the debiasing method normally used in optical polarimetry has a rather unsatisfactory form. Throughout this paper we choose to quote the standard, biased polarization, $P = \sqrt{Q^2 + U^2}$. This has the advantage of making the original Stokes parameters more readily accessible to the reader; Simmons & Stewart (1985) discuss various debiasing schemes. We stress that all *calculations*, such as correction for Galactic polarization, are done on Q and U, which are essentially unbiased.

3. RESULTS

Figure 1 shows the results from the red camera. The top panel gives the flux, F_λ, calculated as the average of the November and January data. The redshift of 3C 109 was measured as $z = 0.3066 \pm 0.0001$, using the narrow [O III] λλ4959, 5007 lines in the two independent spectra. The Hβ and [O III] λλ4959, 5007 emission lines were deblended using a four-component Gaussian fit; a narrow and a broad component of Hβ plus narrow components for the two [O III] lines. The strong night-sky line [O I] λ6300 lies on the blue wing of the broad Hβ component; this region was excluded from the fit because of the increased noise. The four lines were well matched by the Gaussian profiles. Fluxes from the fit are given in Table 2; the relative fluxes are accurate to ±15% for broad Hβ and 10% for the [O III] lines, but probably only 20% for the narrow Hβ component. Absolute fluxes suffer from slit losses and are somewhat less reliable.

The Hα + [N II] blend is more problematic, since our data do not resolve the narrow Hα and [N II] λλ6548, 6583 emission lines. Anticipating some results from below, we chose to use an

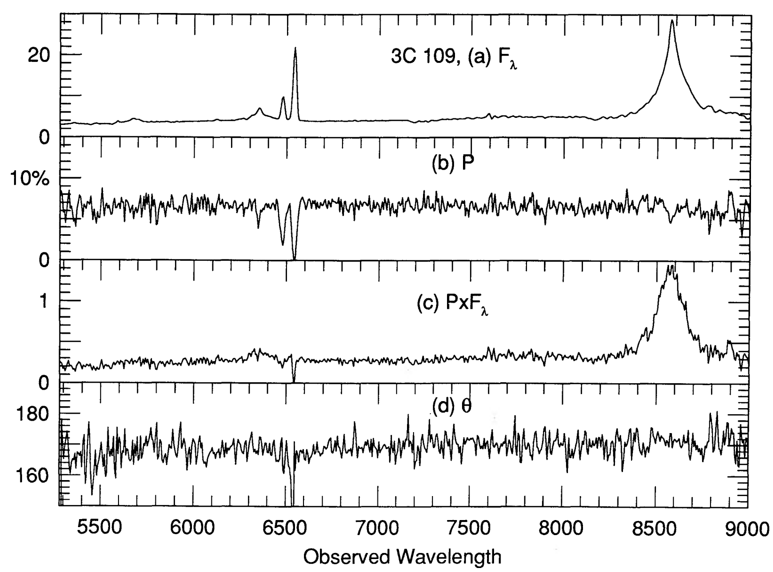

FIG. 1.—The spectrum of (*a*) total integrated light, (*b*) percent polarization, (*c*) polarized flux, and (*d*) position angle of 3C 109 from the red camera data. Note the drop in $P(\lambda)$ across the [O III] lines, as well as smaller drops across the weaker narrow components of Hα and Hβ. The polarization of the broad Balmer lines is the same as the continuum polarization. The flux scales of panels (*a*) and (*c*) are in units of 10^{-16} ergs cm^{-2} s^{-1} Å^{-1}.

