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IUE SPECTRA OF THE SEYFERT 1 GALAXIES Mrk 335 and NGC 4051

SIEK HYUNG[1], HYOUK KIM[1], WOO BAIK LEE[1], SEONG-JAE LEE[2], DONGSU RYU[2], AND HEE-WON LEE[3]
[1]Korea Astronomy Observatory, Whaam-dong Yusong-gu, Taejon 305-348, S. Korea
[2]Dept. of Astronomy and Space Sci, Chungnam National University
[3]Dept. of Astronomy and Space Sci, Yonsei University
E-mail: hyung@kao.re.kr
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ABSTRACT

The international ultraviolet explorer (IUE) spectra of a low dispersion ~6 Å, have been investigated for two Seyfert 1 galaxies, Mrk 335 and NGC 4051, well known for the line variability. The electron densities of broad line region (BLR) of these variable Seyfert 1 galaxies have been derived, which showed a non-linear abrupt variation from 10^8 to 10^{10} cm^{-3} within a month. We also found the excitation (or temperature) changes in the Mrk 335 BLR from the IUE broad line profiles analysis, but no such evidence in the NGC 4051. The large amount of mass inflow activity through the bar or spiral structure of host galaxies, may trigger the density change in BLR and emission line variability for both objects. Mass of the giant black holes appear to be order of 10^7 $M_\odot$ for both variable Seyfert 1's.

Key words : galaxy nucleus : Seyfert 1 – line profiles : IUE spectrum : individual (Mrk 335, NGC 4051)

I. INTRODUCTION

Seyfert 1 galaxies are those with very broad H I, He I, and He II emission lines with FWHM of order 1 to 5 $\times 10^3$ km s^{-1}, whereas the forbidden lines have FWHMs of order 500 km s^{-1}. The electron number densities of BLR are known to be higher – to explain the observed emission line spectra, a model usually requires the high electron densities $N_e \sim 10^9 - 10^{10}$ cm^{-3} and the column densities, $N_H \sim 10^{22} - 10^{23}$ cm^{-2}. The absence of strong broad forbidden emission line indicates that high densities, as well. Using the IUE archival data, one may be able to find the electron density of BLR, quantitatively, using the plasma diagnostic line ratios, similarly done for the symbiotics or Galactic planetary nebulae (Hyung 1994; Hyung and Aller 1996).

Variability monitoring programs with the UV and optical spectra have been intensively under way for a number of AGNs including Mrk 335 and NGC 4051 over nearly two decades. The light curves of the continuum and line emission obtained such a monitoring program show outbursts separated by local minima, while the emission-line responses are slightly delayed. These are now known as a light-travel time effect in the stratificational BLR. Peterson et al. (1985) were the first to point out that the size of the BLR can be predicted by accounting this discrepancy with the help of the photoionization models – see Peterson (1993) for the 'reverberation mapping' or cross-correlation analysis of line and continuum variability.

In spite of numerous studies observationally or theoretically, there appears to be no simple way of finding the number densities in the BLR, which are too large to make use of the relatively simple diagnostics in the high density regime. In this investigation, we use the C III]1909/Si III] 1892 ratio as a density discriminant in BLR, originally proposed by Feibelman (1983) for Symbiotics. Examination of many available archival IUE data confirms that this ratio can become a valid tool to find the density.

Meaningful measurements of the line intensities can be obtained from the IUE spectra, since IUE observations would produce a homogeneous volume of data, which would be useful for the variability detection. We limit our investigation only for these low dispersion IUE short, long wavelength prime (SWP, LWP) spectra. In this study, we have chosen two variable Seyfert 1 galaxies, Mrk 335 and NGC 4051, hoping that time sequence IUE observation of emission lines may give us a hint of the spatial and velocity structure of the BLR. We also measure the spectrum of other non-variable Seyfert 1 galaxies, chosen from the HST snapshot survey by Malkan et al. (1998, MGT hereafter). Among the MGT list objects, only 29 Seyfert 1 galaxies were also observed with the IUE. Since the quality of IUE data were not good enough for our investigation, we investigate the physical condition of Seyfert core, based on the broad emission lines only for 29 Seyfert 1 galaxies.

II. IUE SPECTRUM OF SEYFERT 1 GALAXIES

The physical scale of BLRs in Seyferts are very small – less than 0.1″ even for nearby Seyfert galaxies, unresolved even with HST (see Fig. 1). The only way to confirm its existence to detect broad line. From the diagnostic lines available from the IUE line measurements, we would hopefully be able to derive the physical condition, temperature and density of BLRs.

