The extended narrow line region in Mkn79.

I.Observations.

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Abstract. We present deep long slit spectra of Mkn79 in position angles PA=12° and PA=50° obtained with the WHT. These data prove the existence of an extended narrow line region in PA=12°, which coincides with the triplet radio structure (Ulvested & Wilson 1984) and the observed outflow of material from the nucleus at PA=10° (Whittle et al. 1988). The ratios of the high to low ionization lines indicate a higher level of gas excitation in PA=12° compared to PA=50°. The [NII]λ6583/Hα and [SII]λ6716,31/Hα versus [OIII]λ5007/Hβ line ratios are consistent with excitation by an AGN continuum rather than a HII region.

Key words: galaxies:active – galaxies: individual(MKN79) – galaxies: extended narrow line region– galaxies: Seyfert– observations: galaxies

1. Introduction.

Research on the emission spectra of Active Galactic Nuclei (AGN) has led to the assumption that the emission-line gas can be separated into three regions: the Broad Line Region (BLR); the Narrow Line Region (NLR); and the Extended Narrow Line Region (ENLR). These regions have a different prominence in Seyfert 1 and Seyfert 2 galaxies. In white light, the BLR, NLR and in some cases the ENLR have been observed in Seyfert 1 galaxies, but Seyfert 2 galaxies show strong evidence only for the NLR and ENLR. When studying AGN the problem is to decide whether they are intrinsically different or are merely different manifestations of the same phenomenon. In recent years a belief has grown that the observed differences can be accommodated within a "Unified Scheme". According to this model the diversity between Seyfert 1 and Seyfert 2 galaxies is only due to the varying degree of obscuration and orientation (Antonucci & Miller 1985; Antonucci 1993).

The morphology of the NLR and ENLR indicates that the emission-line gas is aligned with the radio axis and is probably illuminated by an anisotropic beam of ionizing UV-radiation. Indeed, the near-UV continuum (Pogge & De Robertis 1993) and X-ray images of NGC1068 (Wilson et al. 1992) show that the circumnuclear emission has a cone-like geometry, and an elongated morphology in the direction of the radio jet (Hannaford et al. 1988,1991; Ulvestad et al. 1987; Wilson & Ulvestad 1987; Pogge 1988,1989). Similar results with long slit spectroscopy and deep narrow band filter CCD images have been obtained
The Seyfert 1.2 galaxy Mkn79 is one of those having an elongated radio morphology (Ulvstad & Wilson 1984). The radio map shows one component 1 arcsec to the south (PA=182°) and another 1.9 arcsec to the north (PA=12°) of the nucleus. Inspection of the velocity field from [OIII]λ5007 profiles in PA=10° shows double-component peak velocities across the nucleus with shifts relative to the systemic velocity of +100 km s^{-1} and −50 km s^{-1} (Whittle et al. 1988). However the [OIII]5007 and Hα maps do not indicate the spatial extent of the emission (Haniff, Wilson & Ward 1988). This result could be caused by uncertain deconvolution from the seeing (≥1.5") when there is a small separation between the components (≥2"). The systemic velocity of Mkn79 is 6643 km s^{-1} (Heckman, Balick & Sullivan 1978), giving a spatial scale of 630 pc arcsec^{-1}, for H_0=50 km s^{-1} Mpc^{-1} and q_0=0. The rotation velocity obtained from the HI profile width is 220 km s^{-1} (Heckman, Balick & Sullivan 1978). The host galaxy of Mkn79 is extended along a line with PA=65° east of north and with an axes ratio b/a=0.69 (Keel 1980).

The existence of the ENLR in Mkn79 has not been discovered before, although the triplet radio structure (Ulvstad & Wilson 1984) and possible outflow, in addition to the normal galaxy rotation (Whittle et al. 1988), indirectly indicate that an ENLR might exist. In order to study any possible ENLR in Mkn79 we observed the galaxy using the WHT telescope on La Palma in two position angles – along the radio structure in PA=12° and in PA=50° which is close to the global extended structure.