TABLE 2

LINE FLUXES

Line	Flux (10^{-15} ergs cm^{-2} s^{-1})
Broad Lines	
$H\beta_b$	22
$H\alpha_b$	290
Narrow Lines:	
$H\beta_n$	3.8
[O III] λ4959	13.8
[O III] λ5007	42
[N II] λ6548	2.8
$H\alpha_n$	22
[N II] λ6584	4.4

"unpolarized flux" spectrum to isolate the narrow lines from the broad line, which is polarized the same as the adjacent continuum. The unpolarized flux spectrum is created by taking the polarized flux spectrum, $P \times F_\lambda$, in Figure 1*c* and dividing it by a smooth, interpolated continuum polarization, then subtracting this from the observed total flux in Figure 1*a*. Because the broad lines have polarizations identical to the continuum polarization, and the narrow lines are essentially unpolarized, the resulting spectrum contains only the narrow lines. The line fluxes presented in Table 2 were determined using this method, although it must be pointed out that the ratio of narrow Hα to the [N II] lines is very uncertain. The total flux of broad Hα, on the other hand, is probably accurate to $\pm 10\%$.

In Figure 1*b*, there is a marked drop in *P* across the [O III] emission lines. There is a similar, though less dramatic, drop across the position of the narrow Hβ and Hα lines. Across the positions of the broad Balmer lines, however, the polarization remains identical to that of the continuum. The observed [O III] line polarization, with estimated uncertainties, is 0.22% $\pm$0.10% at p.a. 96° $\pm$ 13°.

An estimate of the Galactic reddening toward 3C 109 of $E(B-V) = 0.27$ can be obtained from the maps of Burstein & Heiles (1982). Throughout this paper we will use the parameterization of the optical reddening law by Miller & Mathews (1972) and the UV extension of Seaton (1979). Rudy et al. (1984) have measured some stars close to the line of sight toward 3C 109 and find a Galactic interstellar polarization of 1.0% at 84° (no uncertainties quoted). Hence, while somewhat significant, Galactic reddening and polarization are not dominant in 3C 109. This is also clear from the lack of [O III] polarization mentioned above. Correction of the [O III] polarization for the foreground Galactic component gives 0.77% at p.a. 171°, consistent with the [O III] lines being slightly polarized in the same direction (p.a. 169°.5) as the continuum and broad lines of 3C 109. It must be stressed that the uncertainties in this final [O III] polarization are large and difficult to estimate, but clearly large enough that the [O III] might be intrinsically unpolarized. We shall return to the [O III] polarization at the end of § 4.1.

4. DISCUSSION

4.1. *Origin of the Polarization*

Rudy et al. (1984) suggested that the continuum of 3C 109 is polarized by transmission through aligned dichroic dust grains, a mechanism which operates in the interstellar medium of our own Galaxy. As evidence for this they demonstrated the consistency of the observed polarization with the presumably large reddening implied by the large broad-line Balmer decrement. They further predicted that the [O III] lines would be less highly polarized, as is indeed the case.

Other polarigenic mechanisms are feasible. We can immediately rule out synchrotron radiation for the origin of the continuum polarization, since this mechanism would not polarize the emission lines.

Electron scattering can probably be ruled out by the wavelength dependence shown in Figure 2. The polarization rises from the UV to around 7000 Å, then falls away slowly. Electron scattering can produce such a spectrum in the presence of a second, unpolarized source of light, but this source would have to have the inverse shape, dropping from the UV to 7000 Å (5400 Å in the rest frame) and then rising again toward the IR. This rules out, for example, dilution by starlight from the host galaxy. In any case, the lack of a significant H and K break implies that any normal stellar population must contribute less than 5%–10% of the light at 4000 Å rest wavelength. We therefore rule out electron scattering in 3C 109.

Dust scattering can also produce large polarizations, and the $P(\lambda)$ shape can be quite similar to that observed in 3C 109 (e.g., Trammell, Dinerstein, & Goodrich 1991). However, dust scattering will tend to produce a spectrum which is bluer than the intrinsic spectrum and would if anything produce a Balmer decrement which is *smaller* than the intrinsic decrement. Because the observed broad-line Balmer decrement is 13.4, which changes to 10.7 after correcting for the foreground Galactic reddening, it seems unlikely that the spectrum has been significantly "bluened."