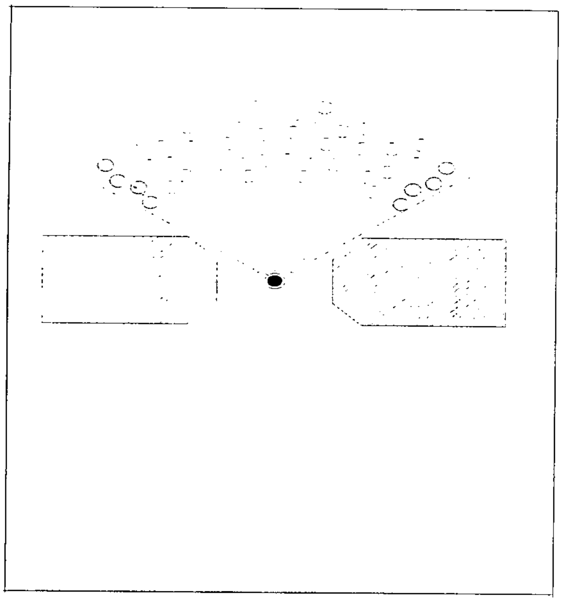

Fig. 1.—Schematic diagram of AGN. Shaded two boxes represent the torus and a small black dot at the center corresponds to the inhomogeneous BLR (~0.1 pc), while small circles above the torus represent NLR of ~100 kpc.

We searched Seyfert 1 galaxies of which a fairly good quality IUE spectral images were available. For a large number of samples in MGT list, the IUE spectral data were not available or useless due to the IUE short exposure times: the exposures were not long enough to register the signal of the targets. Thus, unfortunately, the IUE images of many objects were too weakly observed even for strong emission lines C IV, C III]. On the other hand, we were able to measure the spectral fluxes with a reasonable signal to noise (S/N) ratio in many cases, though. However, it was necessary to separate the overlapped lines with a Starlink/Dipso package, correctly.

(a) Seyfert 1 Galaxies and Variability of BLR Region

For 29 Seyfert galaxies, for which the IUE data are available, we first checked whether the optical data are available from the literature, although the present investigation does not extend to the optical region spectroscopy. Thus, in Table 1, we list only 7 Seyfert 1 galaxies for which a fairly good sample of spectral data are available in both optical and IUE region. The consecutive columns list the name, redshift, interstellar extinction, E(B-V), and the optical spectral data literatures: Wilson and Nath (1990, w90); Cruz-Gonzalez et al. (1994, c94), Hien (1995, h95); Charles and Mark (1993, c95); and Sylvain et al. (1996, s97). The extinction, whether internal or external, are not large or apparently negligible.

The continuum and line shape and intensity variability of Seyfert 1 nuclei are well known in all observable

Table 1.—Seyfert 1 Galaxies (IUE available)

Seyfert 1's	z	E(B-V)	Optical Reference
Mrk 10	0.030	0.05	c95
Mrk 352	0.015	0.05	w90,c94,h95,c95,s97
NGC 1566	0.004	0.02	c95
NGC 5940	0.033	-	c95
NGC 7213	0.006	-	c95
Mrk 335	0.025	0.025	w90,c94*
NGC 4051	0.002	0.00	c95*

Column (4) indicates that the optical data are available. w90: Wilson and Nath (1990); c94: Cruz-Gonzalez et al. (1994); h95: Hien (1995); c95: Charles and Mark (1993); s97: Sylvain et al. (1996).
E(B-V): all values are from Zotti and Gaskell (1985).

wavelength regions, showing time scales from days in X-rays, to months at optical wavelengths. Time variation would provide a strong constraint for theoretical models of the BLR of Seyfert galaxies. The continuum and permitted broad emission lines of Seyfert 1 galaxies, NGC 3783, Mrk 335, Mrk 1330, and NGC 4051, are known to have variabilities. If the broad lines were produced by radially moving photoionized clouds, one would expect to see time variations in such a line propagate from one side of the line to the other.

Although the wavelength dispersion of IUE is 6 Å, (~1200 km s^{-1}), the spectrum of Seyfert 1 galaxies are broad enough to detect any change in H I, He I, and He II emission lines, due to the wide FWHM of order of 5000 km s^{-1}. Here, we chose only two objects, Mrk 335 and NGC 4051 for a detailed IUE spectral line variability study. For the whole 18 years of IUE observations, we found about 93 and 45 images available for Mrk 335 and NGC 4051, respectively. We used the flux calibrated IUE data, processed with the New Spectral Image Processing System (NEWSIPS).

Mrk 335: Quasar-like Seyfert?

Mrk 335 had been observed over the 13 years' IUE observations from 1978 to 1991. The observations, however, were not carried out every year during the 13 years' period. The IUE archival data of Mrk 335 show a number of useful emission lines, i.e. Lyα, C IV 1550, He II 1640, C III] 1909, and Mg II 2800. In Fig. 2, we present one IUE spectrum plot, SWP36928, observed on Sept. 2, 1989 to show its quality. The interstellar extinction has been applied using the value given in Table 1 and the radial velocity has been corrected according to its redshift. Various broad lines and relatively strong continuum are clearly shown in this figure.