In this paper we describe the observational material as well as discuss the ionization properties of the ENLR in Mkn79. The observations and data reduction are described in Section 2. The results are presented in Section 3, and the discussion and conclusion are given in Sections 4 and 5 respectively.

2. Observations and reductions

A series of long-slit spectra of Mkn79 were obtained with the ISIS double spectrograph using the EEV2 and TEK1 CCD detectors on the 4.2m WHT telescope on La Palma during service time on the night of 15-16 February 1994. The galaxy was observed in two positional angles of 12° and 50° (Fig.1).

![Fig. 1. The central region of Mkn79 in blue light. from Mazzarella & Boroson (1993). The radial slit positions in PA=12° and PA=50° are superimposed.](image)

The individual exposure times were limited to 1800 seconds in order to avoid saturating the chip. Spectra were obtained covering two wavelengths ranges; from 3700Å to 5230Å (blue arm) and from 6110Å to 7460Å (red arm). The total exposure times were 6400s and 5400s in PA=12° and PA=50° respectively. The weather conditions were
contains 331 × 1001 pixels. Each pixel corresponds to 0.33 arcsec in the spatial direction, and 1.45Å in the spectral direction. The observation log is presented in Table 1.

### Table 1. Log of observations on 15-16 February 1994 with WHT-ISIS

| Detector | Airmass | PA | Range(Å) | Exposure(s) | Slit |
|----------|---------|----|----------|-------------|------|
| EEV3     | 1.165   | 12 | 6110 – 7460 | 1000        | 1.5  |
| TEK1     | 1.165   | 3700 – 5230 | 1000        |
| EEV3     | 1.138   | 6110 – 7460 | 1800        |
| TEK1     | 1.138   | 3700 – 5230 | 1800        |
| EEV3     | 1.089   | 3700 – 7460 | 1800        |
| EEV3     | 1.074   | 6110 – 7460 | 1800        |
| TEK1     | 1.074   | 3700 – 7460 | 1800        |
| EEV3     | 1.081   | 6110 – 7460 | 1800        |
| TEK1     | 1.081   | 3700 – 5230 | 1800        |
| EEV3     | 1.105   | 6110 – 7460 | 1800        |
| TEK1     | 1.105   | 3700 – 5230 | 1800        |
| EEV3     | 1.142   | 6110 – 7460 | 1800        |
| TEK1     | 1.142   | 3700 – 5230 | 1800        |

### Table 2. Extraction windows in the 2-D images. Width of windows and distance of the centre of the windows from the centre of Mkn79.

| Label     | PA | Width (arcsec) | Distance (arcsec) | Distance (kpc) |
|-----------|----|----------------|-------------------|---------------|
| Region 12 – 1 | 12 | 4              | 15               | 9.45          |
| Region 12 – 2 | 4   | 11             | 6.93             |
| Region 12 – 3 | 4   | 7              | 4.41             |
| Region 12 – 4 | 4   | 3              | 1.89             |
| Nucleus    | 2   | 0              | 0                |
| Region 12 – 5 | 4   | -3             | 1.89             |
| Region 12 – 6 | 4   | -7             | 4.41             |
| Region 12 – 7 | 4   | -11            | 6.93             |
| Region 12 – 8 | 4   | -15            | 9.45             |
| Region 50 – 1 | 50  | 4              | 15               | 9.45          |
| Region 50 – 2 | 4   | 11             | 6.93             |
| Region 50 – 3 | 4   | 7              | 4.41             |
| Region 50 – 4 | 4   | 3              | 1.89             |
| Region 50 – 5 | 4   | -3             | 1.89             |
| Region 50 – 6 | 4   | -7             | 4.41             |
| Region 50 – 7 | 4   | -11            | 6.93             |
| Region 50 – 8 | 4   | -15            | 9.45             |

The emission line fluxes were obtained by fitting gaussian profiles using the Longslit spectral analysis software (Wilkins & Axon 1992). Most lines were well fitted by single skew gaussians. However, multi-component fits were used for the [SII]λ6717,6731 doublet, for the Hα+[NII]λ6548,6583 complex, and to isolate the broad from the narrow components in the Hβ, Hγ and Hδ lines. The multi-component fits were generally good, although it was difficult in the nucleus to separate the [NII]λ6548 and [NII]λ6583 lines from Hα due to the large intensity of the broad Hα component. The errors on the measured fluxes were taken from the fitting software.

