PHYSICAL CONDITIONS IN THE NARROW-LINE REGION OF MARKARIAN 3. II. PHOTOIONIZATION MODELING RESULTS

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ABSTRACT

We have examined the physical conditions in the narrow-line region (NLR) of the Seyfert 2 galaxy Markarian 3, using long-slit spectra obtained with the Hubble Space Telescope/Space Telescope Imaging Spectrograph, and photoionization models. We find three components of photoionized gas in the NLR. Two of these components, characterized by emission lines such as [Ne v] λ3426 and [O iii] λ5007, lie within the envelope of the biconical region described in our previous kinematic study. A component of lower ionization gas, in which lines such as [O ii] λ3727 arise, is found to lie outside the bicone. Each of these components is irradiated by a power-law continuum which is attenuated by intervening gas, presumably closer to the central source. The radiation incident upon the low-ionization gas, external to the bicone, is much more heavily absorbed. These absorbers are similar to the intrinsic UV and X-ray absorbers detected in many Seyfert 1 galaxies, which suggests that the collimation of the ionizing radiation occurs in a circumnuclear wind, rather than a thick, molecular torus. We estimate the mass of the observed NLR emitting gas to be 2 × 10^6 M⊙. It is likely that Markarian 3 acquired this gas through an ongoing interaction with the spiral galaxy UGC 3422.

Key words: galaxies: individual (Markarian 3) – galaxies: Seyfert – line: formation

1. INTRODUCTION

Markarian 3, which is among the brightest Seyfert 2 galaxies, is classified as a Hubble-type SB0 galaxy (Adams 1977). Its systemic velocity is 4050 km s⁻¹ (z = 0.0135) based on H I 21 cm emission (Tifft & Cocke 1988), which yields a distance of 53 Mpc for H₀ = 75 km s⁻¹ Mpc⁻¹. At this distance, 1″ corresponds to 257 pc. The spectropolarimetry of Markarian 3 revealed broad permitted lines and nonstellar continuum emission (Schmidt & Miller 1985). These observations are among those cited as evidence for the "unified" model for active galactic nucleus via a detailed study of the NLR gas. In our earlier paper (Collins et al. 2005, hereafter Paper I), we argued that the NLR is photoionized by the hidden active galactic nucleus (AGN) continuum and that the density of the NLR gas decreases with increasing distance from the center. We modeled the observed continuum as a combination of reddened host galaxy light from an old stellar population, reddened H+ and He⁺⁺ recombination continuum, and scattered light from the central engine with spectral index α = 1 (L_ν ∝ ν⁻α). The host galaxy to scattered light ratio was estimated to be 3:1 at 8125 Å in a 0′′1 × 1′′8 aperture. We fitted the intrinsic ionizing continuum with a two-component power law of the form L_ν ∝ ν⁻α, where α = 2 for 13.6 eV < E < 0.2 keV and α = 1 for 0.2 keV < E < 50 keV. Based on this analysis, we estimated that the amount of intrinsic nonionizing UV continuum scattered into our line of sight is 0.04%.

Kraemer & Harrington (1986) analyzed a combination of International Ultraviolet Explorer and ground-based spectroscopic observations of the Markarian 3 NLR from ultraviolet to infrared wavelengths. Based on this analysis, they found evidence for three components of emission-line gas. A single component would be insufficient to reproduce all the observed emission lines which arise from ionic species with ionization potentials up to 100 eV. Two of their model components included internal dust. The third component, which was the highest in ionization and density and closest to the central source, was assumed to be dust free. Dust emission signatures are evident in the infrared continuum at λ ~ 10 μm (Neugebauer et al. 1976; Rieke 1978; Weedman et al. 2005). Kraemer & Harrington (1986) argued that these arose from hot dust within the two lower-density components. Since dust suppresses

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resonance line emission with large optical depths and the presence of dust requires depletion of C and Mg from the gas phase. This included the dust-free component to match the observed Lyα λ1216, C iv λ1548, 1551, and Mg ii λλ2796, 2803 emission. In this study, we used version 95.06 of the photoionization modeling code CLOUDY (Ferland et al. 1998) as per convention, the photoionization models are parameterized in terms of the ionization parameter, \( U \),
\[
U = \frac{Q(H)}{4\pi r^2 n_H c},
\]
where \( Q(H) \) is the ionizing photon luminosity of the AGN in photons s\(^{-1}\), \( r \) is the radial distance of the emitting cloud from the ionizing radiation source (the AGN in this case), \( n_H \) is the hydrogen number density in cm\(^{-3}\), and \( c \) is the speed of light. The photon luminosity and the spectral energy distribution are related by
\[
Q(H) = \int_{\nu_{\min}}^{\nu_{\max}} \frac{L(\nu)}{h\nu} d\nu.
\]
In Paper I, we parameterized the intrinsic ionizing continuum as follows: \( L(\nu) \propto \nu^{-\alpha} \), where \( \alpha = 1 \) for \( h\nu < 13.6 \text{ eV} \), \( \alpha = 2 \) for \( 13.6 \text{ eV} < h\nu < 200 \text{ eV} \), and \( \alpha = 1 \) for \( h\nu > 200 \text{ eV} \), and \( h \) is Planck's constant. The high-energy continuum slope is from the Turner et al. (1997) estimate (based on ASCA data) of the unabsorbed X-ray spectrum, with normalization such that the unabsorbed 2–10 keV integrated luminosity is \( 10^{44} \text{ erg s}^{-1} \). This is consistent with the intrinsic luminosity derived by Matt et al. (2000) with BeppoSAX data and the prediction

3. PHOTOIONIZATION MODELS

3.1. Preliminary Model Input Parameters

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of Melendez et al. (2008) extrapolated from a Spitzer [O iv] λ25.89 μm measurement. We truncated the continuum on the high-energy end at 10^5 eV. Based on this parameterization, the intrinsic AGN continuum is extremely luminous, with Q(H) ~ 2 × 10^5 photons s^{-1}.

We assume roughly solar chemical composition (e.g., Grevesse & Anders 1989) for all model components and absorbing screens (described in Section 3.4). The abundances relative to H by number are: He = 0.1, C = 3.4 × 10^{-4}, N = 1.2 × 10^{-4}, O = 6.8 × 10^{-4}, Ne = 1.1 × 10^{-4}, Mg = 3.3 × 10^{-5}, Si = 3.1 × 10^{-5}, S = 1.5 × 10^{-5}, Ar = 4.0 × 10^{-6}, and Fe = 4.0 × 10^{-5}.

For model components that included dust (see Section 3.4), we used elemental depletions onto graphite and silicate grains that are half those of the standard Galactic interstellar medium (ISM) depletions. The Galactic ISM depletion fractions are 0.65 for C and 0.50 for O (Snow & Witt 1996); 0.90 for Al, 0.44 for S, 0.90 for Ca, and 0.90 for Ni (Seab & Shull 1983). Snow & Witt (1996) list the ISM depletion for Fe, Mg, and Si as 100%. We used a depletion of 95% for these elements. We do not account for nitrogen depletion since nitrogen is deposited onto grains in ice mantles that would dissociate in the NLR. The gas-phase abundances in the dusty model component are the nominal ISM values listed above multiplied by 0.5 (1 − f_{depletion}), where f_{depletion} represents the Galactic ISM depletion factor for the element of interest.

Our primary constraint on the models is that they reproduce the observed emission-line fluxes. We required that the predicted fluxes of at least three-quarters of the twenty selected bright emission lines, each scaled to the predicted Hβ λ4861 flux, match the data within a factor of 2. We also required that at least half of those lines within that gross limit match the data within ±30%. It is possible to construct models in which the emission-line fluxes match but the emitting clouds5 may be unrealistically large. We implemented additional constraints to ensure that the models fit within our geometrical picture of the NLR and within the observational parameters of the HST/STIS spectra.

3.2. Initial View of the NLR Structure

We initially assumed an NLR geometry based on the results of Ruiz et al. (2001). They studied the kinematics of the Markarian 3 NLR using [O iii] λ5007 measurements from an STIS/CCD slitless spectrum and from the same long-slit data that were presented in Paper I. Extracted spectra from several locations along the long-slit show evidence of two kinematic components: one is redshifted and the other is blueshifted in the rest frame of Markarian 3. These components are interpreted as line-of-sight observations of radially outflowing gas on opposite sides of an NLR bicone. Their best-fit kinematic model assumes an NLR with an angular extent of 2′′ and inner and outer opening half-angles of 15′′ and 25′′, respectively. The bicone is tilted toward the observer in the east and away from the observer in the west by 5′. The position angle of the bicone is 70′′ east of north (Schmitt & Kinney 2000). The host galaxy disk major axis position angle is 28′′ and the inclination of the disk is 33′′ (Schmitt & Kinney 2000). We converted the projected angular separation in arcseconds between the central engine and a measured kinematic component in the NLR into a radial distance using the bicone model opening angles and the 257 pc arcsec^{-1} scale factor from our estimated distance to Markarian 3. Redshifted kinematic components lie on the far side of the bicone and blueshifted components lie on the near side. For the central bin (hereafter angular position 0′′0), we assumed radial distances from the AGN for the redshifted and blueshifted components corresponding to one-quarter of the total 0′′3 bin width.

We required that the model components fit within the intersection of the STIS slit, our measurement bins, and the bicone geometry. These three constraints correspond to the dispersion direction on the plane of the sky, the cross-dispersion direction on the plane of the sky, and the direction perpendicular to the sky plane, respectively. Each measurement bin may be considered as a small cell constrained by the projected slit width (26 pc), the measurement bin height along the slit, and the inner and outer bicone walls.

In this simple picture, we envisioned a model component inside the measurement cell as a brick in which the illuminated face and the emitting face are the same. The model illuminated face is parallel to the cell face defined by the slit width and the lines between the inner and outer bicone walls at the slit edges. The model emitting face area was computed as the ratio a:b of (a) the observed Hβ luminosity (erg s^{-1}) of the measured kinematic component scaled by the fractional contribution of the model component to (b) the predicted Hβ flux (erg s^{-1} cm^{-2}) for the model component. This emitting area must be on the order of cell-face area.

We refer to the distance between the bicone walls as the “bin depth.” We calculate a “model component depth” by taking the ratio of the emitting area to the projected slit width in pc. It is unlikely that the bicone has a sharp cut-off. Kraemer et al. (2008) suggest that the NGC 4151 NLR does not have a sharp edge. Therefore, we allow the model component depth to be up to 1.5 times the “bin depth” at the center of the measurement bin. The height of the model component brick is given by the ratio of the model input parameters column density (in cm^{-2}) and volume number density (cm^{-3}). We required that this height be less than the measurement bin height along the STIS slit.

As a check that all model components fit within a measurement bin, we computed the volume-filling factor of each component. The volume-filling factor is the ratio of the model component brick volume (emitting area multiplied by component height) to the measurement bin volume. We required that the sum of the volume-filling factors of the model components within a bin be less than unity. We modified these geometrical constraints after analyzing the preliminary model results and reviewing the spectral image data (see Section 3.1).

In Paper I, we presented observational evidence that the η_{H} decreases with increasing distance from the AGN. For the modeling, we did not assume a specific functional form for the radial dependence of model cloud number density. We simply required that a cloud must have the same or lower number density than the neighboring cloud in the direction of the AGN.

3.3. Evidence for Emission-Line Gas Outside the Bicone

As shown in Tables 2 and 3 in Paper I, each spectrum extracted along the slit shows a mix of strong emission lines from high- and low-ionization species, e.g., [Ne v] λ3426 and [O iv] λ3727 (the unresolved blend of the 3726.0 Å and 3728.8 Å lines) emission, from the same kinematic component. This suggests that the observed emission along a line of sight to the Markarian 3 NLR may come from a combination of colocated clouds of different ionization states and optical thicknesses. Similar multicomponent models have been used to model the NLR.

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5 We refer to the regions over which we have summed the flux, then separated into individual kinematic components, as “clouds.”
emission in the Sy 1 NGC 4151 (Kraemer et al. 2000) and the Sy 2 NGC 1068 (Kraemer & Crenshaw 2000a, 2000b). The fact that the soft X-ray emission is roughly coincident with the optical emission-line gas in Markarian 3 (Sako et al. 2000) is further evidence for a heterogeneous NLR.

As noted in Section 3.1, the central source in Markarian 3 is quite luminous, which presents a problem for a simple, biconical model of the emission-line gas. For example, \([\text{O} \text{ iii}] \lambda 3727\) is predicted to be the strongest optical forbidden line for photoionized gas characterized by \(U < 10^{-3}\) (Ferland & Netzer 1983). For that limit in \(U\), our estimate for \(Q\) requires a density \(n_1 > 10^{5.7} \text{ cm}^{-3}\) for a cloud at a distance of 100 pc from the central source. However, the critical density for the \(^2D_{5/2}\) level of \(O^+\), the upper level of the 3726 Å line, is \(1.6 \times 10^5 \text{ cm}^{-3}\) (Osterbrock 1989). Therefore, lines from low-ionization species, originating from levels with low critical densities, will be collisionally suppressed since gas directly exposed to the ionization radiation in the inner NLR of Markarian 3 must have densities that significantly exceed the critical density.

The ionizing photon flux can be significantly reduced by an optically thick screen. This effectively reduces the ionization state of the component, but the emission-line flux will be weak due to the low emissivity of the gas. The emission-line flux can be increased by adding more emitting material to the new model component. However, while matching the observed emission lines, we found that the emitting area of the gas can exceed the geometrical limits imposed by the bicone geometry and the STIS slit. This constraint can be met if the new low-ionization state component lies farther from the AGN than the other two model components. This gas would be outside the nominal bicone configuration.

To test whether the lowest ionization state gas is more spatially extended than the high- and medium-ionization state gas, we compared the \([\text{O} \text{ iii}] \lambda 4959\) emission with that of \([\text{O} \text{ ii}] \lambda 3727\) in the STIS spectral images (since these lines have similar fluxes). We extracted a subimage centered on the \([\text{O} \text{ iii}] \lambda 4959\) line from the G430L spectral image. The subimage size corresponds to a dispersion of 4000 km s\(^{-1}\) at 4959 Å and \(3''\) in the cross-dispersion direction. We derived an average continuum value from the line fits described in Paper I and subtracted it from the subimage. We extracted a subimage centered on the \([\text{O} \text{ ii}] \lambda 3727\) line with a size corresponding to the same velocity dispersion as the \([\text{O} \text{ iii}] \lambda 4959\) subimage. We subtracted the local continuum from this subimage. For direct comparison, we used a linear interpolation algorithm to transform the \([\text{O} \text{ ii}] \lambda 3727\) line subimage so that each pixel would have the same velocity width as the \([\text{O} \text{ iii}] \lambda 4959\) line subimage.