High ionization lines, e.g. C IV 1549, may be formed within illuminated clouds surface, while other low ionization lines, Mg II, are formed 3 – 10 times farther out, i.e. extended partially ionized zone. Although we do not know the structure in details, the stratifica-

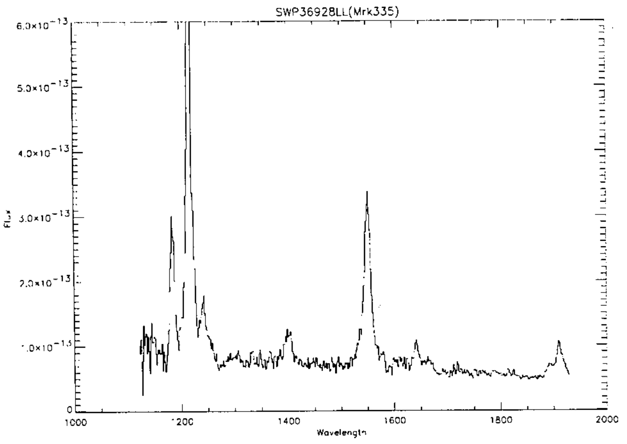

Fig. 2.—IUE Spectrum of the Seyfert 1 galaxy Mrk 335. SWP 36928 (80 min). Observation date is September 2, 1989. Radial velocity (z=0.025) has been corrected.

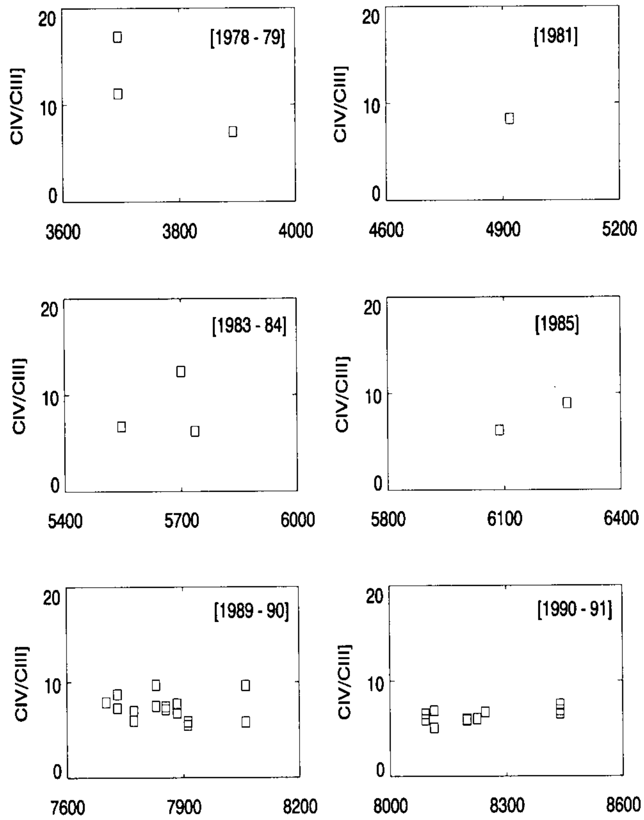

Fig. 3.— I(CIV)/I(C III]): flux ratios of the adjacent excitation lines in Mrk 335. The value (and accordingly excitation) varies in a range between 5 and 17. Each box represents one year period. Horizontal axis is Julian date (+2440000). The average value of around 7 suggests that Mrk 335 is a classical Seyfert 1 galaxy (error bar $\leq$ 0.5) - evidence for an excitation or temperature change.

tion effect may exist in BLR, and the various different kinds of line formation mechanism may contribute to the emission of the lines.

Comparison of two adjacent excitation lines would allow us to find the physical condition of the emission clouds or the BLR. Emission from lines of Lyα, C IV, and C III] arises from fully ionized gas inside the Stromgren sphere. The rise time of the C III] line were found to be longer than that of C IV, which has been believed to be due to a stratification in the BLR (i.e., C III] emitting region is further out from the center). The ratios of C III] 1908 and C IV 1549 relative to Lyα have been used to estimate the ionization parameter U = Φ/N_ec ($\sim$ 0.01), where Φ is the flux of ionizing photons per cm^2 per second incident on the cloud. C IV/Lyα and N V/Lyα increase with increasing U and there appears to be a linear relation of C IV/Lyα versus C IV/C III] (Mushotzky & Ferland 1984). We measure the time sequence variation of the C IV/C III] ratios, which might be used as an indicative of the ionization parameter. High redshift quasars are known to have a value of I(C IV)/I(C III]) $\sim$ 2, while classical Seyfert 1's I(C IV)/I(C III]) ratios are close to 5 (Wu, Boggess & Gull 1983). We obtained all of the line ratios whenever available. In Fig. 3, we plot the time sequence ratio changes. Each box represents one year period. The ratio varies from 5 to 17, which is indicative of the BLR activities. The ratios indicate that the core of Mrk 335 is not of a quasar.

We also measured the line ratios of Si III] 1892 to CIII] 1909, from which one can obtain the density information of the emission region (see the high density symbiotics by Feibelman and Aller 1987). Since these lines are overlapped due to a low dispersion characteristic of the IUE SWP, LWP spectra, we employ the Starlink/Dipso package to measure the line fluxes correctly, which minimize the measurement error. Fig. 4 shows an example of how we measured the line fluxes and as to how to separate Si III] from C III] using the Starlink/Dipso program. One can clearly separate each component, FWHM, intensity, central wavelength etc. Thus, we were able to find the density variability to a high degree of accuracy.

Fig. 5 shows a density variation of Mrk 335 BLR. Each box corresponds to one year period. There are about 35 density points in total. One can clearly see the density fluctuation from the emission of BLR in Mrk 335.