In order to check the accuracy of the flux measurements we have compared the measured ratios of lines emitted from the same upper level with their known values, which reflect the radiative transition probabilities. The ratios of [OIII]λ5007/[OIII]λ4959 and [NII]λ6583/[NII]λ6548 lines from Hα due to the large intensity of the broad Hα component. The errors on the measured fluxes were taken from the fitting software.

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3. Results

This section presents the results of long-slit spectroscopy of Mkn 79 and the emission line measurements in two position angles. The line intensities have been obtained at different distances from the nucleus and in the nucleus itself.

3.1. 2-Dimensional Images

The emission structure in the wavelength ranges around H\(\beta\) and H\(\alpha\) are shown in Fig. 3 for both position angles. The comparison of the 2-D images in both position angles shows the existence of an extended structure in the [OIII]\(\lambda5007,4959\) high ionization lines in PA=12° compared to PA=50°. The extended structure in the [OIII]\(\lambda5007\) line can be detected up to 11 arcsec or 6.8 kpc from the nucleus in PA=12°, compared to approximately 7 arcsec in PA=50° for the same intensity contour. Seeing effects cannot be the reason for these differences as the observations were taken close together during a night with stable weather conditions. The radial flux profiles of the high ionization [OIII]\(\lambda5007\) line shown in Fig. 4 also indicate that the flux in PA=50° falls quicker with the distance from the centre than in PA=12°.

In PA=50° there is also strong emission in the hydrogen lines, and in the low ionization [NII]\(\lambda6548,6583\) and [SII]\(\lambda6717,6731\) lines at some considerable distance from the centre. The line intensity ratios for these regions
**Fig. 3.** The emission structure of Mkn79 around Hβ and Hα. North is at the bottom. a) PA=12° - blue range of the spectrum; b) PA=50° - blue range of the spectrum; c) PA=12° - red range of the spectrum; d) PA=50° - red range of the spectrum. Twenty equally spaced contours between $8 \times 10^{-17}$ erg cm$^{-2}$ Å$^{-1}$ and $8 \times 10^{-18}$ erg cm$^{-2}$ Å$^{-1}$ are plotted.
3.2. The Nucleus of Mkn79.

The optical spectrum of Mkn79 has been studied by Oke & Lauer (1979). They found that the broad-line region in Mkn79 has an electron density \( N_e > 10^8 \) cm\(^{-3}\) in the ionized hydrogen zone and about \( 10^7 \) cm\(^{-3}\) in the neutral zone. They also found that the high-ionization narrow-line region has \( N_e = 10^5 \) cm\(^{-3}\) and its electron temperatures \( T_e \) in the range of 20,000-30,000K. However the low-ionization narrow-line region has electron temperature \( T_e = 10,000 \)K and electron density \( N_e \) from \( 10^3 \) to \( 10^4 \) cm\(^{-3}\), derived from an analysis of the [OII],[NII] and [SII] line ratios.

The optical spectrum of the Mkn79 nucleus in the blue and red is presented in Fig.5. The nuclear spectrum is characterized by emission from high-ionization gas, including lines of HeII, [OIII], [Fe VII] and [Fe X]. A wide range of ionization stages are represented, such as Fe\(^{+9}\) and O\(^{+6}\). The nuclear line ratios are given in Table 3. We note that the Balmer broad to narrow line ratios differ from some others given in the literature (Oke & Lauer 1979; Cohen 1983; De Zotti & Gaskell 1985), probably due to broad line variability (Rosenblatt et al. 1992) and differences in spectral resolution, data quality and seeing which all affect spectral deconvolution. The broad component of H\(\beta\) has an asymmetric profile with a shoulder in the red wing, and does not show a significant change in the asymmetry of this line (Oke & Lauer 1979). However the flux in the lines and in the continuum have significantly changed during the period 1979 - 1984 (Peterson et al. 1982, Peterson & Gaskell 1986, Rosenblatt et al. 1992). The nuclear continuum also clearly shows the ‘small blue bump’ probably due to FeII and Balmer continuum emission, as also found by Oke & Zimmerman (1979).