We show the \([\text{O} \text{ ii}] \lambda 3727\) contours with \([\text{O} \text{ iii}] \lambda 4959\) contours overlaid in Figure 1. Note first the greater spatial extent of the \([\text{O} \text{ ii}] \lambda 3727\) line (\(\sim 2''\)) compared with that of the \([\text{O} \text{ iii}] \lambda 4959\) emission (\(\sim 1.5''\)). The \([\text{O} \text{ ii}] \lambda 3727\) emission is more extended than \([\text{O} \text{ ii}] \lambda 3727\) by five spatial resolution elements in the west and 1 resolution element in the east. The \([\text{O} \text{ ii}] \lambda 3727\) line also shows greater extent in the velocity dispersion axis. On the redshifted side this line is more extended by at least a velocity resolution element, while on the blueshifted side it is extended by up to one resolution element. However, we do not interpret the greater extent in the dispersion direction as evidence that the lower-ionization state gas has significantly different kinematic behavior than the high- and medium-state components comprising the nominal NLR bicone. Instead, this is most likely due to a difference in the spatial distribution of these components within the slit in the dispersion direction. For example, the low-ionization state gas may surround high- and medium-ionization state gas as recently suggested for NGC 4151 (Kraemer et al. 2008). Therefore, the low-ionization state gas may lie outside the nominal bicone configuration.

Another striking difference between the two spectral image contour maps is in the \(0''0\) measurement extraction bin. The \([\text{O} \text{ iii}] \lambda 4959\) line shows a strong blueshifted peak. The \([\text{O} \text{ ii}] \lambda 3727\) line shows no corresponding feature at this position. The observed flux in the \([\text{O} \text{ iii}] \lambda 4959\) line is greater than that in the \([\text{O} \text{ ii}] \lambda 3727\) line in this measurement bin (see Table 2 in Paper I). This contrast in line morphology may also be due to the more extended structure of the low-ionization state gas.

We compared the \([\text{O} \text{ iii}] \lambda 4959\) spectral image morphology to that of \([\text{Ne} \text{ v}] \lambda 3426\) to determine whether there might be evidence for spatial differences between high- and medium-ionization emission-line gas. The contours for those lines shown in Figure 2 show general correspondence for the major inner contour concentrations, although the centroids of the concentrations are slightly offset. The outer contours of both lines on average span the same range in the dispersion direction. In the spatial direction, the 15% contours for \([\text{Ne} \text{ v}] \lambda 3426\) do not extend past \(0.4''\) east, while those for \([\text{O} \text{ iii}] \lambda 4959\) reach \(0.6''\) east. This may indicate that there is less high-ionization state gas this far east along the STIS slit (see the discussion in Section 4.2). We find no evidence for spatial separation between the high- and medium-ionization state gas from this data set. Hence, such components could be colocated within the bicone walls.

Although the \([\text{O} \text{ ii}] \lambda 3727\) and \([\text{O} \text{ iii}] \lambda 4959\) lines show different spatial morphologies, we found the same number...
of kinematic components in each measurement bin for the [O\textsc{ii}] $\lambda$3727 profiles as we did for the [O\textsc{iii}] $\lambda$5007 line. The kinematic components in both lines show the same sign relative to the Markarian 3 systemic velocity, i.e., blueshifted components in [O\textsc{iii}] $\lambda$5007 are blueshifted in [O\textsc{ii}] $\lambda$3727. Redshifted components in the two lines are likewise matched. The [O\textsc{ii}] $\lambda$3727 emitting kinematic components may have slightly different velocities and velocity dispersions than the [O\textsc{iii}] $\lambda$5007 emitting components. However, these differences cannot be distinguished from this data set better than the velocity resolution of $\sim$ 316 km s$^{-1}$ at these wavelengths. Therefore, we maintain the use of the [O\textsc{iii}] $\lambda$5007 line kinematic parameters as templates for separating the blended kinematic components in other emission lines, including [O\textsc{ii}] $\lambda$3727, as described in Section 2.

3.4. Model Components

As noted in the previous section, the STIS spectrum of Markarian 3 NLR shows emission lines from ions spanning a wide range in ionization potential and from energy levels spanning a wide range in critical density for collisional de-excitation. Furthermore, we provided evidence that the [O\textsc{ii}] $\lambda$3727 emission arises in a low-ionization state component that is spatially distinct from the kinematically defined bicone. It is likely that the spectrum along any sight line to the NLR is produced by a heterogeneous ensemble of gas components (Kraemer & Harrington 1986) with different characteristic ionization parameters, hydrogen number densities, and dust-to-gas ratios. In order to fit the observed line ratios and fluxes, we have included up to three model components for each radial position along the slit.

A high-ionization state component (labeled “high”) produces most of the line emission observed from high-ionization potential ionic species such as [Ne\textsc{v}] $\lambda$3426 and [Fe\textsc{vii}] $\lambda$6087. The presence of [Fe\textsc{vii}] emission is evidence that there is little depletion of iron onto dust grains within the high-ionization gas; hence, we assumed that this component is dust free. We included a component with a lower ionization state (labeled “medium”) which would produce lines from lower ionization potential species such as C\textsc{iii} $\lambda$1909, [Ne\textsc{iii}] $\lambda$3869, and [S\textsc{ii}] $\lambda$9532. The extinction-corrected Ly$\alpha$/H$\beta$ ratios (see Table 3 in Paper I) are generally lower than predicted for Case B recombination (Osterbrock 1989). This suggests that dust must be present in some component of the NLR gas. Therefore, following Kraemer & Harrington (1986), we assumed that dust was mixed with the emission-line gas in the “medium” component. However, the presence of strong C\textsc{iii} $\lambda$1909 suggests that the dust/gas ratio is less than in the ISM of the Galaxy (e.g., Mathis et al. 1977). Hence, we selected a 50% depletion factor onto grains for “medium.” The third component (labeled “low”) is situated outside the nominal bicone. We did not include dust in the “low” component since that decreased the emissivity of the gas. This decreased emissivity hampered our ability to reproduce the observed [O\textsc{ii}] $\lambda$3727 flux. However, we cannot rule out the presence of some dust within this component, albeit at less than the ISM dust/gas ratio.

The model components may be either matter bounded or radiation bounded. Binette et al. (1996) described matter-bounded clouds as fully ionized and ionization-bounded (or in this paper “radiation bounded”) clouds as partially ionized. In Paper I (Section 5.2), we inferred the presence of a mixture of matter- and radiation-bounded clouds in the Markarian 3 NLR.
The component boundaries are model output parameters and are discussed in Section 4.2.

Alexander et al. (1999) argued that the NLR emission-line ratios in the Seyfert 1 galaxy NGC 4151 indicated that the ionizing continuum was strongly absorbed above the He ii Lyman limit. In a photoionization analysis of HST/STIS spectra of NGC 4151, Kraemer et al. (2000) demonstrated that the intervening absorbers resembled the intrinsic absorption detected along the line of sight to the active nucleus. Since such an absorber will reduce the He* ionizing photon flux at E \( \gtrsim 54.4 \) eV, the He ii \( \lambda 4686/H\beta \) ratio will be lower than that predicted by photon-counting arguments. Based on previous studies (e.g., Kraemer et al. 2000), much of the NLR gas is matter bounded. This has the effect of increasing He ii \( \lambda 4686/H\beta \) since the H*/H\beta transition zone may not be present. Therefore, to reproduce the observed He ii \( \lambda 4686/H\beta \), it is plausible that the intrinsic continuum is absorbed above the He ii Lyman limit. Based on our preliminary modeling, we found that an absorber with column density \( 10^{20.5} \) cm\(^{-2}\) and ionization parameter \( 10^{-1.5} \) yielded the best fits for these lines ratios (see Figure 3). Since the absorber is required for all of the observed components, it must be well within the size of a detector spatial resolution element (26 pc).

As discussed above, the ionizing radiation to which the “low” component is exposed must be heavily filtered by gas close to the central source. To determine the characteristics of the screening material, we created a grid of screen models with a range in ionization parameter and in column density that absorb more ionizing photons than the screen for the “high” and “medium” ionization state components. The screens were sorted by transmitted photon flux. We selected the screen that appropriately reduced the ionizing continuum flux and yielded the best matches to the data for the lines [O ii] \( \lambda 3727 \) and [N ii] \( \lambda \lambda 6548, 6583 \) relative to H\beta from the emitting cloud of interest. We used three types of absorbers for the low-ionization component: (1) \( U = 10^{-2.5} \) and \( N_{\text{e}} = 10^{20.7} \) cm\(^{-2}\), (2) \( U = 10^{-1.5} \) and \( N_{\text{e}} = 10^{21.6} \) cm\(^{-2}\), and (3) \( U = 10^{-3.0} \) and \( N_{\text{e}} = 10^{21.9} \) cm\(^{-2}\). The screened continua produced by each of these absorbers are shown in Figure 3. These screens absorb nearly all of emitted continuum from 13.6 eV to 200 eV. Most of the low-ionization state clouds were screened by the \( N_{\text{e}} = 10^{21.6} \) cm\(^{-2}\) absorber. However, the easternmost low-ionization state cloud was screened by the \( N_{\text{e}} = 10^{20.7} \) cm\(^{-2}\) absorber, while both the blueshifted and redshifted low-ionization state clouds in the adjacent 0’/3 measurement bin were screened by the \( N_{\text{e}} = 10^{21.9} \) cm\(^{-2}\) absorber.

Interestingly, these absorbers have physical parameters similar to the intrinsic absorbers detected in some Seyfert 1 galaxies. The low-column density absorber that screens the nominal bicone gas is similar to the UV absorbers detected in NGC 5548 (Crenshaw et al. 2003). The screens for the low-ionization state gas have column densities intermediate between those of the UV and X-ray absorbers in NGC 4151 (Kraemer et al. 2001).

4. MODEL RESULTS

4.1. Revised View of the NLR Structure and Final Model Input Parameters

Based on our preliminary analysis, incorporating (1) the Ruiz et al. (2001) kinematics study and (2) the evidence for morphological differences in emission-line spectral images from low- and high-ionization potential ionic species, we developed a revised model for the NLR structure shown in Figure 4. Without higher spatial and spectral resolution observations of the [O ii] \( \lambda 3727 \) line emission, it is difficult to constrain the location of the low-ionization components. As a guide for the models, we located each low-ionization component on the observer’s sight line midway between the outer edge of the NLR bicone and a line that sweeps out two solid angles (east and west) of \( \pi \) steradians each when rotated around the bicone axis. This line is at a 38.7 angle with respect to the bicone axis. The ionizing continuum for the low-ionization region (the lighter gray shaded area in the figure) is more heavily absorbed than that illuminating the high- and medium-ionization regions. As noted, the screening is nonuniform for the low-ionization state gas.

Although we have relaxed our constraint that all the emitting gas lie within the walls of the kinematically derived hollow bicone, we maintained the geometrical constraints for the high- and low-ionization state components. Those components produce nearly all of the [O ii] \( \lambda 5007 \) emission on which the kinematically derived NLR structure is based. We loosely applied similar geometrical constraints on the low-ionization state components using the inner and outer limits described above.

We list the final CLOUDY input parameters for all modeled components corresponding to our measured kinematic components in Table 1 of the Appendix. We did not include a dusty medium-ionization state component for the central blueshifted kinematic component, bin (0’0E (b), 0’3), since a two-component (high+low) model adequately reproduced the observed emission spectrum for this position in the NLR. Figures 5–7 show the hydrogen number density \( n_{\text{H}} \) as a function of radial distance from the AGN for the high-, medium- and low-ionization state components, respectively. Recall that we constrained the NLR density such that clouds farther from the AGN have lower density than those closer to the AGN (see details in Paper I). However, we assumed no specific functional form for the cloud volume number density versus position. For
the high-ionization parameter model components, the $n_H$ decreases faster than $r^{-2}$ in both the east and west along the STIS slit. The $n_H$ within the dusty medium-ionization state component falls off as approximately $r^{-2}$ in the west. It is difficult to draw any conclusion about the radial dependence of the cloud hydrogen density in the east since there are only three data points for this component. The low-ionization state component shows a density decrease in the west consistent with $r^{-2}$. In the east, the data points follow the same functional form as those in the west out to $r \sim 150$ pc. For comparison, Kraemer et al. (2000) found the hydrogen density proportional to $\sim r^{-1.6}$ in the southwest along the STIS slit and $\sim r^{-1.7}$ in northeast for all model cloud components in the NGC 4151 NLR.

4.2. Fit to the Observations

In Tables 2–12 of the Appendix, we list the line fluxes relative to H$\beta$ for each model component, the composite model, and the observed data. The good agreement between the model emission-line ratios and the observed emission-line ratios indicates that our main assumptions about the NLR structure and intrinsic ionizing continuum were reasonable. Furthermore, the ionizing radiation emitted by the central source is sufficient to power the NLR, without additional ionization mechanisms such as shock heating or starbursts. As suggested for other Seyfert galaxies (e.g., Kraemer et al. 2000; Kraemer & Crenshaw 2000a, 2000b), multiple components with a range in ionization states comprise the NLR gas. Although the model predictions are consistent with at least some dust mixed in with the emission-line gas, the dust/gas ratio appears to be substantially less than that in the Galactic ISM. However, perhaps the most striking prediction of these models is that there is a strong contribution from a low-ionization gas component which lies outside the nominal bicone structure. This provides new insight into the nature of the circumnuclear gas close to the AGN, which we will discuss in Section 5.

In Paper I, we suggested that the continuum might be more heavily absorbed in the east than in the west based on the relative weakness of the high-ionization potential emission lines [Ne v] $\lambda 3426$ and [Fe vii] $\lambda\lambda 5722, 6087$ on the eastern side of the NLR. However, we were able to fit these lines using a uniform screen in both directions for the high-ionization state model component from which these observed lines would originate. Indeed, the absorbing screen diagnostic ratio He II $\lambda 4686$/H$\beta$ shows no strong east/west asymmetry. In the models, the effective ionization parameter and number density of the high-ionization state component show no obvious asymmetry or trends with direction either. However, the high-ionization state model components’ emitting areas and masses are greater in the west than in the east. Perhaps the distribution of the high-ionization state gas is asymmetric.