Sparsely sampled 1978–1985 points indicate the BLR densities are about $N_e \sim 10^{10}$ cm^{-3}, except for one point of $N_e \sim 10^8$ in 1984. This lower density point in 1984 seems real, though. There had been many observations in 1989–1991 (5th and 6th boxes). Numerous data points shown in the 5th and 6th boxes during the period of 1988–1991 indicate that two orders of density variation might occur within a month, i.e. $10^{10} - 10^{7.5}$ cm^{-3}. This short period variation indicates the size of BLR is 0.03 pc (0.1 light year) or less.

The variability is non-linear, so we cannot assign

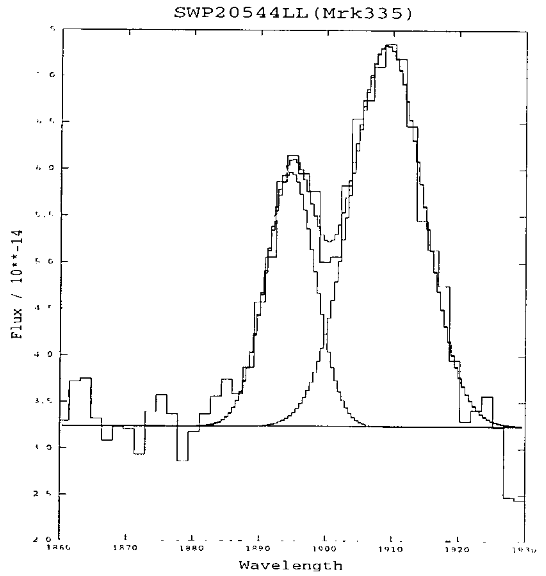

Fig. 4.— Si III] & C III] line profiles of Mrk 335. Two components are separated using the STARLINK/Dipso package. FWHMs are 8.80±0.97Å and 12.860±0.77Å and the fluxes are 2.56 and 5.60 $\times10^{-14}$ erg cm^{-2} Å^{-1} (±15%), respectively. This flux ratio would give the electron density (see text).

any period. It may be associated with variations of the accretion flow of matter onto the central black hole. Density variability in a large fraction of clouds may occur suddenly and sporadically. Although we do not know the structure of the BLR, the large number of clouds may be aligned in a torus. The clouds may form a transient structure if they are related to the accretion disc.

Since the power continuum energy source in Seyferts must be produced by accretion onto a massive black hole, gravitationally bound orbital motions of the BLR clouds might explain the broad emission lines. If gravity due to very large central mass is the only radial force to produce the observed line profiles, the velocities in BLR would be

$$u \simeq \left(\frac{GM_H}{R}\right)^{1/2} \simeq 350 M_7^{1/2} R_{18}^{-1/2} \text{km s}^{-1}$$

where M_7 in 10^7 M$_\odot$ and R_{18} in 10^{18} cm. Assuming u = 1900 km s^{-1} (12 Å from various IUE line profiles) and from the above derivation of BLR size, i.e., 0.03 pc. The size of the BLR, consistent with $R_{pc} = 0.1 L_{46}^{1/2}$ (Peterson 1993), can be found by reverberation mapping, more correctly. Arav et al (1997) derived L_{46} = 0.05, then the BLR size by reverberation mapping is 0.02 pc. We adopted 0.03 pc. Thus, we derived the super-massive black hole mass as 1.3 $\times10^7$ M$_\odot$. It should be noted that there is no evidence

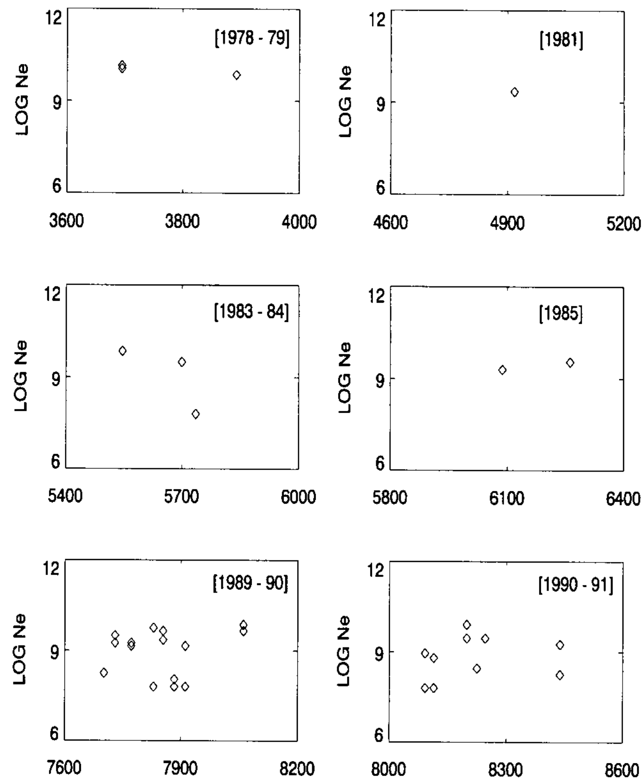

Fig. 5.— Density variation of Mrk 335. Each box represents one year period. Horizontal axis is Julian date (+2440000). The vertical axis is a logarithmic value of electron density (measurement error ±15%). 35 diagnostic points obtained from 13 years' IUE archive data.

of Keplerian motion of BLR, though, and our derivation, based on a very crude data analysis, would remain speculative till more detailed analyses of velocity dispersions of the various broadest lines are done.