Dust transmission polarization within our own Galaxy generally follows a specific wavelength shape, parameterized by Serkowski, Mathewson, & Ford (1975) and elaborated by Wilking et al. (1980). Rudy et al. (1984) did not have data extending far enough into the UV to compare the $P(\lambda)$ shape with this so-called "Serkowski curve," but our data show that $P(\lambda)$ is indeed consistent with a Serkowski law. In Figure 2 we have plotted a curve which corresponds to a Serkowski law with $P(\max) = 1.0\%$ at 5450 Å and p.a. 84°, combined with another which has $P(\max) = 7.7\%$ at 6530 Å at p.a. 169°.5. The first corresponds to the Galactic polarization, while the second corresponds to a Serkowski law with $\lambda(\max) = 5000$ Å, redshifted to the distance of 3C 109. The curve fits the observed continuum polarization quite well. We do not consider the difference of $\lambda(\max) = 5000$ Å used in the redshifted 3C 109 law to be significantly different from the 5450 Å found to be most common in the interstellar medium of our own Galaxy. Such a wavelength difference is not at all unusual in our Galaxy, and there are other complicating factors in 3C 109, such as the exact correction for Galactic polarization and a possible slight dilution by starlight.

A value of $P(\max) = 7.7\%$ implies that a certain minimum amount of reddening must be present, if the dust properties in 3C 109 are similar to those in our own interstellar medium. Serkowski et al. (1975) used a large data base of polarizations and reddenings to show that in our Galaxy $P(\max)/E(B-V) \leq 9\%$. Hence, in 3C 109 we might expect that $E(B-V) \geq 0.86$. There are two consistency checks on this value. The first is the dereddened broad-line Balmer decrement, which becomes less than or equal to 4.2 if $E(B-V) \geq 0.86$. This value seems consistent with observations of other broad-line objects. A second test is the shape of the dereddened continuum of 3C 109. As mentioned above, the lack of a signifi-

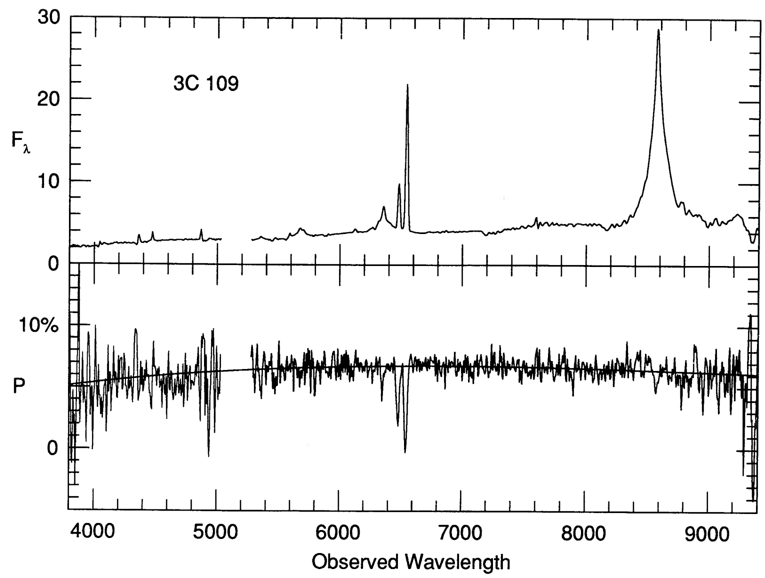

FIG. 2.—The combined blue and red spectra of 3C 109 are shown in the top panel. The bottom panel shows the polarization as a function of wavelength. The blue data have been smoothed by 3 pixels, so that the resolutions in the two cameras are comparable. The feature near 4358 Å, which shows in both panels, is due to incomplete subtraction of the Hg I emission line reflected in the night sky. The smooth curve superposed on the observed polarization is the combination of two "Serkowski laws," as described in the text. One law represents the Galactic foreground polarization, while the other represents polarization from dust transmission at the redshift of 3C 109. The curve fits the data remarkably well, supporting interpretation of the polarization in terms of transmission through aligned dust grains.