3.3. The Extended Narrow Line Region in Mkn79.

The emission spectra extracted at the 8 locations tabulated in Table 2 are shown in Fig. 6. The continuum emission and ionization level decrease with distance from the nucleus. Comparison of the spectra, for similar projected distances, in the two directions indicate that there is a
significant difference in ionization level between them. In \( \text{PA}=12^\circ \) the spectra have a stronger blue continuum than in \( \text{PA}=50^\circ \). The line intensities are also higher in the north (regions 1 - 3) than in the south (regions 6 - 8). Overall, the ionization level is highest north of the nucleus in \( \text{PA}=12^\circ \).

The spectra in regions 4 and 5 are similar to the nucleus, and clearly show broad lines, presumably due to seeing effects. The differences between regions 4 and 5, and between \( \text{PA}=12^\circ \) and \( \text{PA}=50^\circ \) may be due to slight errors in slit placement, determination of the exact location of the nucleus, and differential refraction. With the exception of regions 4 and 5, the emission lines in all other regions are narrow and unresolved. Absorption lines of H & K Ca II are present in the spectra in both directions, but they are stronger in \( \text{PA}=50^\circ \) where the relative host galaxy contribution could be higher.

Our results show that the ENLR Balmer decrement is nearly constant, within the errors, at different distances from the nucleus and in both directions. The average value of the Balmer decrement is about 3.1, corresponding to pure case B recombination. Therefore, we did not make any corrections for reddening to the line fluxes, and associated ratios, presented in this paper.

Several emission line ratios are plotted as functions of cross-section in Figs. 7 and 8. In Fig. 7 we present the ratios...
### Table 4. Line intensities relative to I(H\(\beta_n\)) and errors in PA=12°

| Ion  | \(\lambda^{(a)}\) | Region 1      | Region 2      | Region 3      | Region 4      | Region 5      | Region 6      | Region 7      | Region 8      |
|------|-------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| [OI] | 3813              | 183±26         | 192±18         | 211±17         | 195±17         | 247±26         | 231±22         | 155±20         | 85±15          |
| [NeIII] | 3956              | 68±3           | 124±13         |                |                |                |                |                |                |
| HeI  | 3977              | 18±1           |                |                |                |                |                |                |                |
| [NeIII] | 4056              | 26±2           | 43±4           |                |                |                |                |                |                |
| H\(\delta\) | 4198              | 15±1           |                |                |                |                |                |                |                |
| H\(\gamma\) | 4437              | 43±6           | 52±5           | 49±7           |                |                |                |                |                |
| [OI]  | 4459              | 28±4           | 35±5           | 26±5           |                |                |                |                |                |
| HeII | 4790              | 35±8           | 30±5           |                |                |                |                |                |                |
| H\(\beta\) | 4970              | 100            | 100            | 100            | 100            | 100            | 100            | 100            | 100            |
| [OI]  | 5070              | 112±16         | 114±13         | 170±18         | 261±9          | 332±33         | 94±23          | 42±6           | 36±6           |
| [OI]  | 5121              | 376±56         | 354±36         | 533±26         | 931±29         | 740±73         | 269±31         | 123±21         | 36±8           |
| [O]   | 6440              | 17.7±1.6       | 29.2±3.0       |                |                |                |                |                |                |
| [O]   | 6511              | 9.6±0.9        |                |                |                |                |                |                |                |
| [NI]  | 6695              | 88±21          | 76±11          | 68±7           | 84±9           | 139±21         | 71±16          | 46±8           | 36±7           |
| [NII] | 6708              | 319±34         | 295±28         | 266±14         | 249±12         | 477±49         | 240±28         | 283±43         | 287±46         |
| [NII] | 6727              | 285±39         | 211±22         | 189±11         | 230±11         | 431±45         | 247±29         | 126±20         | 133±21         |
| [SII] | 6863              | 84±5           | 76±5           | 51±4           | 45±3           | 118±14         | 72±9           | 52±12          | 48±8           |
| [SII] | 6881              | 49±8           | 52±4           | 43±3           | 55±4           | 82±11          | 42±6           | 33±8           | 31±8           |
| [ArIII] | 7296              |                |                |                |                |                |                |                |                |