NGC 4051: Variability

NGC 4051 is known as a highly variable, low-luminosity Seyfert 1 galaxy. The X-ray light curve of NGC 4051 by Uttley et al. (1999) over 2.5 years, showed a distinct variation in long-term average flux over time-scales ≥ months. Although the IUE observations were done sparsely, it would be important to derive the density and temperature fluctuation similarly as in Mrk 335.

In Fig. 6, we plot the combined IUE spectra of SWP 33513 (300 min) and LWP 09265 (133 min). This plot covers a full IUE wavelength range from 1200 Å to 3200 Å. The radial velocity has been corrected according to the appropriate redshift z-value. This IUE data show numerous useful lines, i.e. Lyα, C IV 1550, He II 1640, C III] 1909, and Mg II 2800. However, contrary to the relatively bright type 1 Seyfert galaxy Mrk 335, the spectral qualities are relatively poor. The S/N are good enough to measure the broad lines considered, though. Note that one cannot see the 2200 Å dip due to

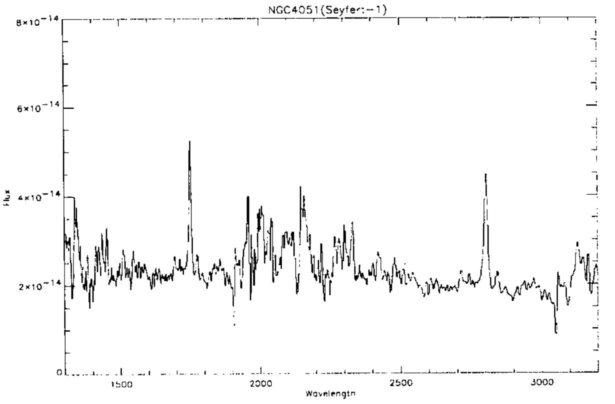

Fig. 6.—IUE spectrum of the Seyfert 1 galaxy NGC 4051. SWP 33531 (300 min) and LWP 09265 (133 min) are merged. Observation dates are May 5, 1988 and Nov. 22, 1990, respectively. E(B-V) and radial velocity (z=0.002) are applied to draw this plot.

the interstellar extinction, which would usually appear in the IUE observation of Galactic planetary nebulae. The dust extinction has not applied, since it appeared to be negligible.

As done for Mrk 335, we similarly measured the C IV/C III] line fluxes to find the ionization parameter indication. In Fig. 7, we plot the ratios of C IV/C III] for NGC 4051. Compare them with the Mrk 335 case! Note the ratios did not change very much over the long IUE observation period, which stays as the same as of about 2. This value is close to that of the distant classical quasar, implying that the BLR of NGC 4051 resembles the high redshift quasar. NGC 4051 may be closer to our Galaxy, while Mrk 335 or others in Table 1 are of classical Seyfert type. Can we find any variability in the Galaxy?

As in the case of Mrk 335, the electron number densities have been derived from two lines, i.e. Si III] 1892, and CIII] 1909, using the STARLINK/Dipso package. In Fig. 8, we present the density variation of NGC 4051 from 1978 to 1994. Most observations were sparsely carried out except for those in 1994. Especially, the 1994's data indicate the density variation also exists in the BLR of NGC 4051. The overall electron number density is close to 10^{10} cm^{-3}. Note that the variation period is relatively shorter than that of Mrk 335, about 10-15 days ($\sim$ 0.04 ly). Apparently the electron density of NGC 4051 BLR is slightly higher and the density fluctuation occurred within a shorter period in NGC 4051 than in Mrk 335. This might indicate that the variation of the BLR emission of NGC 4051 is more strongly related to a sudden mass flow activity through an accretion disc. The density variation may be closely related to the quasar-like core characteristic (see the CIV/C III] ratio in Fig. 7). In 1994, we see a large amount of density drop and recovery (6th box of Fig.