We list additional CLOUDY model output values, derived parameters, and geometrical constraints in Table 13 of the Appendix. The emitting area, component depth, bin depth, component height, and bin height were defined in
Section 4.1. The ratios of component to bin depths for the high-
and medium-ionization state model components meet the geo-
metrical constraint (upper limit of 1.5). The component heights
for these components are much less than their corresponding
measurement bin heights. Within each measurement bin, the
sum of the volume-filling factors for the high- and medium-
ionization components is less than unity. Therefore, it is un-
likely that clouds at low-radial distance from the AGN within
the kinematically defined bicone shield clouds at higher radial
distances.

Three of the low-ionization components have component
depth to bin depth ratios that exceed the 1.5 upper limit: (0′.3E,
0′.3), (−0′.7W, 0′.3), and (−1′.0W, 0′.3). The second of these
two has a filling factor near unity. It is possible this component
may shield NLR gas located farther from the AGN
(measurement bin −1′.0W, 0′.3), although we did not explore
this possibility.

We created alternate models for the (−0′.7W, 0′.3) com-
ponent. In these models, the number density ranged from 10^{2.0}
cm^{-3} to 10^{2.5} cm^{-3} and the column density ranged from 10^{19}
cm^{-3} to 10^{23} cm^{-3}. All models with good line fits violated one
or another geometrical constraint. However, the geometry of
the low-ionization state gas outside the kinematically defined
bicone is not well constrained. We conclude that more low-
ionization gas is required to match the observed line ratios than
would fit within the geometrical guidelines selected for the gas
outside the nominal bicone. The extent of the low-ionization gas
along our lines of sight in the (0′.3E, 0′.3), (−0′.7W, 0′.3),
and (−1′.0W, 0′.3) measurement bins likely exceeds our geo-
metrical guidelines for these components. It is possible that
the lines of sight in the measurement bins (0′.3E, 0′.3), (−0′.7W,
0′.3), and (−1′.0W, 0′.3) intersect background or foreground
extended narrow-line region (ENLR) gas.

Based on the predicted electron temperatures (Table 13, the
Appendix) and densities (Tables 2−12, the Appendix), it is
apparent that the colocated “high” and “medium” components
are not generally in pressure equilibrium. A more highly ionized
apparent that the colocated “high” and “medium” components
with distance than our models predict.

2001). However, it is likely that the clouds are at least partially
confined, otherwise the density would decrease more rapidly
2 kinematic component) lines. The Mg II flux is overestimated
or in the galaxy plane (position −1′.0W; r; see Figure 4). The
corrected line fluxes at these positions may be more sensitive
to uncertainties in the extinction correction than those at other
positions. In particular, the positions 0′.3E (r) and 0′.0W (r) are
in the region along the STIS slit that shows the greatest reddening
(see Figure 8 in Paper I).

The model line fits for the position 0′.5E (r) did not meet the
criterion that half the model lines match the data within ±30%. Generally, the line fluxes in this component are underestimated
by the model. If the column density of the “medium” ionization
state model component is increased, improved fits to the data
are likely. However, the emitting area will still violate our
geometrical constraint for this measurement bin. This position
is the most heavily reddened along the STIS slit and the UV lines
shortward of 2400 Å are poorly fit. It is, thus, possible that the
poor fits are due to overcorrecting the measured line fluxes for
extinction as discussed above. The underestimated He II λ4686
model line flux may be an indication that the intrinsic absorption
corrected line fluxes at these positions may be more sensitive
to uncertainties in the extinction correction than those at other
positions. In particular, the positions 0′.3E (r) and 0′.0W (r) are
in the region along the STIS slit that shows the greatest reddening
(see Figure 8 in Paper I).

The model line fits for the position 0′.5E (r) did not meet the
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state model component is increased, improved fits to the data
are likely. However, the emitting area will still violate our
geometrical constraint for this measurement bin. This position
is the most heavily reddened along the STIS slit and the UV lines
shortward of 2400 Å are poorly fit. It is, thus, possible that the
poor fits are due to overcorrecting the measured line fluxes for
extinction as discussed above. The underestimated He II λ4686
model line flux may be an indication that the intrinsic absorption
screen is too thick for this measurement position.

The [S III] λ9532 is underpredicted in the bins 0′.3E (r), 0′.0E
(b), 0′.0W (r), −0′.3W (b) and −0′.0W (r). Again, this may be
due to uncertainty in the shape of the extinction curve, and in
this case the long baseline between the emitted line wavelength
and the He II λ4686 extinction reference line wavelength.

The predicted Lyα λ1216/H β λ4861 ratio is low at positions
0′.3E (r), 0′.3E (r), 0′.0W (r), −0′.7W (r), −1′.0W (r). As
described above, the extinction curve used to correct these
observations (Koornneef & Code 1981) is steeper than the
Galactic curve (Savage & Mathis 1979) at wavelengths shorter
than 2200 Å. The actual extinction curve required for Markarian
3 may lie somewhere between these two.

Two positions 0′.3E (b) and 0′.0E (b) show overestimated C IV
λ1548, 1551 flux. It is likely that the measurements for these
lines at this position are poor, although this is not reflected in
the ±1σ error bars. Even though the flux ratio of the doublet
is constrained (2:1), it is difficult to separate the four (2 doublet ×
2 kinematic component) lines. The Mg II flux is overestimated
at position 0′.0E (b). This is also likely due to poor separation
of the blended doublet/kinematic component lines.

4.3. Model Comparison with X-Ray Data

We compared our model estimated X-ray lines with those
observed by Sako et al. (2000) with Chandra/HETGS. They
obtained a spectrum from 0.5 < E < 10 keV (or 1 < λ < 24 Å)
through the 11′′ × 19′′ aperture. The aperture was oriented
with the cross-dispersion (longer) axis at position angle 90°
to measure the flux from the entire NLR + ENLR. They detected 18
resonance lines from the highly ionized H-like and He-like ionic
species of O, Ne, Mg, Si, and S. They also detected ten lines from
Fe24 to Fe25. They suggested that the X-ray emission-line
gas was photoionized by the central source, thus it is useful to
determine what, if any, contribution the UV/optical emission-
line gas may have to the X-ray spectrum.

For each X-ray line, we summed the fluxes computed by
CLOUDY for all of our model components. To compare our
predicted lines with the Sako et al. (2000) observations, we must
normalize the predictions using one of the lines in common.
We assumed that the O16 gas has the same distribution as the
Hα gas and used the O VII λ22.10 line for normalization. We
found a predicted flux of ∼10^{-14} erg s^{-1} cm^{-2}. This is 30% of
the observed flux for this line. The estimate is reasonable
considering the difference in aperture sizes between STIS and
HETGS. Our models predict significant emission only from the other oxygen lines observed: the predicted $\lambda\text{O} \equiv 23.160/\lambda\text{O} \equiv 22.10$ ratio is 0.5 and the $\lambda\text{O} \equiv 23.8/\lambda\text{O} \equiv 22.10$ ratio is 0.7. These ratios are somewhat higher than those reported in Sako et al. (2000). The physical conditions (e.g., optical depth and/or microturbulence) may be different in the $\lambda\text{O}$ emitting gas which lacks a strong UV/optical footprint. Also, since the models underestimate the observed flux for lines from the higher ionization potential ionic species, it is likely that the Markarian 3 NLR contains a yet higher ionization component, which produces little or no UV/optical emission-line flux. Given the low volume-filling factors predicted for the UV/optical emission-line clouds (see Table 13 in the Appendix), and the weak attenuation of the ionizing continuum expected from the highly ionized gas, the X-ray emitters could be colocated with the “high” and “medium” components without any obvious effect. In this case, the volume-filling factors for the X-ray emitters would far exceed those of the UV/optical knots, perhaps filling the bicone envelope.

5. COLLIMATION OF THE IONIZING RADIATION

Based on our models, the ionizing photon flux (and hence the gas ionization state) in the NLR decreases with increasing polar angle from the symmetry axis (nearly coincident with the sky plane). We suggest that the collimation of the ionizing radiation is not sharply defined by an opaque molecular torus as described in most unified model scenarios. Some alternative mechanisms for collimation are a “torus atmosphere” or an accretion disk wind.

Evans et al. (1993) proposed a torus atmosphere model for NGC 4151 with a column density of order $10^{20} - 10^{21} \text{ cm}^{-2}$ that absorbed X-rays but transmitted nonionizing UV/optical radiation. Another model suggested by Evans et al. (1993) was a clumpy torus composed of clouds with a range of column densities and spatial distributions fortuitously arranged to allow transmission of the optical BLR and continuum emission while absorbing X-ray emission. Feldmeier et al. (1999) suggested that the intrinsic X-ray absorption detected in the Seyfert 1 galaxy Markarian 6 arose in a similar torus “atmosphere” of larger column density ($10^{22} \text{ cm}^{-2}$). Interestingly, the narrow line region in each of these galaxies appears as a linear (as opposed to circular) feature in $\lambda\text{O}$ images (Schmitt & Kinney 1996; Schmitt et al. 2003). This morphological similarity with Markarian 3 suggests that these three NLRs share a common orientation.

In the hydromagnetic wind model of Konigl & Kartje (1994), an outflow is driven by the angular momentum lost by matter in an accretion disk. The outflow is stratified such that density increases with distance from the nucleus. Electrons in the wind collimate the ionizing radiation which decreases with increasing polar angle. The gas close to the symmetry axis is highly ionized and the ionization state decreases with radius and polar angle.

The gas ionization state and density gradients are consistent with our picture of the circumnuclear gas in Markarian 3 developed from the analysis of the NLR emission. However, the ionizing radiation in our models is collimated through absorption by the circumnuclear gas instead of electron scattering. In the Konigl & Kartje (1994) model, the outer regions of the wind at high polar angle may contain dust. This dust may obscure the AGN as required by the unified model, but it is not considered a physically distinct opaque component such as the putative torus.

We did not include dust in our model screens. The screens may lie within the dust sublimation radius (see Barvainis 1987) or they may be part of a wind that originates in a dust-free region. However, the physical conditions in the screening gas are not well constrained, so we cannot rule out the possibility that they contain dust. The main point is that the characteristics of the NLR are consistent with collimation of the ionizing radiation by ionized absorbers. Moreover, Markarian 3 may not be a unique case. Kraemer et al. (2008) used $\lambda\text{O}$ images obtained with $HST$/WFPC2 to map the ionization structure of the NLR in NGC 4151. They found that the ionization state of the NLR, determined by the $\lambda\text{O}$/$\lambda\text{O}$ ratio, dropped with increasing distance from the bicone axis, which is also consistent with a collimation of the ionization radiation by gas near the AGN.

6. BLACK HOLE MASS, ACCRETION RATE, AND OUTFLOW

Woo & Urry (2002) derived a black hole mass of $\approx 4.5 \times 10^8 M_\odot$ for Markarian 3 based on the $M_{\text{BH}}$–stellar velocity dispersion relationship. Using the bolometric luminosity of the model input continuum, $2 \times 10^{45} \text{ erg s}^{-1}$, we estimate that the AGN is radiating at $\sim 3.5\%$ of its Eddington limit. Kraemer et al. (2004) and Peterson et al. (2004) show evidence that many AGNs radiate at $\sim 10\%$ of their Eddington limits.

We estimated the mass of the NLR gas using the volume and number density values for the clouds (see Table 13 in the Appendix), obtaining a value of $2 \times 10^8 M_\odot$ for the small portion of the NLR gas modeled in this study. By comparison, the NLR mass estimated for NGC 4151 from the photoionization models by Kraemer et al. (2000) is $\sim 4 \times 10^8 M_\odot$. This would correspond to $\sim 2 \times 10^8 M_\odot$ for the larger region sampled in Markarian 3. We estimate that we have sampled and modeled one-sixth of the hollow bicone volume with a 400 pc extent along the bicone axis. Assuming that the NLR mass distribution is roughly azimuthally symmetric, the total NLR mass along the 400 pc extent is $1.2 \times 10^7 M_\odot$. This is on the order of the mass of a late-type dwarf galaxy. For comparison, a typical late-type dwarf galaxy, such as the LMC, has an atomic hydrogen mass on the order of $10^8 M_\odot$ (Swaters et al. 2002; Staveley-Smith et al. 2003), while the dwarf elliptical galaxy NGC 205 has an $H_\alpha$ mass of approximately $10^7 M_\odot$ (Welch et al. 1998). Noordermeer et al. (2005) found an $H_\alpha$ bridge between Markarian 3 and UGC 3422, a type SAB(rs)b galaxy $\sim 100$ kpc to the northwest, in the Westerbork $H_\alpha$ Spiral and Irregular Galaxy Survey (WHISP). This interaction is likely responsible for the large amount of emission-line gas inferred by the models and for triggering and sustaining the level of activity observed in Markarian 3.

The mass accretion rate, $\dot{M}$, is determined from the time derivative of Einstein’s mass-energy equivalence relation and by assuming an efficiency, $\eta$, for the conversion of matter to light

$$\dot{M} = \frac{L}{\eta c^2}. \quad (3)$$

Based on our estimated bolometric luminosity, and assuming $\eta = 0.1$, the accretion rate is $0.35 M_\odot \text{ yr}^{-1}$. This can be compared to the mass outflow rate that we derived using the cloud masses from the models, their distances from the AGN, and their radial velocities relative to the AGN. We converted the line-of-sight cloud velocities to outflow velocities relative to the central source using the bicone model geometry. We obtained a mass outflow rate of $\sim 15 M_\odot \text{ yr}^{-1}$, or 42 times the accretion
rate. This suggests that most of the infalling material is blown out before it can be accreted by the central source at the epoch of these observations. We find that the observed NLR outflow kinetic energy is $2 \times 10^{55}$ erg. The kinetic energy luminosity, $3 \times 10^{42}$ erg s$^{-1}$, is a small fraction of the bolometric luminosity. Note that these estimates are lower limits for Markarian 3 since we modeled only a portion of the entire NLR.

7. SUMMARY

We have examined the physical conditions in the NLR of the Seyfert 2 galaxy Markarian 3, using low-resolution, long-slit data obtained with HST/STIS (see Paper I) and photoionization models. The main results of our photoionization modeling analysis are as follows.