cant H and K break in the spectrum indicates that there is little contribution of light from starlight in the host galaxy. We can than feel comfortable in dereddening the entire spectrum by $E(B-V) = 0.86$. Before applying this reddening calculation, but after correction for Galactic reddening, the spectral shape of 3C 109 is $\alpha = -2.0 \pm 0.3$, where $f_\nu \propto \nu^\alpha$. After correcting for $E(B-V) = 0.86$ at the redshift of 3C 109, $\alpha = 1.0 \pm 0.3$, which is very blue and is discussed in § 5.2. Figure 3 shows the spectral shape after this dereddening, along with power laws of $\alpha = 1.0$ and $\alpha = 0.5$. We note here that infrared spectroscopy, perhaps of the Pa α line at 2.45 μm (redshifted), may provide a better estimate of the reddening.

The reddening of the narrow-line region (NLR) is of interest as well. Unfortunately, our spectral resolution prevents an accurate deblending of the [N II] emission lines from Hα, as discussed above. Using the values in Table 2, with 20% uncertainties in each line flux, we find that $H\alpha_n/H\beta_n = 4.5 \pm 1.4$ after correcting for Galactic reddening. This value is consistent with no internal reddening of the NLR, although the small polarization of [O III] probably indicates some reddening. If some fraction of the [O III] flux is polarized by the same dust that polarizes the BLR and continuum, then the [O III] polarization of $\sim 0.77\%$ (§ 3) indicates that this fraction is $\sim 10\%$. Dereddening this by $E(B-V) = 0.86$ and assuming that the other 90% of the observed [O III] flux is neither reddened nor polarized, we find that $\sim 64\%$ of the intrinsic [O III] flux is obscured and reddened by the dust in 3C 109. While it is not clear that the BLR/continuum reddening should be used to deredden the obscured part of the NLR, this exercise demonstrates that a substantial fraction of the NLR might actually be obscured.

4.2. *Continuum Slope*

Two compelling reasons why the high polarization of 3C 109 has an origin in dust transmission polarization are the excellent fit of $P(\lambda)$ by a normal Serkowski law, and the large observed broad-line Balmer decrement, which points to substantial reddening of the BLR. However, the problem with this interpretation is that dereddening the observed spectrum by the amount required by such a high polarization produces an "intrinsic" spectral shape which rises very steeply toward the blue. Studies of samples of quasars by Sanders et al. (1989) and Barvainis (1990) do not contain any objects with spectral slopes, α, greater than 0.5. While $\alpha = 0.5$ is ruled out at nearly the 2 σ level, we note that there are a number of uncertainties in calculations along the route to Figure 3 which are not immediately apparent in the figure. We expect that the formal error underrepresents the true uncertainties.

We used a reddening of $E(B-V) = 0.86$ and would have needed $E(B-V) = 0.73$ to recover a continuum slope of $\alpha = 0.5$. This would imply either $P(\max) = 6.6\%$, clearly ruled out by the data in Figure 1, or else $P(\max)/E(B-V) = 10.5\%$. Such a high value of $P(\max)/E(B-V)$ is not seen in the high-polarization objects in Serkowski et al. (1975), but neither does it seem out of the realm of possibility. Many Galactic stars are polarized by passage through more than one dust cloud or spiral arm, and hence their net polarization can be diluted by differing position angles in the clouds. In 3C 109 we may be seeing a more isolated, single dust feature, which is very highly organized.