\(F(H\(\beta\))^{(b)}\) | 4970 | 2.8±0.3 | 13.5±1.0 | 34.0±7.2 | 522.1±15.8 | 134.4±12.9 | 11.25±1.1 | 5.2±0.6 | 3.9±0.5 |

(a) Observed wavelength  
(b) Flux of narrow component of H\(\beta\) in units of \(10^{-17}\text{erg s}^{-1}\text{cm}^{-2}\)

### Table 5. Line intensities relative to I(H\(\beta_n\)) and errors in PA=50°

| Ion  | \(\lambda^{(a)}\) | Region 1      | Region 2      | Region 3      | Region 4      | Region 5      | Region 6      | Region 7      | Region 8      |
|------|-------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| [OI] | 3813              | 221±41         | 180±31         | 241±24         | 221±11         | 261±22         | 209±29         | 96±11         | 112±10         |
| [NeIII] | 3956              | 57±8           | 87±5           | 99±10          | 39±10          |                |                |                |                |
| HeI  | 3977              | 29±3           | 41±6           |                |                |                |                |                |                |
| [NeIII] | 4056              | 32±2           | 15±3           |                |                |                |                |                |                |
| H\(\delta\) | 4198              | 26±2           | 28±3           |                |                |                |                |                |                |
| H\(\gamma\) | 4437              | 61±14          | 63±4           | 56±12          | 36±6           | 25±6           | 22±7           |                |                |
| [OI]  | 4459              | 18±2           | 32±5           | 30±5           |                |                |                |                |                |
| HeII | 4790              | 31±4           | 27±5           |                |                |                |                |                |                |
| H\(\beta\) | 4970              | 100            | 100            | 100            | 100            | 100            | 100            | 100            | 100            |
| [OI]  | 5070              | 10±2           | 37±6           | 116±13         | 284±15         | 274±11         | 99±13          | 10±6           | 10±6           |
| [OI]  | 5121              | 41±7           | 96±15          | 370±34         | 888±45         | 875±78         | 294±48         | 31±6           | 31±5           |
| [O]   | 6440              | 32±5           | 52±7           |                |                |                |                |                |                |
| [O]   | 6511              | 11±2           | 17±3           |                |                |                |                |                |                |
| [NI]  | 6695              | 56±15          | 80±13          | 57±8           | 84±17          | 107±34         | 84±14          | 42±6           | 62±9           |
| [NI]  | 6708              | 276±36         | 268±27         | 241±22         | 289±21         | 519±52         | 231±33         | 302±19         | 395±22         |
| [NI]  | 6727              | 141±21         | 187±22         | 208±20         | 300±21         | 383±44         | 233±32         | 124±9          | 163±11         |
| [SII] | 6863              | 65±11          | 64±9           | 58±7           | 41±4           | 99±11          | 76±12          | 41±8           | 52±6           |
| [SII] | 6881              | 36±4           | 50±8           | 49±8           | 43±4           | 68±8           | 44±9           | 27±6           | 34±5           |
| [ArIII] | 7296              |                |                |                |                |                |                |                |                |

\(F(H\(\beta\))^{(b)}\) | 4970 | 9.9±1.2 | 12.6±1.4 | 24.8±2.2 | 403.7±19.4 | 111.7±9.4 | 13.7±1.8 | 32.5±2.1 | 33.6±1.8 |