1. We have shown that the Markarian 3 NLR UV/optical emission spectrum can be modeled using photoionization as the sole excitation mechanism. The bulk of the emission-line gas lies within the envelope of the biconical region described in the kinematic model of Ruiz et al. (2001). We modeled the emission from this region using two components, labeled “high” and “medium” to describe their relative ionization state. We determined that the ionizing continuum incident upon this gas is best modeled as a broken power law (see Paper I), filtered through a layer of intervening gas, closer to the AGN, that causes some attenuation above the He II Lyman limit.

2. There is a third component of emission (“low”) in which lines from levels with low-critical densities from low-ionization species, e.g., [OII] $\lambda 3727$, arise. In order for such a component to exist in the inner NLR of Markarian 3, it must be heavily shielded from the ionizing source, presumably by an optically thick intervening absorber. Given the nature of the shielding and the low emissivity of low-density gas irradiating in such a manner, the “low” component must lie outside the nominal emission bicone. The different morphologies of the [OII] $\lambda 3727$ and [OIII] $\lambda 4959$ lines are strong evidence for such a scenario.

3. The model parameters used to describe the intervening absorbers are similar to those derived from photoionization studies of intrinsic UV and X-ray absorbers in Seyfert 1 galaxies (Kraemer et al. 2001; Crenshaw et al. 2003). This suggests that intrinsic absorbers are responsible for the collimation of the ionizing continuum, rather than the thick molecular torus described by unified models (Antonucci 1993).

4. The volume filling of the emission-line components is generally small ($<0.01$), and the clouds of different ionization states are not in pressure equilibrium. The cloud densities decrease with radial distance, which suggests that they are not fully confined. Interestingly, our models predicted only 30% of the O VII $\lambda 22.10$ flux reported by Sako et al. (2000) and negligible fractions of the observed flux for higher ionization states. The additional soft X-ray emission-line gas could lie between the bicone walls, and may partially confine the UV/optical clouds.

5. We found that the ionizing radiation could be produced by accretion onto a black hole of $M_{BH} > 10^8 M_\odot$, with the system radiating at $< 10\%$ of its Eddington luminosity. The mass outflow rate exceeds the inferred accretion rate by a factor of $\sim 40$.

6. The large amount of NLR gas is consistent with that in a dwarf elliptical galaxy. This mass, the high luminosity of the ionizing continuum, and the dust structure (described in Paper I) may be indications of a recent merger or fueling event. Indeed, the H I map of Noordermeer et al. (2005) shows evidence of such an interaction with the neighboring spiral galaxy UGC 3422.

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Facilities: HST(StIS)
## APPENDIX

### Table 1

| Bin(1)          | Model component (2) | Distance (pc) (3) | Screen $U$ (4) | Screen $N_e$ (cm$^{-2}$) (5) | Fractional contribution (cm$^{-3}$) (6) | $n_H$ (cm$^{-3}$) (7) | $N_e$ (cm$^{-2}$) (8) |
|-----------------|---------------------|-------------------|----------------|-----------------------------|----------------------------------------|-------------------|-------------------|
| (0.2E)          | high                | 143               | $10^{-1.5}$    | $10^{20.4}$                 | 0.35                                    | $10^{2.74}$        | $10^{22.5}$       |
|                 | med.                | 143               | $10^{-1.5}$    | $10^{20.4}$                 | 0.35                                    | $10^{2.68}$        | $10^{20.0}$       |
|                 | low                 | 155               | $10^{-2.5}$    | $10^{20.7}$                 | 0.30                                    | $10^{2.84}$        | $10^{22.5}$       |
| (0.3E, b, 0.3E) | high                | 73                | $10^{-1.5}$    | $10^{20.4}$                 | 0.25                                    | $10^{2.49}$        | $10^{22.0}$       |
|                 | med.                | 74                | $10^{-1.5}$    | $10^{20.4}$                 | 0.45                                    | $10^{2.99}$        | $10^{21.1}$       |
|                 | low                 | 82                | $10^{-3.0}$    | $10^{21.9}$                 | 0.30                                    | $10^{2.16}$        | $10^{22.0}$       |
| (0.3E, r, 0.3E) | high                | 68                | $10^{-1.5}$    | $10^{20.4}$                 | 0.25                                    | $10^{3.99}$        | $10^{21.5}$       |
|                 | med.                | 68                | $10^{-1.5}$    | $10^{20.4}$                 | 0.45                                    | $10^{3.49}$        | $10^{20.7}$       |
|                 | low                 | 74                | $10^{-3.0}$    | $10^{21.9}$                 | 0.30                                    | $10^{1.00}$        | $10^{22.0}$       |
| (0.0E, b, 0.3E) | high                | 18                | $10^{-1.5}$    | $10^{20.4}$                 | 0.70                                    | $10^{0.00}$        | $10^{22.0}$       |
|                 | med.                | 18                | $10^{-1.5}$    | $10^{20.4}$                 | 0.00                                    | ...               | ...               |
|                 | low                 | 21                | $10^{-1.5}$    | $10^{21.6}$                 | 0.30                                    | $10^{4.00}$        | $10^{23.0}$       |
| (0.0E, r, 0.3E) | high                | 18                | $10^{-1.5}$    | $10^{20.4}$                 | 0.20                                    | $10^{5.85}$        | $10^{21.5}$       |
|                 | med.                | 18                | $10^{-1.5}$    | $10^{20.4}$                 | 0.50                                    | $10^{5.00}$        | $10^{22.3}$       |
|                 | low                 | 21                | $10^{-1.5}$    | $10^{21.6}$                 | 0.30                                    | $10^{5.25}$        | $10^{23.5}$       |
| (0.3W, b, 0.3W) | high                | 68                | $10^{-1.5}$    | $10^{20.4}$                 | 0.40                                    | $10^{8.84}$        | $10^{22.0}$       |
|                 | med.                | 68                | $10^{-1.5}$    | $10^{20.4}$                 | 0.30                                    | $10^{8.84}$        | $10^{22.0}$       |
|                 | low                 | 74                | $10^{-1.5}$    | $10^{21.6}$                 | 0.30                                    | $10^{3.32}$        | $10^{22.5}$       |
| (0.3W, r, 0.3W) | high                | 73                | $10^{-1.5}$    | $10^{20.4}$                 | 0.40                                    | $10^{3.50}$        | $10^{22.5}$       |
|                 | med.                | 73                | $10^{-1.5}$    | $10^{20.4}$                 | 0.30                                    | $10^{3.50}$        | $10^{22.5}$       |
|                 | low                 | 82                | $10^{-1.5}$    | $10^{21.6}$                 | 0.30                                    | $10^{5.25}$        | $10^{22.0}$       |
| (0.5W, b, 0.2W) | high                | 130               | $10^{-1.5}$    | $10^{20.4}$                 | 0.40                                    | $10^{4.46}$        | $10^{21.5}$       |
|                 | med.                | 130               | $10^{-1.5}$    | $10^{20.4}$                 | 0.30                                    | $10^{4.46}$        | $10^{20.5}$       |
|                 | low                 | 140               | $10^{-1.5}$    | $10^{21.6}$                 | 0.30                                    | $10^{5.85}$        | $10^{22.0}$       |
| (0.5W, r, 0.2W) | high                | 138               | $10^{-1.5}$    | $10^{20.4}$                 | 0.40                                    | $10^{2.86}$        | $10^{22.0}$       |
|                 | med.                | 138               | $10^{-1.5}$    | $10^{20.4}$                 | 0.30                                    | $10^{3.56}$        | $10^{20.0}$       |
|                 | low                 | 156               | $10^{-1.5}$    | $10^{21.6}$                 | 0.30                                    | $10^{4.50}$        | $10^{22.5}$       |
| (0.7W, b, 0.3E) | high                | 211               | $10^{-1.5}$    | $10^{20.4}$                 | 0.20                                    | $10^{5.57}$        | $10^{21.8}$       |
|                 | med.                | 211               | $10^{-1.5}$    | $10^{20.4}$                 | 0.45                                    | $10^{5.57}$        | $10^{21.0}$       |
|                 | low                 | 239               | $10^{-1.5}$    | $10^{21.6}$                 | 0.35                                    | $10^{5.25}$        | $10^{22.0}$       |
| (1.0W, b, 0.3E) | high                | 291               | $10^{-1.5}$    | $10^{20.4}$                 | 0.10                                    | $10^{0.08}$        | $10^{21.0}$       |
|                 | med.                | 291               | $10^{-1.5}$    | $10^{20.4}$                 | 0.50                                    | $10^{5.50}$        | $10^{20.5}$       |
|                 | low                 | 329               | $10^{-1.5}$    | $10^{21.6}$                 | 0.40                                    | $10^{2.00}$        | $10^{21.5}$       |
| Line   | Wavelength (Å) | Line match | High-U model | Med.-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|--------|----------------|------------|--------------|--------------|-------------|-----------------|---------------|------------------|
| Lyα    | 1216           | 0          | 24.05        | 23.78        | 5.92        | 18.52           | 38.97 ± 38.35 | 0.5 ± 0.5        |
| N v    | 1240           | 1          | 0.71         | 0.06         | 0.11        | 0.30            | 0.56 ± 0.84   | 0.5 ± 0.8        |
| C iv   | 1549           | 1          | 4.02         | 0.88         | 0.74        | 1.93            | 1.82 ± 1.08   | 1.1 ± 0.7        |
| C m i  | 1909           | 0          | 0.12         | 1.88         | 1.59        | 1.18            | 3.43 ± 2.54   | 0.3 ± 0.2        |
| C n i  | 2326           | 0          | 0.00         | 1.00         | 1.90        | 0.60            | 1.84 ± 1.17   | 0.3 ± 0.2        |
| [Ne iv] | 2424         | 1          | 0.15         | 0.15         | 0.02        | 0.11            | 0.16 ± 0.14   | 0.7 ± 0.6        |
| Mg ii  | 2798           | 1          | 0.01         | 0.24         | 2.45        | 0.82            | 1.03 ± 0.42   | 0.8 ± 0.3        |
| [Ne v] | 3426           | 1          | 0.49         | 0.03         | 0.01        | 0.19            | 0.36 ± 0.17   | 0.5 ± 0.2        |
| [O ii] | 3727           | 1          | 0.03         | 0.06         | 14.19       | 4.29            | 3.05 ± 1.34   | 1.4 ± 0.6        |
| [Ne iii] | 3869        | 1          | 0.88         | 1.74         | 1.24        | 1.29            | 1.30 ± 0.56   | 1.0 ± 0.4        |
| [S ii] | 4074           | 0          | 0.00         | 0.03         | 0.24        | 0.08            | 0.48 ± 0.20   | 0.2 ± 0.1        |
| [O iii] | 4363          | 1          | 0.12         | 0.23         | 0.04        | 0.13            | 0.21 ± 0.08   | 0.6 ± 0.2        |
| He ii  | 4686           | 1          | 0.10         | 0.26         | 0.03        | 0.14            | 0.27 ± 0.11   | 0.5 ± 0.2        |
| [O iii] | 5007          | 1          | 14.59        | 18.40        | 1.95        | 12.13           | 9.75 ± 3.50   | 1.2 ± 0.4        |
| [Fe v i] | 6087         | 1          | 0.04         | 0.01         | 0.01        | 0.02            | 0.03 ± 0.01   | 0.6 ± 0.2        |
| [O i]  | 6300           | 1          | 0.00         | 0.00         | 1.67        | 0.50            | 0.92 ± 0.29   | 0.5 ± 0.2        |
| Hα    | 6563           | 1          | 2.90         | 2.80         | 3.01        | 2.90            | 2.56 ± 0.82   | 1.1 ± 0.4        |
| [N ii] | 6584           | 1          | 0.00         | 0.10         | 7.73        | 2.35            | 3.75 ± 1.18   | 0.6 ± 0.2        |
| [S ii] | 6724           | 1          | 0.00         | 0.01         | 3.61        | 1.09            | 1.67 ± 0.38   | 0.7 ± 0.2        |
| [S iii] | 9532         | 1          | 0.01         | 1.09         | 1.78        | 0.92            | 1.21 ± 0.34   | 0.8 ± 0.2        |
| \(f_{\text{model}}\) | 4861       | ...        | 0.35         | −0.22        | −0.44       | 0.04            | ...           | ...              |
| \(f_{\text{data}}\) | 4861        | ...        | ...          | ...          | ...         | ...             | 38.12 ± 9.85  | ...              |

Notes.