A number of other effects inside the host galaxy might account for the apparent extreme blueness of the dereddened 3C 109 continuum. The constancy of $P(\lambda)$ across the broad lines places stringent limits on any possibilities which involve decoupling the broad line and continuum lines of sight, and the constancy of $\theta(\lambda)$ provides further constraints. Thus, we rule out the possibility that the continuum is first "bluened" by dust reflection, and then reddened and polarized by dust transmission. This is unlikely, as the dust reflection would presumably polarize the light, and then only a very special geometry would allow $\theta(\lambda)$ to be constant in wavelength, and $P(\lambda)$ to reproduce a Serkowski law. Another possibility is that some unknown, unreddened, and unpolarized continuum dominates the spectrum. Hence, in dereddening the entire observed spec-

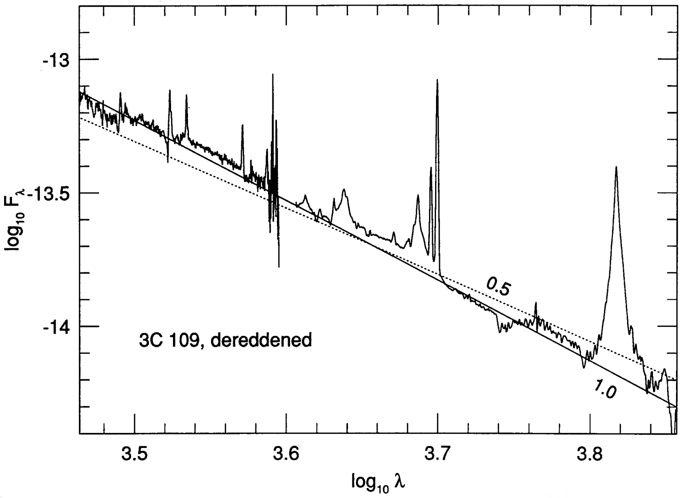

FIG. 3.—The spectrum of 3C 109 has been dereddened by the Galactic foreground reddening, then deredshifted and dereddened by the minimum reddening expected from 3C 109 itself [$E(B-V) = 0.86$]. Applying this minimum correction makes the deduced intrinsic spectrum of 3C 109 very blue, as shown by the superposed power law, which has $\alpha = 1.0$ ($f_\nu \propto \nu^\alpha$). The dotted line shows a power law of slope $\alpha = 0.5$, the largest value typically found in quasars. Note that the narrow lines have been dereddened by the same amount as the broad lines and the continuum, which is not necessarily correct.

trum we have mistakenly dereddened this extra component. However, this would imply that the actual polarization of the *polarized* continuum component would be higher than we have assumed, the deduced minimum reddening correspondingly larger, and the reddening correction would then produce an even bluer spectrum than we have been discussing. Further, the broad Balmer lines would have higher polarization than the adjacent continuum, as they would be less diluted. The only way around these two problems is to postulate a very blue unpolarized component which does not contribute significantly at Hβ, but does at shorter wavelengths. Hot stars are a possibility, although clearly a normal galaxy spectrum is ruled out. Such a continuum would have to contribute approximately one-third the light at the shortest wavelengths covered, which would imply an *intrinsic* polarization of the AGN nucleus in the blue of close to 9%. The stars would also be constrained to have an undetectable Balmer jump. This possibility is ad hoc, and we rule out dilution by significant amounts of starlight of any sort.

Another explanation was suggested to us by J. S. Miller. If the nucleus of 3C 109 were surrounded by a spherical shell of dust, all of which was encompassed by our spectrograph slit, then the amount of reddening observed would be proportional only to the absorption cross section σ(abs), not to σ(abs) + σ(scatt), σ(scatt) being the scattering cross section. In the interstellar medium the dust is usually in an intervening cloud, hence $E(B-V) \propto \sigma(\text{abs}) + \sigma(\text{scatt})$. By using the minimum $E(B-V)/P(\text{max})$ derived from our Galaxy we may be inadvertently using too high a reddening. For spherical symmetry we should instead use

$$E(B-V) = \frac{\sigma(\text{abs})}{\sigma(\text{abs}) + \sigma(\text{scatt})} \frac{P(\text{max})}{9\%} .$$