(a) Observed wavelength  
(b) Flux of narrow component of H\(\beta\) in units of \(10^{-17}\text{erg s}^{-1}\text{cm}^{-2}\)
of the high ionization [OIII]λ5007 line to the low ionization [OII]λ3727, [NII]λ6583 and Hβ lines in both position angles. The ratios of low ionization lines in both position angles are presented in Fig. 8. In order to avoid involving widely separated lines, we formed the intensity ratios of low ionization lines in the blue and red wavelength ranges with Hβ and Hα respectively. The asymmetric structure in the high ionization line ratios seen in Fig. 7 are not seen in Fig. 8. Also, the high ionization line asymmetry is not seen at a comparable projected distance in PA=50°. These results support our earlier statement regarding a higher level of gas excitation in the ENLR north of the nucleus in PA=12°. The minima of the low ionization line ratios which are seen in the centre of the galaxy (Fig. 8), also indicate a higher level of gas ionization in the nucleus similar to that seen in NGC4151 (Robinson et al. 1994).

As poor seeing is the likely reason for the appearance of broad lines in regions 4 and 5, the HeIIλ4686/Hβ line...
intensity ratios in these regions could well describe conditions in the nucleus. The ratio of these lines in the nucleus and in regions 4 and 5 are similar, with an average value of 0.30±0.02. Assuming the existence of a relatively hard continuum in the nucleus of Mkn79, which causes the observed $I_{\text{HeII}}/I_{\text{H}\beta}$ ratio, we can estimate the spectral index of this powerlaw continuum using the observed line ratio. The ionizing photon energy for the HeII686 line ($h\nu \geq 54.6$) is 4 times higher than that for H$\beta$ ($h\nu \geq 13.6$).

We can estimate, following Robinson et al. (1994), the ratio of ionizing photon luminosities $Q_{\text{HeII}}$ and $Q_{\text{H}\beta}$ in the HeII$\lambda$686 and H$\beta$ lines for a powerlaw continuum, $F_{\nu} \propto \nu^\alpha$, as

$$\log(Q_{\text{HeII}}/Q_{\text{H}\beta}) = 0.6 \times \alpha,$$

where $\alpha$ is the spectral index.
For the average observed line ratio, the required spectral index is $\alpha \leq -1.36 \pm 0.05$, in agreement with that derived from the low-resolution IUE spectra by Oke & Zimmerman (1979). The observed line ratio could be also consistent with a limiting blackbody ionizing continuum of temperature $T \leq 1.25 \times 10^5$K (Binette et al. 1988).

3.4. The ENLR Kinematics

Using high resolution spectroscopy (spatial resolution of about 0.3 arcsec), Whittle et al. (1988) found double-component peak velocities for [OIII]\$5007$ in PA=10° across the nucleus, with shifts relative to a systemic velocity of +100 km s$^{-1}$ and -50 km s$^{-1}$. The separation between the two velocity peaks is about 2-3 arcsec. Our data, shown in Fig. 9 using an extraction window of 1 arcsec, also show the changes in velocity, with a relative shift.
of 150 km s\(^{-1}\) in the [OIII]\(\lambda\) 5007 line which is nearly the same in both directions. Because our spectra have poorer spatial resolution compared to the spectra studied by Whittle et al. (1988), and also suffer worse seeing, we cannot confirm the validity of the double-peaked effect in PA=12\(^{\circ}\). The velocity dispersion across the image is \(V_d=200 \pm 75\) km s\(^{-1}\) in PA=12\(^{\circ}\) and is similar in PA=50\(^{\circ}\). The line-of-sight systematic velocity in the nucleus is 6675\(\pm\)25 km s\(^{-1}\), which is close to the value obtained by Whittle et al. (1988).

4. Analysis of the results.

A major question in the investigation of the ENLR is understanding whether the emission lines arise by photoionization of the gas in the galactic disk by the central AGN ionizing continuum source, or whether there are other local sources for the gas ionization (young stars, extended X-ray emission or shocks). A powerful tool in discriminating between these various effects is to use line diagnostic diagrams (Baldwin et al., 1981; Veilleux & Osterbrock, 1987; Robinson et al., 1987). These diagrams help give a clear understanding of the mechanism of gas heating and ionization, and can separate HII regions and planetary nebula from the ENLR and nuclei of AGN.