a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.
b High-U model. Boundary: \(m; \log_{10}(U) = -0.29; \log_{10}(n_{HI}) = 2.74 \text{ cm}^{-3}\); cloud \(\log_{10}(n_{HI}) = 22.5 \text{ cm}^{-2}\); fractional contribution = 0.35.
c Medium-U model. Boundary: \(m; \log_{10}(U) = -2.23; \log_{10}(n_{HI}) = 4.68 \text{ cm}^{-3}\); cloud \(\log_{10}(n_{HI}) = 20.0 \text{ cm}^{-2}\); fractional contribution = 0.35.
d Low-U model. Boundary: \(m; \log_{10}(U) = 2.23; \log_{10}(n_{HI}) = 2.84 \text{ cm}^{-3}\); cloud \(\log_{10}(n_{HI}) = 22.5 \text{ cm}^{-2}\); fractional contribution = 0.30; screen \(\log_{10}(n_{HI}) = 20.7 \text{ cm}^{-2}\).
e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with \(E(B-V) = 0.19\). We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to \(E(B-V) = 0.31\). See Paper I for details.
f Logarithm of model Hβ flux. Units: \(\log_{10}(\text{erg s}^{-1} \text{ cm}^{-2})\).
g Observed Hβ flux. Units: \(10^{-15} \text{ erg s}^{-1} \text{ cm}^{-2}\).
Table 3
Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (0′′.3E, b, 0′′.3)

| Line     | Wavelength (Å) | Line matcha | High-U modelb | Med.-U modelc | Low-U modeld | Composite model | Observed datae | Model/data ratio |
|----------|----------------|-------------|---------------|---------------|---------------|----------------|----------------|-----------------|
| Lyα      | 1216           | 1           | 26.07         | 4.13          | 2.65          | 9.17           | 9.90 ± 0.7     | 0.9 ± 0.7       |
| N v      | 1240           | 1           | 1.69          | 0.02          | 0.00          | 0.43           | 0.46 ± 0.7     | 0.9 ± 1.5       |
| C iv     | 1549           | 0           | 11.44         | 0.61          | 0.55          | 3.30           | 0.57 ± 0.34    | 5.7 ± 3.4       |
| C iii    | 1909           | 1           | 0.32          | 1.64          | 0.03          | 0.83           | 1.65 ± 0.97    | 0.5 ± 0.3       |
| C ii     | 2326           | 1           | 0.00          | 0.21          | 1.09          | 0.42           | 0.68 ± 0.36    | 0.6 ± 0.3       |
| [Ne iv]  | 2424           | 1           | 0.48          | 0.08          | 0.00          | 0.16           | 0.31 ± 0.15    | 0.5 ± 0.2       |
| Mg ii    | 2798           | 1           | 0.02          | 0.61          | 2.88          | 1.14           | 0.73 ± 0.24    | 1.6 ± 0.5       |
| [Ne v]   | 3426           | 1           | 1.40          | 0.03          | 0.00          | 0.37           | 0.63 ± 0.24    | 0.6 ± 0.2       |
| [O ii]   | 3727           | 1           | 0.02          | 0.16          | 4.20          | 1.34           | 2.58 ± 0.93    | 0.5 ± 0.2       |
| [Ne iii] | 3869           | 1           | 1.36          | 1.78          | 0.75          | 1.36           | 1.26 ± 0.44    | 1.1 ± 0.4       |
| [S ii]   | 4074           | 1           | 0.00          | 0.15          | 0.44          | 0.20           | 0.37 ± 0.13    | 0.5 ± 0.2       |
| [O iii]  | 4686           | 1           | 0.29          | 0.23          | 0.00          | 0.18           | 0.15 ± 0.05    | 1.2 ± 0.4       |
| Hα       | 5007           | 1           | 0.25          | 0.08          | 0.01          | 0.10           | 0.16 ± 0.05    | 0.6 ± 0.2       |
| [O i]    | 5007           | 1           | 0.10          | 0.01          | 0.00          | 0.03           | 0.03 ± 0.01    | 1.0 ± 0.3       |
| [O i]    | 5600           | 1           | 0.00          | 0.33          | 3.06          | 1.07           | 1.15 ± 0.31    | 0.9 ± 0.2       |
| Hα       | 6563           | 1           | 2.90          | 2.84          | 2.98          | 2.90           | 3.21 ± 0.86    | 0.9 ± 0.2       |
| [N ii]   | 6584           | 1           | 0.00          | 0.89          | 9.13          | 3.14           | 5.26 ± 1.38    | 0.6 ± 0.2       |
| [S ii]   | 6724           | 1           | 0.00          | 0.28          | 6.29          | 2.01           | 1.68 ± 0.31    | 1.2 ± 0.2       |
| [S ii]   | 9532           | 1           | 0.01          | 1.11          | 1.55          | 0.96           | 1.03 ± 0.24    | 0.9 ± 0.2       |
| fmodel  |             | 4861        | ...           | 0.52          | 1.01          | −0.64          | 0.74           | ...            |
| fmobs   |             | 4861        | ...           | ...           | ...           | ...            | ...            | 16.77 ± 3.59    |

Notes.
a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.
b High-U model. Boundary: m; log10(U) = −0.45; log10(nH) = 3.49 cm⁻³; cloud log10(NH) = 22.0 cm⁻²; fractional contribution = 0.25.
c Medium-U model. Boundary: r; log10(U) = −1.95; log10(nH) = 4.99 cm⁻³; cloud log10(NH) = 21.1 cm⁻²; fractional contribution = 0.45.
d Low-U model. Boundary: m; log10(U) = −3.08; log10(nH) = 5.16 cm⁻³; cloud log10(NH) = 22.0 cm⁻²; fractional contribution = 0.30; screen log10(NH) = 21.9 cm⁻².
e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with E(B − V) = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to E(B − V) = 0.26. See Paper I for details.
f Logarithm of model Hβ flux. Units: log10(erg s⁻¹ cm⁻²).
g Observed Hβ flux. Units: 10⁻¹⁵ erg s⁻¹ cm⁻².
### Table 4

Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (0\textdegree3E, r, 0\textdegree3)

| Line        | Wavelength (Å) | Line match | High-U model | Med-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|-------------|----------------|------------|--------------|-------------|-------------|-----------------|---------------|------------------|
| Lyα         | 1216           | 1          | 28.43        | 8.17        | 2.76        | 11.61           | 19.97 ± 11.55 | 0.6 ± 0.3        |
| N v         | 1240           | 1          | 0.89         | 0.01        | 0.01        | 0.23            | 0.22 ± 0.13   | 1.0 ± 0.6        |
| C iv        | 1549           | 1          | 11.27        | 0.21        | 0.60        | 3.09            | 2.11 ± 0.74   | 1.5 ± 0.5        |
| C ii        | 1909           | 1          | 0.88         | 1.44        | 0.09        | 0.89            | 0.77 ± 0.32   | 1.2 ± 0.5        |
| C ii        | 2326           | 1          | 0.00         | 0.37        | 1.77        | 0.69            | 0.81 ± 0.31   | 0.9 ± 0.3        |
| [Ne iv]     | 2424           | 0          | 0.63         | 0.01        | 0.00        | 0.16            | 0.38 ± 0.13   | 0.4 ± 0.1        |
| Mg ii       | 2798           | 1          | 0.04         | 1.03        | 3.29        | 1.46            | 0.96 ± 0.23   | 1.5 ± 0.4        |
| [Ne v]      | 3426           | 1          | 1.24         | 0.00        | 0.00        | 0.31            | 0.41 ± 0.12   | 0.8 ± 0.2        |
| [O ii]      | 3727           | 1          | 0.02         | 0.10        | 7.63        | 2.34            | 3.03 ± 0.80   | 0.8 ± 0.2        |
| [Ne ii]     | 3869           | 1          | 1.54         | 1.62        | 1.01        | 1.42            | 1.29 ± 0.33   | 1.1 ± 0.3        |
| [S ii]      | 4074           | 1          | 0.00         | 0.25        | 0.47        | 0.25            | 0.48 ± 0.12   | 0.5 ± 0.1        |
| [O iii]     | 4363           | 1          | 0.34         | 0.24        | 0.00        | 0.19            | 0.17 ± 0.04   | 1.1 ± 0.3        |
| He ii       | 4686           | 1          | 0.27         | 0.06        | 0.01        | 0.10            | 0.17 ± 0.04   | 0.6 ± 0.1        |
| [O iii]     | 5007           | 1          | 23.64        | 10.60       | 0.06        | 10.70           | 11.17 ± 2.44  | 1.0 ± 0.2        |
| [Fe v]t    | 6087           | 1          | 0.16         | 0.00        | 0.00        | 0.04            | 0.04 ± 0.01   | 1.1 ± 0.3        |
| [O i]       | 6300           | 1          | 0.00         | 0.38        | 2.88        | 1.04            | 1.28 ± 0.25   | 0.8 ± 0.2        |
| Hα          | 6563           | 1          | 2.89         | 2.82        | 2.94        | 2.87            | 3.28 ± 0.70   | 0.9 ± 0.2        |
| [N ii]      | 6584           | 1          | 0.00         | 0.81        | 9.17        | 3.12            | 5.09 ± 1.01   | 0.6 ± 0.1        |
| [S ii]      | 6724           | 1          | 0.00         | 0.17        | 5.59        | 1.76            | 2.43 ± 0.33   | 0.7 ± 0.1        |
| [S iii]     | 9532           | 0          | 0.03         | 1.16        | 1.66        | 1.03            | 2.13 ± 0.37   | 0.5 ± 0.1        |

**Notes.**

a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.

b High-U model. Boundary: \( \log_{10}(U) = -0.89; \ log_{10}(n_H) = 3.99 \text{ cm}^{-3}; \) cloud \( \log_{10}(N_e) = 21.5 \text{ cm}^{-2}; \) fractional contribution = 0.25.

c Medium-U model. Boundary: \( r; \ log_{10}(U) = -2.39; \ log_{10}(n_H) = 5.49 \text{ cm}^{-3}; \) cloud \( \log_{10}(N_e) = 20.7 \text{ cm}^{-2}; \) fractional contribution = 0.45.

d Low-U model. Boundary: \( m; \ log_{10}(U) = -2.83; \ log_{10}(n_H) = 3.00 \text{ cm}^{-3}; \) cloud \( \log_{10}(N_e) = 22.0 \text{ cm}^{-2}; \) fractional contribution = 0.30; \( \log_{10}(N_e) = 21.9 \text{ cm}^{-2}. \)

e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with \( E(B - V) = 0.19. \) We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to \( E(B - V) = 0.24. \) See Paper I for details.

f Logarithm of model Hβ flux. Units: \( \log_{10}(\text{erg s}^{-1} \text{ cm}^{-2}). \)

# Logarithm of model Hβ flux. Units: \( 10^{-15} \text{ erg s}^{-1} \text{ cm}^{-2}. \)
| Line          | Wavelength (Å) | Line match | High-U model | Med.-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|--------------|---------------|------------|--------------|--------------|-------------|-----------------|--------------|-----------------|
| Lyα          | 1216          | 0          | 36.59        | ...          | 4.39        | 26.93           | 6.78 ± 4.69 | 4.0 ± 2.8       |
| N v          | 1240          | 1          | 0.67         | ...          | 0.14        | 0.51            | 0.40 ± 0.28 | 1.3 ± 0.9       |
| C iv         | 1549          | 0          | 7.30         | ...          | 1.79        | 5.65            | 0.41 ± 0.22 | 13.7 ± 7.4      |
| C iii        | 1909          | 1          | 0.50         | ...          | 0.79        | 0.59            | 0.71 ± 0.39 | 0.8 ± 0.4       |
| C ii         | 2326          | 1          | 0.00         | ...          | 2.85        | 0.85            | 0.60 ± 0.27 | 1.4 ± 0.6       |
| [Ne iv]      | 2424          | 1          | 0.21         | ...          | 0.02        | 0.15            | 0.22 ± 0.09 | 0.7 ± 0.3       |
| Mg ii        | 2798          | 0          | 0.30         | ...          | 3.81        | 1.16            | 0.40 ± 0.11 | 2.9 ± 0.8       |
| [Ne v]       | 3426          | 1          | 0.69         | ...          | 0.02        | 0.49            | 0.44 ± 0.16 | 1.1 ± 0.4       |
| [O ii]       | 3727          | 1          | 0.00         | ...          | 7.59        | 2.28            | 2.44 ± 0.78 | 0.9 ± 0.3       |
| [Ne iii]     | 3869          | 1          | 1.50         | ...          | 1.20        | 1.41            | 0.99 ± 0.33 | 1.4 ± 0.5       |
| [S ii]       | 4074          | 1          | 0.00         | ...          | 0.86        | 0.26            | 0.17 ± 0.07 | 1.5 ± 0.6       |
| [O iii]      | 4363          | 1          | 0.31         | ...          | 0.02        | 0.23            | 0.20 ± 0.06 | 1.2 ± 0.4       |
| H α          | 5007          | 1          | 19.95        | ...          | 1.18        | 14.32           | 11.06 ± 3.07 | 1.3 ± 0.4       |
| [Fe v]       | 6087          | 1          | 0.08         | ...          | 0.01        | 0.06            | 0.08 ± 0.03 | 0.7 ± 0.3       |
| [O i]        | 6300          | 1          | 0.00         | ...          | 2.36        | 0.71            | 0.90 ± 0.23 | 0.8 ± 0.2       |
| Hα           | 6563          | 1          | 3.25         | ...          | 2.96        | 3.16            | 2.77 ± 0.83 | 1.1 ± 0.3       |
| [N ii]       | 6584          | 1          | 0.00         | ...          | 9.60        | 2.88            | 3.76 ± 0.98 | 0.8 ± 0.2       |
| [S ii]       | 6724          | 1          | 0.00         | ...          | 3.86        | 1.16            | 1.42 ± 0.32 | 0.8 ± 0.2       |
| [S iii]      | 9532          | 1          | 0.05         | ...          | 1.84        | 0.59            | 1.09 ± 0.28 | 0.5 ± 0.1       |
| f_Hβ model  f | 4861         | ... | 2.05         | ...          | 1.25        | 1.92            | ...          | ...             |
| f_Hβ data  f | 4861         | ... | ...          | ...          | ...         | 18.87 ± 3.67    | ...          | ...             |

Notes.

a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.

b High-U model. Boundary: m; log10(U) = −0.75; log10(nH) = 5.00 cm−3; cloud log10(Nc) = 22.0 cm−2; fractional contribution = 0.70.

c No medium-U model component required for this observed kinematic component.

d Low-U model. Boundary: m; log10(U) = −2.52; log10(nH) = 4.00 cm−3; cloud log10(Nc) = 23.0 cm−2; fractional contribution = 0.30; screen log10(Nc) = 21.6 cm−2.

e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with E(B − V) = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to E(B − V) = 0.22. See Paper I for details.

f Logarithm of model Hβ flux. Units: log10(erg s−1 cm−2).