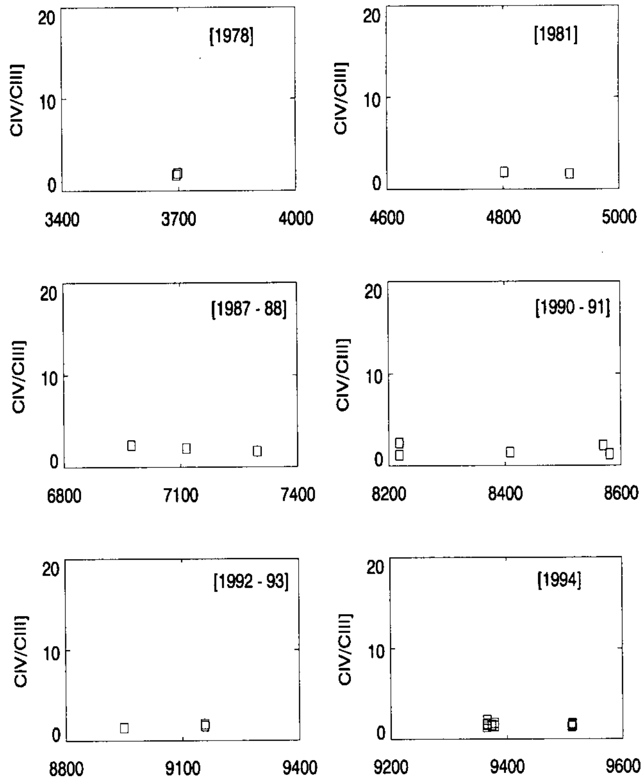

Fig. 7.— CIV / C III] Flux ratios in NGC 4051. Each box represents one year period. Horizontal axis is Julian date (+2440000). The ratios are around 2, which imply that NGC 4051 might have a quasar-like core. The excitation remains fairly constant (constant temperature?).

8) but no change at all in its excitation (6th box of Fig. 7).

The diameter of the entire broad line emitting region can be guessed from an observed line variability period. From the above density variation and a certain period, we found that the emission of BLR of NGC 4051 is to be confined within 0.015 pc (or 0.04 ly). Similarly as in Mrk 335, we are able to derive the super massive black hole mass as 9.5×10^6 $M_\odot$ (1600 km s^{-1}, 10 Å). The mass of the NGC 4051 central engine appears to be smaller than that of Mrk 335.

We also confirmed time variations of the C IV 1500 and Lyα profiles and intensities as well as Lyα to C IV ratio for both Mrk 335 and NGC 4051. Apparently, the circum-nuclear region of NGC 4051 is more compact but less active than that of Mrk 335. Thus, the temperature or excitation remains the same as in the BLR of NGC 4051.

The covering factor of the BLR clouds can be estimated by comparing the number of H-ionizing photons produced by the central continuum source to the Lyα photon number. This is a measure of the number of ionizing photons absorbed in the BLR. The typical value

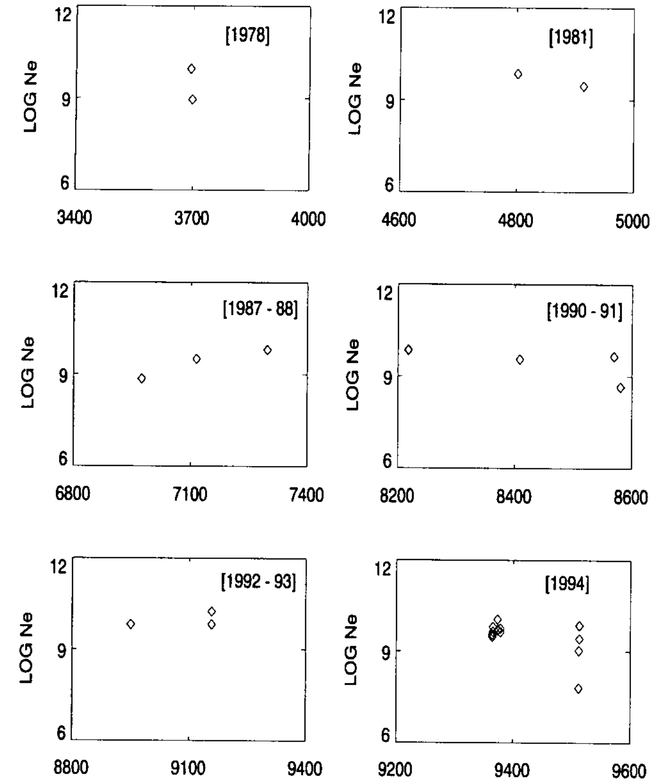

Fig. 8.— Density variation of NGC 4051. Each box represents one year period. Horizontal axis is Julian date (+2440000). 29 diagnostic points obtained from 16 years' IUE archive data. Densities, obtained from the ratio of Si III] 1892/CIII] 1909, indicates a sharp variation within a short period, i.e. one month (strong mass flow activity?).

in AGN is ~0.1 (Nahum et al. 1997). The equivalent width (EW) of C IV 1549/51 increases as the continuum luminosity decreases, probably because the covering factor increases, accordingly. In Fig. 9, we present EW of C IV 1549/51. Since the covering factor changes within a short period of time, the BLR structure itself is likely to be unstable due to a mass flow activity of an accretion disc.

The accretion rate, which may occur through a torus, appear closely related to the density change in BLR, although we do not know the detailed characteristic of mass flow from our simple analysis. However, one might expect transition of the disc from a radiatively efficient Shakura–Sunayev or standard disc to an inefficient advection-dominated flow. Possibly Seyferts with abrupt, high amplitude variability may eventually result in a more stable dynamical state, i.e. non-variable Seyfert 1 galaxies.

Other Seyfert 1's:

Variability of other Seyfert 1 galaxies in Table 1 were not known. We derived the C IV/C III] ratios for all of Seyfert 1 galaxies in Table 1, to see any unusual phenomenon, strong circumnuclear activity or the quasar-like emission. As mentioned above, this ratio is use to infer the ionization parameter and quasar-like Seyferts has a low ionization parameter value of 2.