In the case of extinction by very small particles (Rayleigh scattering), or by particles with albedos of close to unity, the extinction cross section is almost entirely due to scattering, and the observed $E(B-V)$ can then be quite close to zero, even for large values of P(max). For nonspherical geometry, which is clearly more appropriate for 3C 109, the factor in front of P(max)/9% increases until it becomes unity for a covering factor of zero, as is the case in our own interstellar medium. Note that this explanation argues for the dust being close to the nucleus, where it is easier to have a large covering factor while keeping all of the dust within the spectograph slit, and at the same time not reddening the starlight and NLR excessively. Rudy et al. (1984) also argued that the dust was probably close to the nucleus, based on the infrared colors of 3C 109 and the implied dust temperatures.

Our conclusion is that the continuum and broad lines of 3C 109 are indeed reddened and polarized by transmission through dust within the host galaxy of the AGN. A smaller effect is also imprinted by our own Galaxy's interstellar medium. Use of the standard relation between P(max) and $E(B-V)$ found in our Galaxy gives an intrinsic slope $\alpha = 1.0 \pm 0.3$. This is higher than $\alpha = 0.5$, the most extreme value normally found in active galaxies. However, use of the galactic relation between P(max) and $E(B-V)$ is of unknown validity, and the true intrinsic slope might be near 0.5, consistent with other AGNs. In any case, the dust grains in 3C 109 must be very efficient in their ability to polarize light.

4.3. *Geometry*

Antonucci (1984) reported that radio galaxies seem to separate into two classes defined by the relative alignment of their radio morphologies and their optical polarization position angles. He found that the polarization position angles tended to be either parallel or perpendicular to the radio axes in the two groups and placed 3C 109 in his "parallel" group. Antonucci interpreted these alignment properties as polarization by scattering either in a thin disk (the parallel group) or a thick disk (the perpendicular group). VLA maps by both Antonucci (1984) and Baum et al. (1988) indicate a radio p.a. of $144° \pm 6°$, which is 26° away from our polarization position angle of 170°. More recent VLA maps with higher dynamic range reveal a jet to the SE at p.a. 151°, while VLBI observations show an extension 3–4 mas long in p.a. 128° (T. Venturi 1991, private communication). These values are 19° and 42° away from our optical polarization p.a., respectively.

In 3C 109, however, the polarization arises in foreground dust, and hence its relationship to any inner disk is questionable. In most Seyfert galaxies the radio axis does not appear to be intimately connected to the rotation axis of the stars, and hence to any dusty spiral arms which might polarize the nucleus. In fact, in edge-on Seyfert galaxies which *are* polarized by transmission through a foreground spiral arm the polarization position angle tends to lie parallel to the spiral arm (Thompson & Martin 1988) and shows little relationship to the radio axis. Kotanyi & Ekers (1979) studied eight elliptical radio galaxies with dust lanes and found that the lanes were perpendicular (to within 30°) of the radio axes. Furthermore, Elvius & Hall (1964) showed that in the well-known radio galaxy NGC 5128 (Cen A) the optical polarization p.a. lies along the dust lane, as it does for the Seyfert galaxies discussed by Thompson & Martin. If 3C 109 has a dust lane, it is presumably oriented at an angle of ~20°–40° from the radio axis, at the extreme of values observed by Kotanyi & Ekers. Rudy et al. (1984) argue that the dust in 3C 109 probably occurs close enough to the nucleus that it reddens the continuum and BLR, but not much of the NLR. Alternatively, the polarizing dust could lie further out in the galaxy, but from the right viewing angle obscure only the BLR. Optical images of 3C 109 by Baum et al. (1988) do not show any obvious asymmetry which could perhaps be attributed to a dust lane and hence compared to the polarization p.a. There is also the exciting possibility that in 3C 109 and similar objects we may be starting to probe the magnetic field strength and configuration in AGNs. Rudy et al. (1984) discuss this aspect of the polarization measurements briefly.