g Observed Hβ flux. Units: 10−13 erg s−1 cm−2.
### Table 6

Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (0''0W, r, 0''3)

| Line       | Wavelength (Å) | Line match<sup>a</sup> | High-U model<sup>b</sup> | Med.-U model<sup>c</sup> | Low-U model<sup>d</sup> | Composite model | Observed data<sup>e</sup> | Model/data ratio |
|------------|----------------|------------------------|--------------------------|-------------------------|----------------------|------------------|-------------------------|-----------------|
| Lyα        | 1216           | 0                      | 34.80                    | 1.37                    | 2.19                 | 8.30             | 54.35 ± 14.72          | 0.2 ± 0.1       |
| N v        | 1240           | 1                      | 5.10                     | 1.05                    | 0.06                 | 1.56             | 2.46 ± 0.66           | 0.6 ± 0.2       |
| C iv       | 1549           | 1                      | 37.32                    | 5.63                    | 0.91                 | 10.55            | 6.51 ± 1.12            | 1.6 ± 0.3       |
| C iii      | 1909           | 0                      | 1.12                     | 2.68                    | 0.17                 | 1.62             | 4.99 ± 1.07            | 0.3 ± 0.1       |
| C ii       | 2326           | 1                      | 0.00                     | 0.46                    | 1.23                 | 0.60             | 1.13 ± 0.26            | 0.5 ± 0.1       |
| [Ne iv]    | 2424           | 1                      | 1.26                     | 0.72                    | 0.00                 | 0.61             | 1.17 ± 0.22            | 0.5 ± 0.1       |
| Mg ii      | 2798           | 1                      | 0.05                     | 0.43                    | 2.28                 | 0.91             | 0.70 ± 0.12            | 1.3 ± 0.2       |
| [Ne v]     | 3426           | 1                      | 4.31                     | 1.93                    | 0.00                 | 1.83             | 1.43 ± 0.24            | 1.3 ± 0.2       |
| [O iii]    | 3727           | 1                      | 0.00                     | 0.32                    | 2.75                 | 0.98             | 1.39 ± 0.40            | 0.7 ± 0.2       |
| [Ne iii]   | 3869           | 1                      | 1.71                     | 3.42                    | 0.57                 | 2.22             | 1.72 ± 0.30            | 1.3 ± 0.2       |
| [S ii]     | 4074           | 1                      | 0.00                     | 0.52                    | 0.68                 | 0.46             | 0.36 ± 0.06            | 1.3 ± 0.2       |
| [O iv]     | 4363           | 1                      | 0.77                     | 0.88                    | 0.00                 | 0.60             | 0.32 ± 0.05            | 1.9 ± 0.3       |
| H<sub>α</sub> | 4686          | 1                      | 0.67                     | 0.23                    | 0.01                 | 0.25             | 0.32 ± 0.05            | 0.8 ± 0.1       |
| [O iii]    | 5007           | 1                      | 22.54                    | 26.58                   | 0.12                 | 17.83            | 15.87 ± 2.61           | 1.1 ± 0.2       |
| [Fe v]     | 6087           | 1                      | 0.21                     | 0.09                    | 0.00                 | 0.09             | 0.10 ± 0.02            | 0.9 ± 0.2       |
| [O i]      | 6300           | 1                      | 0.00                     | 2.02                    | 2.14                 | 1.65             | 0.88 ± 0.16            | 1.9 ± 0.3       |
| H<sub>α</sub> | 6563           | 1                      | 2.79                     | 2.87                    | 3.08                 | 2.92             | 3.31 ± 0.69            | 0.9 ± 0.2       |
| [N ii]     | 6584           | 1                      | 0.00                     | 1.34                    | 7.45                 | 2.90             | 3.16 ± 0.49            | 0.9 ± 0.1       |
| [S ii]     | 6724           | 1                      | 0.00                     | 2.18                    | 3.82                 | 2.24             | 2.45 ± 0.44            | 0.9 ± 0.2       |
| [S iii]    | 7532           | 1                      | 0.00                     | 0.00                    | 0.00                 | 0.00             | 0.00 ± 0.00            | 0.0 ± 0.0       |
|<sup>f</sup><sub>mod</sub> | 4861          | ...                    | 1.25                     | 1.66                    | 1.47                 | 1.55             | ...                     | ...            |
|<sup>g</sup><sub>mod</sub> | 4861          | ...                    | ...                      | ...                    | ...                 | ...              | ...                     | ...            |

Notes.

<sup>a</sup> 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.

<sup>b</sup> High-U model. Boundary: <i>m</i>: log<sub>10</sub>(<i>U</i>) = 0.60; log<sub>10</sub>(<i>N</i><sub>α</sub>) = 4.85 cm<sup>−3</sup>; fractional contribution = 0.20.

<sup>c</sup> Medium-U model. Boundary: <i>r</i>: log<sub>10</sub>(<i>U</i>) = 0.75; log<sub>10</sub>(<i>N</i><sub>α</sub>) = 5.00 cm<sup>−3</sup>; cloud log<sub>10</sub>(<i>N</i><sub>α</sub>) = 22.3 cm<sup>−2</sup>; fractional contribution = 0.50.

<sup>d</sup> Low-U model. Boundary: <i>m</i>: log<sub>10</sub>(<i>U</i>) = 2.77; log<sub>10</sub>(<i>N</i><sub>α</sub>) = 4.25 cm<sup>−3</sup>; cloud log<sub>10</sub>(<i>N</i><sub>α</sub>) = 23.5 cm<sup>−2</sup>; fractional contribution = 0.30; screen log<sub>10</sub>(<i>N</i><sub>α</sub>) = 21.6 cm<sup>−2</sup>.

<sup>e</sup> We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with <i>E(B − V)</i> = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to <i>E(B − V)</i> = 0.40. See Paper I for details.

<sup>f</sup> Logarithm of model Hα flux. Units: 10<sup>−16</sup> erg s<sup>−1</sup> cm<sup>−2</sup>.

<sup>g</sup> Observed Hα flux. Units: 10<sup>−15</sup> erg s<sup>−1</sup> cm<sup>−2</sup>.
Table 7
Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (∼0\′′.3W, b, 0\′′.3)

| Line     | Wavelength (Å) | Line match\(^a\) | High-U model\(^b\) | Med-U model\(^b\) | Low-U model\(^b\) | Composite model | Observed data\(^c\) | Model/data ratio |
|----------|----------------|------------------|-------------------|------------------|------------------|-----------------|-------------------|------------------|
| Ly\(\alpha\) | 1216          | 1                | 28.14             | 27.01            | 6.60             | 21.34           | 18.58 ± 5.76     | 1.1 ± 0.3        |
| N \(\nu\) | 1240          | 1                | 0.49              | 0.53             | 0.03             | 0.36            | 0.69 ± 0.22      | 0.5 ± 0.2        |
| C \(\nu\)  | 1549          | 1                | 5.08              | 10.96            | 2.14             | 5.96            | 3.06 ± 0.60      | 1.9 ± 0.4        |
| C \(m\)   | 1909          | 1                | 0.35              | 5.13             | 0.14             | 1.72            | 1.36 ± 0.37      | 1.3 ± 0.4        |
| C \(n\)   | 2326          | 1                | 0.00              | 0.06             | 1.15             | 0.36            | 0.64 ± 0.13      | 0.6 ± 0.1        |
| [Ne \(iv\)] | 2424        | 1                | 0.25              | 1.53             | 0.00             | 0.56            | 0.46 ± 0.09      | 1.2 ± 0.2        |
| Mg \(n\)  | 2798          | 1                | 0.02              | 0.12             | 2.36             | 0.75            | 0.75 ± 0.10      | 1.0 ± 0.1        |
| [Ne \(v\)] | 3426          | 1                | 0.57              | 0.99             | 0.00             | 0.52            | 0.78 ± 0.12      | 0.7 ± 0.1        |
| [O \(iii\)] | 3727        | 1                | 0.02              | 0.02             | 5.35             | 1.62            | 2.60 ± 0.36      | 0.6 ± 0.1        |
| [Ne \(iii\)] | 3869       | 1                | 1.11              | 2.19             | 0.74             | 1.32            | 1.38 ± 0.19      | 1.0 ± 0.1        |
| [S \(ii\)] | 4074          | 1                | 0.00              | 0.00             | 0.42             | 0.13            | 0.17 ± 0.04      | 0.8 ± 0.2        |
| [O \(ii\)] | 4363          | 1                | 0.17              | 0.64             | 0.00             | 0.26            | 0.29 ± 0.04      | 0.9 ± 0.1        |
| He \(n\)  | 4686          | 1                | 0.11              | 0.74             | 0.01             | 0.27            | 0.21 ± 0.03      | 1.3 ± 0.2        |
| [O \(iii\)] | 5007          | 1                | 17.75             | 23.59            | 0.06             | 14.19           | 13.84 ± 1.63     | 1.0 ± 0.1        |
| [Fe \(vii\)] | 6087        | 1                | 0.07              | 0.29             | 0.00             | 0.09            | 0.11 ± 0.02      | 0.8 ± 0.1        |
| [O \(i\)]  | 6300          | 1                | 0.00              | 0.00             | 2.60             | 0.78            | 0.96 ± 0.10      | 0.8 ± 0.1        |
| H\(\alpha\) | 6563          | 1                | 3.07              | 2.74             | 2.97             | 2.94            | 3.67 ± 0.38      | 0.8 ± 0.1        |
| [N \(ii\)] | 6584          | 1                | 0.00              | 0.02             | 8.51             | 2.56            | 5.07 ± 0.50      | 0.5 ± 0.0        |
| [S \(ii\)] | 6724          | 1                | 0.00              | 0.00             | 5.26             | 1.58            | 2.15 ± 0.16      | 0.7 ± 0.1        |
| [S \(iii\)] | 9532         | 0                | 0.05              | 0.37             | 1.63             | 0.62            | 1.48 ± 0.13      | 0.4 ± 0.0        |

Notes.
\(^a\) 1 = Model and data line ratios relative to H\(\beta\) match within a factor of 2; 0 = no match.
\(^b\) High-U model. Boundary: \(m; \log_{10}(U) = -0.74; \log_{10}(n_H) = 3.84 \text{ cm}^{-3}\); cloud \(\log_{10}(N_e) = 22.0 \text{ cm}^{-3}\); fractional contribution = 0.40.
\(^c\) Medium-U model. Boundary: \(m; \log_{10}(U) = -1.74; \log_{10}(n_H) = 4.84 \text{ cm}^{-3}\); cloud \(\log_{10}(N_e) = 20.0 \text{ cm}^{-3}\); fractional contribution = 0.30.
\(^d\) Low-U model. Boundary: \(m; \log_{10}(U) = -2.95; \log_{10}(n_H) = 3.32 \text{ cm}^{-3}\); cloud \(\log_{10}(N_e) = 22.5 \text{ cm}^{-3}\); fractional contribution = 0.30; screen \(\log_{10}(N_e) = 21.6 \text{ cm}^{-3}\).
\(^e\) We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with \(E(B-V) = 0.19\). We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to \(E(B-V) = 0.22\). See Paper I for details.
\(^f\) Logarithm of model H\(\beta\) flux. Units: \(\log_{10}(\text{erg s}^{-1} \text{ cm}^{-2})\).
\(^g\) Observed H\(\beta\) flux. Units: \(10^{-15} \text{ erg s}^{-1} \text{ cm}^{-2}\).
| Line          | Wavelength (Å) | Line match | High-U model | Med.-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|--------------|----------------|------------|--------------|--------------|-------------|-----------------|---------------|-----------------|
| Lyα          | 1216           | 1          | 27.23        | 16.97        | 10.88       | 19.25           | 29.68 ± 7.08  | 0.6 ± 0.1       |
| N v          | 1240           | 0          | 0.46         | 0.86         | 0.04        | 0.45            | 1.29 ± 0.31   | 0.3 ± 0.1       |
| C iv         | 1549           | 1          | 3.30         | 13.27        | 3.34        | 6.30            | 6.28 ± 0.90   | 1.0 ± 0.1       |
| C iv         | 1909           | 1          | 0.67         | 4.51         | 0.19        | 1.68            | 2.20 ± 0.52   | 0.8 ± 0.2       |
| C iv         | 2326           | 1          | 0.00         | 0.03         | 1.49        | 0.46            | 0.59 ± 0.09   | 0.8 ± 0.1       |
| [Ne iv]      | 2424           | 1          | 0.13         | 2.08         | 0.00        | 0.68            | 0.76 ± 0.11   | 0.9 ± 0.1       |
| Mg ii        | 2798           | 1          | 0.04         | 0.08         | 2.96        | 0.93            | 1.05 ± 0.10   | 0.9 ± 0.1       |
| [Ne v]       | 3426           | 1          | 0.39         | 1.82         | 0.00        | 0.70            | 1.07 ± 0.12   | 0.7 ± 0.1       |
| [O iii]      | 3727           | 1          | 0.03         | 0.02         | 7.08        | 2.14            | 2.45 ± 0.27   | 0.9 ± 0.1       |
| [Ne iii]     | 3869           | 1          | 1.17         | 2.29         | 0.93        | 1.43            | 1.38 ± 0.15   | 1.0 ± 0.1       |
| [S ii]       | 4074           | 1          | 0.00         | 0.00         | 0.45        | 0.13            | 0.27 ± 0.04   | 0.5 ± 0.1       |
| [O ii]       | 4363           | 1          | 0.16         | 0.70         | 0.00        | 0.27            | 0.21 ± 0.03   | 1.3 ± 0.2       |
| He ii        | 4686           | 1          | 0.07         | 0.64         | 0.01        | 0.22            | 0.23 ± 0.02   | 1.0 ± 0.1       |
| [O iii]      | 5007           | 1          | 18.83        | 27.41        | 0.09        | 15.78           | 14.20 ± 1.35  | 1.1 ± 0.1       |
| [Fe vii]     | 6087           | 1          | 0.04         | 0.25         | 0.00        | 0.09            | 0.12 ± 0.01   | 0.8 ± 0.1       |
| [O i]        | 6300           | 1          | 0.00         | 0.00         | 2.73        | 0.82            | 0.72 ± 0.06   | 1.1 ± 0.1       |
| Hα           | 6563           | 1          | 3.17         | 2.75         | 2.93        | 2.97            | 2.48 ± 0.22   | 1.2 ± 0.1       |
| [N ii]       | 6581           | 1          | 0.00         | 0.01         | 8.93        | 2.68            | 3.25 ± 0.27   | 0.8 ± 0.1       |
| [S ii]       | 6724           | 1          | 0.00         | 0.00         | 4.85        | 1.45            | 1.58 ± 0.09   | 0.9 ± 0.1       |
| [S iii]      | 9532           | 0          | 0.08         | 0.13         | 1.81        | 0.61            | 1.85 ± 0.13   | 0.3 ± 0.0       |

**Table 8**

Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (−0.33 W, r, o.3)

**Notes.**

a) 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.
b) High-U model. Boundary: m; log_{10}(U) = −0.46; log_{10}(N_{H}) = 3.50 cm⁻²; cloud log_{10}(N_{e}) = 22.5 cm⁻²; fractional contribution = 0.40.c) Medium-U model. Boundary: m; log_{10}(U) = −1.46; log_{10}(N_{H}) = 4.50 cm⁻²; cloud log_{10}(N_{e}) = 20.5 cm⁻²; fractional contribution = 0.30.d) Low-U model. Boundary: m; log_{10}(U) = −2.98; log_{10}(N_{H}) = 3.25 cm⁻²; cloud log_{10}(N_{e}) = 22.0 cm⁻²; fractional contribution = 0.30; screen log_{10}(N_{e}) = 21.6 cm⁻².e) We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with E(B − V) = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to E(B − V) = 0.21. See Paper I for details.
f) Logarithm of model Hβ flux. Units: log_{10}(erg s⁻¹ cm⁻²).
g) Observed Hβ flux. Units: 10⁻¹⁵ erg s⁻¹ cm⁻².
Table 9

Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (~0.75W, b, 0.2)

| Line      | Wavelength (Å) | Line match | High-U model | Med.-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|-----------|----------------|------------|--------------|--------------|-------------|-----------------|---------------|-----------------|
| Lyα       | 1216           | 1          | 25.48        | 13.99        | 11.42       | 17.81           | 14.08 ± 8.35  | 1.3 ± 0.8       |
| N v       | 1240           | 1          | 6.2          | 0.06         | 0.03        | 0.27            | 0.49 ± 0.32   | 0.6 ± 0.4       |
| C IV      | 1549           | 1          | 8.57         | 1.41         | 3.34        | 4.85            | 2.68 ± 0.96   | 1.8 ± 0.6       |
| C III     | 1909           | 0          | 0.76         | 1.87         | 0.15        | 0.91            | 2.45 ± 1.03   | 0.4 ± 0.2       |
| C IV      | 2326           | 1          | 0.00         | 0.05         | 1.21        | 0.38            | 0.69 ± 0.26   | 0.5 ± 0.2       |
| [Ne iv]   | 2424           | 1          | 0.54         | 0.26         | 0.00        | 0.29            | 0.50 ± 0.18   | 0.6 ± 0.2       |
| Mg II     | 2798           | 1          | 0.03         | 0.15         | 2.61        | 0.84            | 1.07 ± 0.27   | 0.8 ± 0.2       |
| [Ne v]    | 3426           | 1          | 0.99         | 0.09         | 0.00        | 0.42            | 0.66 ± 0.18   | 0.6 ± 0.2       |
| [O III]   | 3727           | 1          | 0.03         | 0.05         | 6.19        | 1.89            | 2.08 ± 0.55   | 0.9 ± 0.2       |
| [Ne iii]  | 3869           | 1          | 1.36         | 1.78         | 0.82        | 1.33            | 1.17 ± 0.30   | 1.1 ± 0.3       |
| [S ii]    | 4074           | 1          | 0.00         | 0.01         | 0.35        | 0.11            | 0.10 ± 0.03   | 1.1 ± 0.3       |
| [O II]    | 4363           | 1          | 0.27         | 0.24         | 0.00        | 0.18            | 0.26 ± 0.07   | 0.7 ± 0.2       |
| He I      | 4686           | 1          | 0.24         | 0.20         | 0.01        | 0.16            | 0.15 ± 0.04   | 1.1 ± 0.3       |
| [O III]   | 5007           | 1          | 21.48        | 19.58        | 0.06        | 14.48           | 13.45 ± 2.90  | 1.1 ± 0.2       |
| [Fe v]    | 6087           | 1          | 0.15         | 0.03         | 0.00        | 0.07            | 0.12 ± 0.16   | 0.6 ± 0.8       |
| [O i]     | 6300           | 1          | 0.00         | 0.00         | 2.72        | 0.82            | 0.63 ± 0.12   | 1.3 ± 0.2       |
| Hα        | 6563           | 1          | 2.86         | 2.81         | 2.95        | 2.87            | 2.63 ± 0.52   | 1.1 ± 0.2       |
| [N ii]    | 6584           | 1          | 0.00         | 0.05         | 8.66        | 2.61            | 4.75 ± 0.94   | 0.6 ± 0.1       |
| [S ii]    | 6724           | 1          | 0.00         | 0.01         | 5.23        | 1.57            | 0.93 ± 0.14   | 1.7 ± 0.3       |
| [S iii]   | 9532           | 1          | 0.03         | 0.68         | 1.78        | 0.75            | 1.12 ± 0.19   | 0.7 ± 0.1       |
| f_{model} | 4861           | ...        | 0.03         | 0.05         | -0.83       | -0.09           | ...           | ...             |
| f_{data}  | 4861           | ...        | ...          | ...          | ...         | ...             | 9.03 ± 1.41   | ...             |

Notes.

a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.
b High-U model. Boundary: m; log_{10}(U) = -0.92; log_{10}([N ii]) = 21.5 cm⁻²; fractional contribution = 0.40.
c Medium-U model. Boundary: m; log_{10}(U) = -1.92; log_{10}([N ii]) = 44.6 cm⁻²; cloud log_{10}(N_e) = 20.5 cm⁻²; fractional contribution = 0.30.
d Low-U model. Boundary: m; log_{10}(U) = -3.04; log_{10}([N ii]) = 28.5 cm⁻²; cloud log_{10}([N ii]) = 22.0 cm⁻²; fractional contribution = 0.30; screen log_{10}(N_e) = 21.6 cm⁻².
e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with E(B - V) = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to E(B - V) = 0.15. See Paper I for details.
f Logarithm of model Hβ flux. Units: log_{10}(erg s⁻¹ cm⁻²).
g Observed Hβ flux. Units: 10⁻¹⁵ erg s⁻¹ cm⁻².
Table 10
Line Ratios (Relative to H\(\beta\)) from Model Components, Composite, and Observations for Position (−0.5W, r, 0.2)

| Line     | Wavelength (\(\AA\)) | Line match\(^a\) | High-U model\(^b\) | Med.-U model\(^c\) | Low-U model\(^d\) | Composite model | Observed data\(^e\) | Model/data ratio |
|----------|-----------------------|------------------|--------------------|--------------------|--------------------|-----------------|---------------------|------------------|
| Ly\(\alpha\) | 1216                  | 1                | 24.30              | 24.06              | 7.18               | 19.09           | 21.30 ± 2.18       | 0.9 ± 0.1        |
| N \(\text{v}\) | 1240                  | 1                | 2.12               | 0.25               | 0.08               | 0.95            | 1.05 ± 0.11        | 0.9 ± 0.1        |
| C \(\text{v}\) | 1549                  | 1                | 12.76              | 5.30               | 2.35               | 7.40            | 7.42 ± 0.52        | 1.0 ± 0.1        |
| C \(\text{iii}\) | 1909                  | 1                | 0.30               | 0.06               | 0.22               | 1.41            | 1.85 ± 0.13        | 0.8 ± 0.1        |
| C \(\text{iv}\) | 2326                  | 1                | 0.00               | 0.07               | 1.41               | 0.44            | 0.57 ± 0.04        | 0.8 ± 0.1        |
| [Ne iv]   | 2424                  | 1                | 0.54               | 0.99               | 0.00               | 0.51            | 0.91 ± 0.06        | 0.6 ± 0.0        |
| Mg \(\text{ii}\) | 2798                  | 1                | 0.02               | 0.15               | 2.40               | 0.77            | 0.48 ± 0.04        | 1.6 ± 0.1        |
| [Ne \(\text{v}\)] | 3426                  | 1                | 1.64               | 0.39               | 0.00               | 0.77            | 1.04 ± 0.05        | 0.7 ± 0.0        |
| [O \(\text{iii}\)] | 3727                  | 1                | 0.02               | 0.06               | 8.24               | 2.50            | 1.64 ± 0.08        | 1.5 ± 0.1        |
| [Ne \(\text{iii}\)] | 3869                  | 1                | 1.30               | 2.29               | 0.87               | 1.47            | 1.47 ± 0.07        | 1.0 ± 0.0        |
| [S \(\text{ii}\)] | 3974                  | 1                | 0.00               | 0.01               | 0.33               | 0.10            | 0.19 ± 0.01        | 0.5 ± 0.0        |
| [O \(\text{ii}\)] | 4363                  | 1                | 0.30               | 0.45               | 0.00               | 0.26            | 0.20 ± 0.02        | 1.3 ± 0.1        |
| He \(\text{ii}\) | 4686                  | 1                | 0.31               | 0.59               | 0.01               | 0.30            | 0.29 ± 0.01        | 1.0 ± 0.0        |
| [O \(\text{iii}\)] | 5007                  | 1                | 19.71              | 25.10              | 0.12               | 15.45           | 15.69 ± 0.59       | 1.0 ± 0.0        |
| [Fe \(\text{viii}\)] | 6087                  | 1                | 0.10               | 0.11               | 0.00               | 0.07            | 0.10 ± 0.01        | 0.7 ± 0.1        |
| [O \(\text{i}\)] | 6300                  | 1                | 0.00               | 0.00               | 2.43               | 0.73            | 0.57 ± 0.02        | 1.3 ± 0.0        |
| H\(\alpha\) | 6563                  | 1                | 2.80               | 2.78               | 2.97               | 2.84            | 2.30 ± 0.20        | 1.2 ± 0.1        |
| [N \(\text{ii}\)] | 6584                  | 1                | 0.00               | 0.05               | 8.53               | 2.57            | 2.44 ± 0.08        | 1.1 ± 0.0        |
| [S \(\text{ii}\)] | 6724                  | 1                | 0.00               | 0.01               | 5.34               | 1.60            | 1.16 ± 0.03        | 1.4 ± 0.0        |
| [S \(\text{iii}\)] | 9532                  | 1                | 0.00               | 0.60               | 1.74               | 0.70            | 1.24 ± 0.04        | 0.6 ± 0.0        |
| \(f_{\text{model}}\) \(H\beta\) | 4861                  | ...              | −0.13              | −0.60              | −0.71              | −0.37           | ...                | ...             |
| \(f_{\text{data}}\) \(H\beta\) | 4861                  | ...              | ...                | ...                | ...                | 20.81 ± 0.57     | ...                | ...             |

Notes.

\(^a\) 1 = Model and data line ratios relative to H\(\beta\) match within a factor of 2; 0 = no match.
\(^b\) High-U model. Boundary: \(m; \log_{10}(U) = −0.38; \log_{10}(N_U) = 2.86 \text{ cm}^{-2}\); cloud \(\log_{10}(N_{\text{c}}) = 22.0 \text{ cm}^{-2}\); fractional contribution = 0.40.
\(^c\) Medium-U model. Boundary: \(m; \log_{10}(U) = −1.88; \log_{10}(N_U) = 4.36 \text{ cm}^{-2}\); cloud \(\log_{10}(N_{\text{c}}) = 20.0 \text{ cm}^{-2}\); fractional contribution = 0.30.
\(^d\) Low-U model. Boundary: \(m; \log_{10}(U) = −2.78; \log_{10}(N_U) = 2.50 \text{ cm}^{-2}\); cloud \(\log_{10}(N_{\text{c}}) = 22.5 \text{ cm}^{-2}\); fractional contribution = 0.30; screen \(\log_{10}(N_{\text{s}}) = 21.6 \text{ cm}^{-2}\).
\(^e\) We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with \(E(B − V) = 0.19\). We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to \(E(B − V) = 0.16\). See Paper I for details.
\(^f\) Logarithm of model H\(\beta\) flux. Units: \(\log_{10}(\text{erg s}^{-1} \text{ cm}^{-2})\).
\(^g\) Observed H\(\beta\) flux. Units: \(10^{-15} \text{ erg s}^{-1} \text{ cm}^{-2}\).

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Table 11
Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (−0.7W, r, 0.3)

| Line         | Wavelength (Å) | Line match | High-U model | Med.-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|--------------|----------------|------------|--------------|--------------|-------------|-----------------|---------------|------------------|
| (1)          | (2)            | (3)        | (4)          | (5)          | (6)         | (7)             | (8)           | (9)              |
| Lyα          | 1216           | 1          | 24.38        | 5.26         | 11.76       | 11.36           | 20.81 ± 1.48  | 0.5 ± 0.0        |
| N v          | 1240           | 1          | 3.27         | 0.16         | 0.07        | 0.75            | 0.98 ± 0.42   | 0.8 ± 0.3        |
| C iv         | 1549           | 1          | 20.71        | 2.80         | 3.54        | 6.64            | 5.04 ± 0.30   | 1.3 ± 0.1        |
| C ii         | 1909           | 0          | 0.55         | 1.77         | 0.22        | 0.98            | 2.09 ± 0.14   | 0.5 ± 0.0        |
| C i          | 2326           | 1          | 0.00         | 0.02         | 1.46        | 0.52            | 0.62 ± 0.03   | 0.8 ± 0.0        |
| [Ne iv]      | 2424           | 1          | 0.94         | 0.57         | 0.00        | 0.45            | 0.78 ± 0.08   | 0.6 ± 0.1        |
| Mg ii        | 2798           | 1          | 0.04         | 0.09         | 2.69        | 0.99            | 0.90 ± 0.04   | 1.1 ± 0.0        |
| [Ne v]       | 3426           | 1          | 2.80         | 0.43         | 0.00        | 0.75            | 0.76 ± 0.03   | 1.0 ± 0.0        |
| [O ii]       | 3727           | 1          | 0.02         | 0.08         | 8.46        | 3.00            | 1.72 ± 0.06   | 1.7 ± 0.1        |
| [Ne iii]     | 3869           | 1          | 1.46         | 1.99         | 0.94        | 1.52            | 1.43 ± 0.08   | 1.1 ± 0.1        |
| [S iii]      | 4074           | 1          | 0.00         | 0.00         | 0.32        | 0.11            | 0.20 ± 0.02   | 0.6 ± 0.1        |
| [O iii]      | 4363           | 1          | 0.43         | 0.31         | 0.00        | 0.22            | 0.20 ± 0.02   | 1.1 ± 0.1        |
| He ii        | 4686           | 1          | 0.51         | 0.21         | 0.01        | 0.20            | 0.24 ± 0.01   | 0.8 ± 0.0        |
| [O ii]       | 5007           | 1          | 21.66        | 22.82        | 0.10        | 14.64           | 14.37 ± 0.56  | 1.0 ± 0.0        |
| [Fe v]       | 6087           | 1          | 0.14         | 0.08         | 0.00        | 0.06            | 0.08 ± 0.01   | 0.8 ± 0.1        |
| [O i]        | 6300           | 1          | 0.00         | 0.00         | 2.53        | 0.89            | 0.52 ± 0.02   | 1.7 ± 0.1        |
| Hα           | 6563           | 1          | 2.74         | 2.83         | 2.93        | 2.85            | 3.12 ± 0.10   | 0.9 ± 0.0        |
| [N ii]       | 6584           | 1          | 0.00         | 0.02         | 8.51        | 2.99            | 2.59 ± 0.11   | 1.2 ± 0.1        |
| [S ii]       | 6724           | 1          | 0.00         | 0.00         | 4.97        | 1.74            | 0.95 ± 0.02   | 1.8 ± 0.0        |
| [S iii]      | 9532           | 1          | 0.00         | 0.25         | 1.83        | 0.75            | 1.22 ± 0.04   | 0.6 ± 0.0        |
| f model, f   | 4861           | ...        | −0.73        | −0.37        | −1.29       | −0.61           | ...           | ...              |
| f data, f    | 4861           | ...        | ...          | ...          | ...         | 30.28 ± 0.69    | ...            | ...              |