In order to investigate the physical conditions at different distances from the centre in Mkn79 we plot several diagnostic diagrams involving combinations of line ratios in Fig. 10. We also show the results of a series of photoionization models computed using the CLOUDY photoionization code (Ferland, 1991) for plane parallel slabs of gas, of constant density \(N_e=100\) cm\(^{-3}\), assuming solar abundances. Because the energy distribution of the ionizing continuum in the nucleus of Mkn79 is poorly known we made the calculations for both powerlaw and blackbody energy distributions. The powerlaw continuum has a spectral index \(\alpha=-1.5\) in the range from 0.008 Ryd to 8000 Ryd. The blackbody continuum temperature is 1.3\(\times\)10\(^{5}\)K. Robinson et al. (1987) show that this continuum has a similar mean ionizing photon energy as a powerlaw continuum, with \(\alpha=-1.5\) at approximately 35eV, and both produce line intensity ratios in agreement with the typical observed spectra of AGN. We calculated spectra for a wide range in ionization parameter \(U\), where \(U=F/(c \times N_e)\), and \(F\) is the ionizing photon flux.

In the [NII]\(\lambda\)6583/H\(\alpha\) and [SII]\(\lambda\)6717,31/H\(\alpha\) versus [OIII]\(\lambda\)5007/H\(\beta\) diagnostic diagrams, regions 1-6 in PA=12\(^{\circ}\), including all regions north of the nucleus, and regions 3-6 in PA=50\(^{\circ}\), are located in positions which are usually occupied by the narrow line regions of AGN (Veilleux & Osterbrock, 1987). Again this indicates that the ENLR in Mkn79 has an elongation in position angle=12\(^{\circ}\), but the ionizing cone from the centre could be quite wide, as in NGC4151 (Robinson et al. 1994) and includes several regions in PA=50\(^{\circ}\). The regions south of
the nucleus (12-7, 12-8) and also the regions associated
with the strong hydrogen emission (50-1, 50-2, 50-7, 50-8)
are located in positions corresponding to HII regions.

In order to further constrain the ENLR phenomenon
in Mkn79 we need to consider the ionizing photon budget
by comparing the number of ionizing continuum photons
available with the number required to produce the hydrogen
line emission (Wilson et al., 1988). The number of ionising photons \( N_{H\beta} \) necessary to produce a \( \text{H}\beta \) luminosity \( L_{H\beta} \) is

\[
N_{H\beta} = 2.1 \times 10^{52} \left( \frac{L_{H\beta}}{10^{40} \text{erg s}^{-1}} \right) \text{photons s}^{-1},
\]
conditions. The Hβ luminosity taken from our results is $3.8 \times 10^{41}$ erg s$^{-1}$ for a central region of $2 \times 1.5$ arcsec$^2$.

The number of photons in a powerlaw ionizing continuum between $\nu_1$ and $\nu_2$ is

$$N_i = 4\pi R^2 C(\alpha h)^{-1} (\nu_1^{-\alpha} - \nu_2^{-\alpha}) \text{photons s}^{-1}$$

where $R = 132.86$ Mpc is the distance to Mkn79 ($H_0=50$ km s$^{-1}$ Mpc$^{-1}$) and $C$ is the constant in the powerlaw spectrum. We take $\nu_1 = 3.3 \times 10^{15}$ Hz and $\nu_2 = 4.8 \times 10^{17}$ Hz and the spectral index $\alpha = -1.3$. The continuum luminosity of the central region within this range is $1.2 \times 10^{51}$ photons s$^{-1}$, assuming no interstellar reddening. However a colour excess of $\sim 0.22$ has been suggested for Mkn79 based on the $\lambda 2175$ interstellar feature (Oke & Zimmerman 1979) and from line intensity ratios (Tsvetanov & Yancoulova 1989). Assuming this colour index, the continuum luminosity is $4.7 \times 10^{53}$ photons s$^{-1}$. Using the reddening corrected continuum luminosity and assuming a covering factor of 10% for the Hβ emitting gas in the central region, the ratio $N_{H\beta}/N_i = 17$. This large ratio suggests that the ionizing continuum in Mkn79 is emitted anisotropically, being brighter towards the ENLR than in our direction. Alternatively, the continuum has a strong EUV/soft X-ray excess in addition to the powerlaw spectrum used above.