The very presence of dust in radio galaxies might be considered somewhat surprising, since radio-loud AGNs reside predominantly in elliptical galaxies, which are relatively dust free when compared to the spirals in which most radio-quiet Seyfert nuclei live. However, if an elliptical galaxy containing a radio AGN encounters and perhaps cannibalizes a spiral galaxy, the spiral galaxy will spill its dust along the encounter plane, which will probably be unrelated to the radio axis. If the dust remains aligned, it might obscure and polarize the active nucleus for some time after the encounter. As gas and dust from the galaxies settle into the BLR, the dust can continue to polarize the continuum light until it is destroyed in the harsh radiation field of the central region. Evidence for tidal distortions of the host galaxies of radio-loud AGNs is presented by, for example, Heckman et al. (1986). In particular, Fanaroff-Riley class II sources like 3C 109 seem more likely to be heavily distorted.

3C 109 has been classified as an N galaxy, due to the visibility of the surrounding galaxy (e.g., Baum et al. 1988). However, if we deredden the nucleus of 3C 109 by $E(B-V) = 0.86$ relative to its host galaxy, we would completely swamp the starlight by nuclear light, and 3C 109 would be classified as a quasar. A reddening of $E(B-V) = 0.86$ corresponds to an extinction of $A(V) = 2.7$. When this is combined with the Galactic reddening toward 3C 109, the resulting extinction correction is -3.2 mag. Véron-Cetty & Véron (1989) give an absolute V-magnitude of -23.4 for 3C 109, which when corrected gives -26.6. Even if we adopt the more conservative value of $E(B-V) = 0.73$, derived from constraints in the slope of the optical continuum, we still have $V = -26.2$. 3C 109 is, then, an intrinsically rather bright quasar, dimmed along our line of sight by intervening dust.

In the absence of dust, 3C 109 would be classified as a quasar. The fact that the [O III] lines have low polarization suggests that 3C 109 might be similar to some Seyfert 2 galaxies (e.g., Miller & Goodrich 1990) and contain an inner dusty torus partially obstructing our view of the nucleus, but allowing a clear view to at least part of the NLR. On the other hand, as noted above, we cannot rule out a fortuitously placed dust lane well out in the galaxy. 3C 109 is a steep-spectrum, lobe-dominated radio source; VLA maps (Antonucci 1984; Baum et al. 1988) show that the lobe separation is substantially greater than the lobe width. These features suggest that 3C 109 lies close to the plane of the sky. If an inner dust torus were involved in 3C 109, we might have to change our viewing angle by a large amount in order to see the nucleus unobscured. Depending on the importance of relativistic beaming, we might then see a core-dominated radio morphology. If a kiloparsec-scale dust lane is involved, however, then only a small change in aspect would allow us a direct view of the nucleus, and 3C 109 would be classified as a steep-spectrum, lobe-dominated quasar.

The radio morphology of 3C 109 suggests that it is close to the plane of the sky. Conversely, the high dereddened optical luminosity suggests, according to most relativistic beaming models (e.g., Scheuer 1987; Barthel 1989), that the object does *not* lie particularly close to the plane of the sky. Such an apparent inconsistency is not unknown; the giant radio sources 4C 34.47 (Barthel et al. 1989) and 4C 74.26 (Riley & Warner 1990) have radio sizes and morphologies indicating that they are close to the plane of the sky, and yet they are luminous quasars. 4C 34.47 also shows superluminal motion, which also indicates that the radio jets are in fact not far from our line of sight. Finally, we note that many of the recent "unification" theories have attempted to explain the apparent differences between radio galaxies and quasars as an effect solely of relativistic beaming. As 3C 109 has shown us, and analogous to some of the work on Seyfert galaxies, dust obscuration can also play a major role in our classification of AGNs. In any event, it is clear that 3C 109 is a prime example of how an aspect-dependent effect can alter our perception of what type of object we are observing.

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