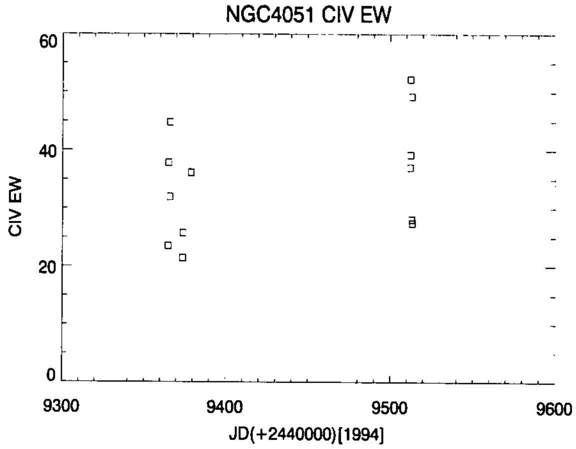

Fig. 9.— EW Variation of CIV 1500 in NGC 4051. EW also varies as the density varies seen in Fig. 8.

In Fig. 10, we present the ratios for all of Seyfert 1's in Table 1. The NGC 4051, NGC 7213 and NGC 1566 ratios show the values close to the quasar's ratio, i.e. ~2, while Mrk 335, Mrk 10, and NGC 5940 are of typical Seyfert 1's. Note the C IV/C III] ratio of ~20 in Mrk 352. This galaxy really has a higher ionization parameter. This object, of which Hubble classification is of elliptical, has a smooth and low surface brightness. We need to investigate more in details on this object with further observational data in the future.

The EW of C IV 1549/51 would increase as the continuum luminosity decreases, when the covering factor increases. NGC 4051, NGC 1566, and Mrk 10 show the EW of about 40, close to the value of highly redshift quasars, while the rest of objects are of classical Seyfert 1's, i.e. 60–140. On the other hand, NGC 7213 has a large value (confusing the argument above in Fig. 10). From Figures 10 and 11, we conclude that NGC 4051, NGC 1566 and Mrk 10 may be classified as a quasar-like object, while NGC 7213 is an ambiguous case.

How can one relate the strong activity of BLR to a host galaxy? If Seyferts are powered by the accretion of matter onto massive black holes, how does the gas in the host galaxy approach the black hole? Since gas easily transfers angular momentum to stars in strong bars, inner bars are likely candidates. However, even with the HST, it is not easy to distinguish the circumnuclear structure. The episodic and self-regulating process of cutting off (turning off the AGN) and re-developing short-lived (~ 10^7 yrs) runaway bar instabilities may exist, although there is no any direct evidence of connection of this structure to the host galactic bars. See the Hubble Space Telescope Near Infrared Camera and

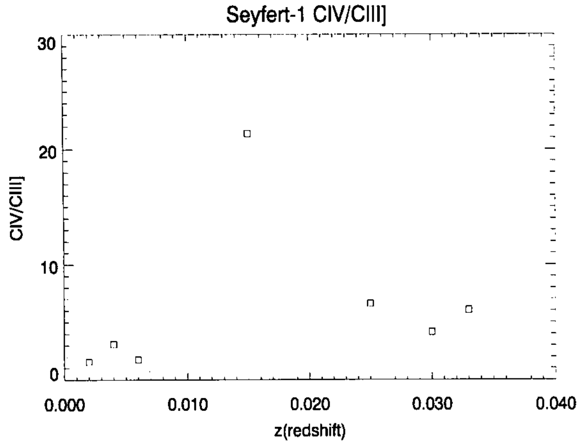

Fig. 10.—CIV / C III] flux ratios of Seyfert 1's. Seyfert 1 galaxies are arranged according to the redshift values: NGC 4051 (z=0.002), NGC 1566 (z=0.004), NGC 7213 (z=0.006), Mrk 352 (0.015), Mrk 335 (z=0.025), Mrk 10 (z=0.03), and NGC 5940 (z=0.033).

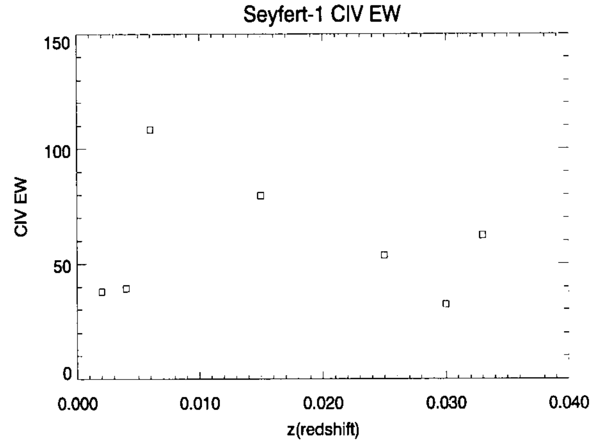

Fig. 11—Equivalent width of C IV 1549/51. As in Fig. 10, Seyfert 1 galaxies are arranged according to the redshift

Multi-object Spectrometer (NICMOS) imaging of nuclear dust morphology, which suggests that the strong barred potentials cannot be a primary mechanism of driving gas into the nuclear region (Regan & Mulchaey 1999). Spiral arms which can be traced to the nucleus up to the limit of a few 10 pc ($< 0.1''$) may be a possible fueling mechanism.