The radial ionization structure in PA=12° and PA=50° shows significant variation in the physical conditions along these directions. We can estimate the physical conditions at different distances from the nucleus, and in the nucleus itself, by the traditional method of using various line intensity ratios (Osterbrock 1989). The nuclear electron temperature can be derived from the line intensity ratio $I_{[SII]\lambda 6717}/I_{[OIII]\lambda 5007, 4959}$. The observed ratio corresponds to an electron temperature $T_e \geq 25000$ K for $N_e = 600$ cm$^{-3}$ for $T_e = 25000$ K. The error-bars in the line ratio prohibit detailed analysis, but allow a rough estimation of the electron density in regions distant from the centre.

The trend of the ratio is different north and south of the nucleus. There is a sharper increase south of the galaxy in both position angles between the NLR and the ENLR. The ratio appears constant, within the errors, south of the nucleus and corresponds to the low density limit, with $N_e < 80$ cm$^{-3}$. North of the nucleus the ratio indicates a smooth decrease in the electron density.

The density-sensitive $[SII]\lambda 6717/[SII]\lambda 6731$ line ratio in PA=12° and PA=50° is shown in Fig. 11. The observed NLR $[SII]\lambda 6717/[SII]\lambda 6731$ line ratio of 0.84±0.1 corresponds to an electron density $N_e = 600$ cm$^{-3}$ for $T_e = 25000$ K. The error-bars in the line ratio prohibit detailed analysis, but allow a rough estimation of the electron density in regions distant from the centre. The trend of the ratio is different north and south of the nucleus. There is a sharper increase south of the galaxy in both position angles between the NLR and the ENLR. The ratio appears constant, within the errors, south of the nucleus and corresponds to the low density limit, with $N_e < 80$ cm$^{-3}$. North of the nucleus the ratio indicates a smooth decrease in the electron density.

![Fig. 11. Radial variation of the density-sensitive [SII]6717/[SII]6731 ratio in PA=12° and PA=50°.](image-url)
position angles, the electron density decreases by at least an order of magnitude, while the distance from the centre increases by a factor of 10. Thus the density appears to fall off by the inverse distance or more steeply, implying an ionization gradient across the northern ENLR. It should be noted that significant hydrogen line emission is also observed at a large distance from the centre in position angle PA=50°. However, this emission is caused by the presence of HII regions in the host galaxy of Mkn79.

The source of the gas ionization in the ENLR of Mkn79 might be connected with the observed outflow of material from the nucleus of Mkn79 at PA=10° (Whittle et al. 1988) or with the radio structure at PA=12° (Ulvestad & Wilson 1984). These and other possible explanations of our results, together with more detailed modelling of the ENLR in Mkn79 will be presented in a future paper.

5. Conclusions

We present deep long-slit spectra of Mkn79 at two position angles. The main results of our investigation of these spectra are as follows.

1. We find an extended narrow line region in Mkn79, particularly in PA=12°.

2. The gas excitation is higher in the north in PA=12° compared to a comparable projected distance in PA=50°. The average value of the Balmer decrement in the ENLR in both position angles is about 3.1, indicating that the ENLR in Mkn79 is not strongly reddened.

3. The Balmer decrement $(I(Hα)_k/I(Hβ)_k)$ is 3.5 for the BLR, 3.8 for the NLR, and 3.1 for the ENLR.

The electron temperature in the NLR derived from the line intensity ratio $I_{[OIII]λ5007}/I_[OII]λλ3727,3729$ is $T_e \geq 25000K \pm 5000K$, and the electron density estimated from the observed $[OIII]λ5007/Hβ$ diagnostic diagrams the high ionization line regions are located in positions which usually occupied by narrow line regions of AGN (Veilleux & Osterbrock 1987). The distant regions south of the nucleus and also the regions associated with strong hydrogen line emission are located in positions usually occupied by HII regions.

5. The observed variation of the density-sensitive $[SII]λ6717/[SII]λ6731$ line ratio suggests a significant decrease in ENLR gas density with increasing distance north of the nucleus.

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