Notes.

a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.
b High-U model. Boundary: m; log10(U) = −0.45; log10(nH) = 2.57 cm−3; cloud log10(N/L) = 21.8 cm−2; fractional contribution = 0.20.
c Medium-U model. Boundary: m; log10(U) = −1.45; log10(nH) = 3.57 cm−3; cloud log10(N/L) = 21.0 cm−2; fractional contribution = 0.45.
d Low-U model. Boundary: m; log10(U) = −2.90; log10(nH) = 2.25 cm−3; cloud log10(N/L) = 22.0 cm−2; fractional contribution = 0.35; screen log10(N/L) = 21.6 cm−2.
e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with E(B − V) = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to E(B − V) = 0.14. See Paper I for details.
f Logarithm of model Hβ flux. Units: log10(erg s−1 cm−2).
g Observed Hβ flux. Units: 10−15 erg s−1 cm−2.
Table 12
Line Ratios (Relative to Hβ) from Model Components, Composite, and Observations for Position (−1°0W, r, 0°3)

| Line       | Wavelength (Å) | Line match | High-U model | Med.-U model | Low-U model | Composite model | Observed data | Model/data ratio |
|------------|---------------|------------|--------------|--------------|-------------|-----------------|---------------|-----------------|
| Lyα        | 1216          | 0          | 32.25        | 12.53        | 24.86       | 19.43           | 42.54 ± 13.18 | 0.5 ± 0.2       |
| N v        | 1240          | 1          | 7.59         | 0.18         | 0.08        | 0.88            | 0.86 ± 0.28   | 1.0 ± 0.3       |
| C iv       | 1549          | 1          | 14.05        | 3.63         | 6.08        | 5.65            | 5.32 ± 1.00   | 1.1 ± 0.2       |
| C iii      | 1909          | 0          | 0.09         | 2.57         | 0.30        | 1.41            | 4.74 ± 6.71   | 0.3 ± 0.4       |
| C iv       | 2326          | 0          | 0.00         | 0.03         | 1.53        | 0.63            | 1.66 ± 2.11   | 0.4 ± 0.5       |
| [Ne iv]    | 2424          | 1          | 0.17         | 0.77         | 0.00        | 0.40            | 0.76 ± 0.19   | 0.5 ± 0.1       |
| Mg ii      | 2798          | 1          | 0.00         | 0.10         | 2.80        | 1.17            | 1.91 ± 0.24   | 0.6 ± 0.1       |
| [Ne v]     | 3426          | 1          | 2.89         | 0.41         | 0.00        | 0.49            | 0.53 ± 0.08   | 0.9 ± 0.1       |
| [O ii]     | 3727          | 1          | 0.00         | 0.11         | 8.98        | 3.65            | 4.05 ± 0.57   | 0.9 ± 0.1       |
| [Ne iii]   | 3869          | 1          | 0.00         | 2.07         | 0.96        | 1.42            | 1.36 ± 0.19   | 1.0 ± 0.1       |
| [S ii]     | 4074          | 1          | 0.00         | 0.00         | 0.26        | 0.10            | 0.07 ± 0.04   | 1.4 ± 0.8       |
| [O iii]    | 4363          | 1          | 0.00         | 0.35         | 0.00        | 0.18            | 0.18 ± 0.04   | 1.0 ± 0.2       |
| He ii      | 4686          | 1          | 0.90         | 0.38         | 0.01        | 0.29            | 0.25 ± 0.03   | 1.1 ± 0.1       |
| [O iii]    | 5007          | 1          | 0.03         | 23.98        | 0.12        | 12.04           | 12.26 ± 1.41  | 1.0 ± 0.1       |
| [Fe v]     | 6087          | 0          | 0.00         | 0.11         | 0.00        | 0.05            | ...           | ...             |
| [O i]      | 6300          | 1          | 0.00         | 0.00         | 2.24        | 0.90            | 0.77 ± 0.08   | 1.2 ± 0.1       |
| Hα         | 6536          | 1          | 2.60         | 2.81         | 2.90        | 2.82            | 3.52 ± 0.36   | 0.8 ± 0.1       |
| [N ii]     | 6584          | 1          | 0.00         | 0.03         | 7.54        | 3.03            | 4.27 ± 0.44   | 0.7 ± 0.1       |
| [S ii]     | 6724          | 1          | 0.00         | 0.01         | 3.65        | 1.46            | 2.03 ± 0.15   | 0.7 ± 0.1       |
| [S iii]    | 9532          | 1          | 0.00         | 0.32         | 1.83        | 0.90            | 1.28 ± 0.12   | 0.7 ± 0.1       |
| f_Hβ       | 4861          | ...        | −2.05        | −0.95        | −1.83       | −1.20           | ...           | ...             |
| f_data     | 4861          | ...        | ...          | ...          | ...         | 4.55 ± 0.38     | ...           | ...             |

Notes.

a 1 = Model and data line ratios relative to Hβ match within a factor of 2; 0 = no match.

b High-U model. Boundary: m; log10(U) = −0.24; log10(mH) = 2.08 cm−3; cloud log10(Nc) = 21.0 cm−2; fractional contribution = 0.10.

c Medium-U model. Boundary: m; log10(U) = −1.66; log10(mH) = 3.50 cm−3; cloud log10(Nc) = 20.5 cm−2; fractional contribution = 0.50.

d Low-U model. Boundary: m; log10(U) = −2.93; log10(mH) = 2.00 cm−3; cloud log10(Nc) = 21.5 cm−2; fractional contribution = 0.40; screen log10(Nc) = 21.6 cm−2.

e We corrected all observed fluxes for Galactic extinction using the Savage & Mathis (1979) extinction curve with E(B − V) = 0.19. We applied an additional correction for Markarian 3 internal extinction using the LMC curve of Koornneef & Code (1981). For this measurement bin, the internal extinction correction corresponded to E(B − V) = 0.12. See Paper I for details.

f Logarithm of model Hβ flux. Units: log10(erg s−1 cm−2).

g Observed Hβ flux. Units: 10−15 erg s−1 cm−2.
| Bin       | Model | Bound | U    | Hβ flux (erg s⁻¹ cm⁻²) | Emitting area (pc²) | Component depth (pc) | Bin depth (pc) | Component height (pc) | Bin height (pc) | Filling factor | T_avg (K) |
|-----------|-------|-------|------|------------------------|---------------------|----------------------|-------------------|----------------------|----------------|--------------|-----------|
| (0.5'E, 0.3) | high m | 10⁻⁰.⁰² | 2.23 × 10⁻⁰⁰ | 211 | 8 | 26 | 19 | 79 | 10⁻¹.₁₂ | 17000 |
|           | med. m | 10⁻².²³ | 6.06 × 10⁻⁰¹ | 777 | 29 | 26 | < 1 | 79 | 10⁻⁵.⁰⁰ | 12000 |
|           | low m | 10⁻².⁶⁹ | 3.63 × 10⁻⁰¹ | 1111 | 42 | 42 | 15 | 79 | 10⁻⁰.⁷¹ | 9000 |
| (0.3'E, b, 0.3) | high m | 10⁻⁰.⁴⁵ | 3.33 × 10⁻⁰⁰ | 44 | 1 | 14 | 1 | 66 | 10⁻².⁷⁰ | 16000 |
|           | med. i | 10⁻¹.⁹⁵ | 1.04 × 10⁻⁰¹ | 25 | 0 | 14 | < 1 | 66 | 10⁻⁵.⁴⁵ | 12000 |
|           | low m | 10⁻³.⁰⁹ | 2.28 × 10⁻⁰¹ | 777 | 29 | 25 | 2 | 66 | 10⁻¹.³⁸ | 8000 |
| (0.3'E, r, 0.3) | high m | 10⁻⁰.⁸⁹ | 3.43 × 10⁻⁰⁰ | 74 | 2 | 12 | < 1 | 66 | 10⁻³.⁴² | 15000 |
|           | med. i | 10⁻².³⁹ | 1.43 × 10⁻⁰¹ | 32 | 1 | 12 | < 1 | 66 | 10⁻⁶.⁰⁹ | 9000 |
|           | low m | 10⁻².₈³ | 2.91 × 10⁻²⁰ | 1055 | 40 | 20 | 3 | 66 | 10⁻⁰.⁹⁹ | 9000 |
| (0.⁰'E, b, 0.3) | high m | 10⁻⁰.⁷₅ | 1.10 × 10⁻⁰² | 4 | 0 | 4 | < 1 | 66 | 10⁻⁴.⁶⁴ | 16000 |
|           | med. m | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . | . . . |
|           | low m | 10⁻².₅₂ | 1.₈₀ × 10⁻⁰¹ | 11 | 0 | 6 | 3 | 66 | 10⁻².⁴₆ | 11000 |
| (0.⁰W, r, 0.³) | high m | 10⁻⁰.₆₀ | 1.₇₉ × 10⁻⁰¹ | 13 | 0 | 4 | < 1 | 66 | 10⁻⁴.₄⁹ | 18000 |
|           | med. i | 10⁻⁰.₇₅ | 4.₄₇ × 10⁻⁰¹ | 13 | 0 | 4 | < 1 | 66 | 10⁻³.₈₄ | 15000 |
|           | low m | 10⁻².₇₇ | 2.₉₃ × 10⁻⁰¹ | 12 | 0 | 6 | 6 | 66 | 10⁻².₁₇ | 9000 |
| (0.₃⁰W, b, 0.₃) | high m | 10⁻⁰.₇₄ | 8.₇₅ × 10⁻⁰⁰ | 18 | 0 | 12 | < 1 | 66 | 10⁻₃.₃₇ | 15000 |
|           | med. m | 10⁻¹.₇₄ | 6.₉₇ × 10⁻⁰¹ | 177 | 6 | 12 | < 1 | 66 | 10⁻₅.₄₀ | 16000 |
|           | low m | 10⁻².₉₅ | 9.₃₀ × 10⁻⁰¹ | 133 | 5 | 20 | 5 | 66 | 10⁻₁.₇₁ | 8000 |
| (0.₃⁰W, r, 0.₃) | high m | 10⁻⁰.₄₆ | 1.₁₉ × 10⁻⁰¹ | 16 | 0 | 14 | 3 | 66 | 10⁻₂.₆₄ | 1₈000 |
|           | med. m | 10⁻¹.₄₆ | 9.₆₀ × 10⁻⁰¹ | 155 | 5 | 1₄ | < 1 | 66 | 10⁻₄.₆₇ | 1₆000 |
|           | low m | 10⁻².₉₈ | 4.₄₈ × 10⁻⁰¹ | 33₃ | 1₂ | 2₅ | 2 | 66 | 10⁻₁.₈₄ | 9000 |
| (0.₅⁰W, b, 0.₂) | high m | 10⁻⁰.₹₂ | 1.₄₀ × 10⁻⁰⁰ | 1₂₂ | 4 | 2₄ | < 1 | 5₃ | 10⁻₂.₈₆ | 1₄₀₀₀ |
|           | med. m | 10⁻₁.₉₂ | 1.₁₂ × 10⁻⁰⁰ | ₈₅ | 3 | 2₄ | < 1 | ₅₃ | 10⁻₅.₀₂ | 1₃₀₀₀ |
|           | low m | 10⁻₃.₀₄ | 1.₄₈ × 10⁻₀₁ | ₆₄₄ | 2₄ | 3₈ | ₅ | ₅₃ | 10⁻₁.₂₄ | ₈₀₀₀ |
| (0.₅⁰W, r, 0.₂) | high m | 10⁻₀.₃₈ | 7.₅₆ × 10⁻₀₁ | ₃₈₈ | ₁₄ | 2₇ | ₅ | ₅₃ | 10⁻₁.₃₁ | ₁₇₀₀₀ |
|           | med. m | 10⁻₁.₈₈ | 2.₄₈ × 10⁻₀¹ | ₈₈₈ | ₃₄ | ₂₇ | < ₁ | ₅₃ | 10⁻₄.₄₆ | ₁₄₀₀₀ |
|           | low m | 10⁻₂.₇₈ | ₁.₉₈ × 10⁻₀¹ | ₁₁₁₁ | ₄₂ | ₄₇ | ₃₃ | ₅₃ | 10⁻₀.₂₅ | ₉₀₀₀ |
| (0.₇₇W, r, 0.₃) | high m | 10⁻₀.₄₅ | ₁.₉₂ × 10⁻₀¹ | ₁₁₁₁ | ₄₂ | ₄₁ | ₆ | ₇₉ | 10⁻₁.₃₃ | ₁₇₀₀₀ |
|           | med. m | 10⁻₁.₄₅ | ₄.₃₃ × 10⁻₀¹ | ₁₁₁₁ | ₄₂ | ₄₁ | < ₁ | ₇₉ | 10⁻₂.₉₃ | ₁₄₀₀₀ |
|           | low m | 10⁻₂.₉₀ | ₅.₁₀ × 10⁻₀₂ | ₇₃₃₃ | ₂₈₂ | ₇₂ | ₁₉ | ₇₉ | 10⁻₀.₆₄ | ₉₀₀₀ |
| (1)⁰W, b, 0.₃) | high m | 10⁻₀.₂₄ | ₉.₀₄ × 10⁻₀₃ | ₁₇₇₇ | ₆₈ | ₅₆ | ₃ | ₆₆ | 10⁻₁.₂₉ | ₂₆₀₀₀ |
|           | med. m | 10⁻₁.₆₆ | ₁.₁₃ × 10⁻₀¹ | ₇₁₁ | ₂₇ | ₅₆ | < ₁ | ₆₆ | 10⁻₃.₆₁ | ₁₃₀₀₀ |
|           | low m | 10⁻₂.₉₃ | ₁.₄₈ × 10⁻₀₂ | ₄₃₃₃ | ₁₆₆ | ₉₉ | ₁₁ | ₆₆ | 10⁻₀.₅₈ | ₁₀₀₀₀ |

Note.

*“m” indicates that the model cloud is matter bounded and “i” indicates that it is ionization bounded.*
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