III. DISCUSSION

We have investigated the low dispersion IUE spectra of Seyfert 1 galaxies, for the study of BLR activity. Detailed investigation of BLR structure or exact mass flow mechanism is beyond the scope of the current study. Using the IUE lines Si III] 1892, and CIII] 1909, we derived the density in BLR of Mrk 335 and NGC 4051. Since the lines overlapped due to a close location, we had to separate them with the STARLINK/Dipso package. The result was fine and we were able to show the density of BLR fluctuates up to two orders! Apparently, the electron density changes could happen in BLR due to the mass flow activity through an accretion disc. When the density changes occur due to the proportional (to the luminosity) change in the accretion rate, the excitation change may occur, as well. The IUE carbon line analysis indicates that the excitation of Mrk 335 occurs but not NGC 4051, though.

Photoionization models can be constructed by introducing the ionizing continuum source of energy distribution such as $L_\nu \propto \nu^{-1}$ incident upon the gas mixed with various chemical elements. In the standard photoionization models, the BLR had been modeled as a single-zone ionized plasma or a single photoionized BLR cloud (Wills et al. 1985). However, the emission lines observed in quasars and Seyferts are usually regarded as arising from the the collective motions of an ensemble of individual clouds with source of ionizing radiation. Thus, a more elaborate photoionization simulation with the fragmented multiple clouds and filling factor may be required, in which the emission lines are calculated from the gas irradiated by non-stellar radiation, typical of active galaxies.

Arav et al. (1997) analyzed the Keck high-resolution ($\sim$6 km s^{-1}), high S/N ratio ($\sim$400 at Hα) spectroscopy of Mrk 335. If the BLR is composed of spherical clouds, their photoionization simulation required $\sim 10^7$ clouds in the BLR of Mrk 335, assuming that each cloud is a single type and thermally broadened with $T_e = 2 \times 10^4$ K. The cloud was also assumed to have a single value of $N_e = 10^{10}$ cm^{-3} and L=10^{46} erg s^{-1}. We found that there is a large density variation of about 2 orders within a month. What caused such a large density variation? Shock phenomenon can only enhance the density up to a few times! How can one explain this density variation found in the spectra with large number of clouds? Since the density information is from the whole BLR region, one must assume that the number density of majority of 10^7 clouds has changed coherently by a factor of 100! Boller et al. (1997) reported evidence for a rapid X-ray variability of about 57 times increase in just 2 days in Seyfert 1 galaxy IRAS 13224-3809. Relativistic Doppler boosting effects have been generally believed to explain the X-ray variability. However, it is still difficult to relate the variation of X-ray quanta with the density variation for numerous clouds of BLR – it would be relatively easy in case of BLR excitation variation, though. Does this spectroscopic evidence reflect a large density variation (or fluctuation) of torus in a BLR? There are many possible explanations including an occultation effect (or search light effect) on different regions of BLR or it could be due to a differential variability in excitation of in/outflowing clouds. Detailed analysis is beyond the scope of our current investigation.

To study the structure of circumnuclear region of AGN, we must also study the emission of narrow line region, NLR. The origin of the heating and ionization of the NLR and extended narrow-line region (ENLR) of Seyfert galaxies is still controversial. The strategically important diagnostic line ratios would provide a powerful tool to distinguish between abundances and excitations of the targets. This would enable us to identify the nature of the ionization sources as to whether they are due to massive stars, hard radiation (from the AGNs), or shocks. Can the photoionizing shocks in the BLR power the extended narrow emission zone? The CFHT/OASIS or WHT/TAURUS velocity maps would provide a clue on the geometry and kinematics of AGN substructures, e.g. disk or ring; its rotation or interaction, shock, photoionization, etc. We must also investigate the other diagnostic sensitive emission lines in the optical wavelength region, e.g. [OIII] 4363 /(4959+5007), [SII] 6716/6731, and [NII]/Hα ratios, which would allow us to infer the physical condition of the NLRs, i.e. temperature and density - photoionization or shock heating created by the interaction between the interstellar medium (ISM) and the BLR material (Wilson & Willis 1980). In the future, we will investigate the objects in more details, using the optical spectral data published literatures (in Table 1).

In summary, we derived the BLR densities of variable Seyfert 1 galaxies and estimated the order of central black hole mass. Mrk 335 appears to have more massive black holes than NGC 4051 does. The electron densities that we found as $10^8 - 10^{10}$ cm^{-3}, agree with the other derivations: in order to reduce the flux in [OIII]4959,5007 to less than 1 % of its low density value, densities must be greater than 10^8 cm^{-3}, while the upper limit of $\sim 10^{10}$ cm^{-3} is required by the presence of the CIII]1909 line. The excitation characteristics of NGC 4051, however, is of quasar-like type, whereas Mrk 335 is not. NGC 4051, NGC 1566 and Mrk 10 BLRs excitations appear to resemble that of a distant quasar. Although NGC 1566 and Mrk 10 are not variable, it is worth while monitoring the possible variability. Due to the poor quality of the IUE data in many case, we could not find the physical condition of the central engine for other Seyfert 1 galaxies. Nonetheless, we confirm that the C III]/Si III] ratio can become a valid tool in finding the number density of BLR.

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