MRK 744 AND MRK 1066: TWO SEYFERT GALAXIES WITH STRONG ABSORPTION-LINE SPECTRA

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Received 1982 September 30; accepted 1982 December 6

ABSTRACT

Spectrophotometric observations of the nuclei of two Seyfert galaxies, Mrk 744 and Mrk 1066, are reported. Both these objects have strong absorption-line spectra due to the underlying galaxies. A least squares fitting procedure was used to decompose the spectra into the galaxy contribution, the power-law featureless continuum, and the emission-line spectrum. Equivalent widths of the G, b, and $E_2$ absorption features were measured and the corresponding values of the fraction of power-law contribution at 4800 Å calculated and compared to the least squares results. The two, fairly independent sets of measurements agree well, indicating a featureless continuum fraction at X4800 Å, $f$, of 0.41 ± 0.08 and a spectral index $\alpha = 1.0 \pm 0.1$ for Mrk 744, and $f = 0.55 \pm 0.02$, $\alpha = 2.4 \pm 0.2$ for Mrk 1066. It is suggested that Seyfert 1.8 galaxies like Mrk 744, and Seyfert 1.9 galaxies as well, may be objects in which the broad-line emitting region is seen nearly edge-on, so that the effects of extinction by dust are unusually large.

Subject headings: galaxies: individual — galaxies: nuclei — galaxies: Seyfert

I. INTRODUCTION

Mrk 744 is the westernmost galaxy in the interacting pair NGC 3786–3788, number 294 in the Arp (1966) atlas. It was first classified as a Seyfert galaxy by Afanas'ev, Denisyuk, and Lipovetskii (1979), who noted the presence of a broad Hα component. Subsequent spectra of Mrk 744 were obtained with the 6 m telescope of the Special Astrophysical Observatory, and analyzed by Afanas'ev, Lipovetskii, and Shapovalova (1979, hereafter ALS 79). These authors reported some 142 individual emission lines and blends of emission lines, including many due to various Fe ions, Ca v, Ne iv, Ar iv, Mn vi, K iv, Ar v, and Ni ii. They also reported the Na i D λλ5890, 5896 in absorption, indicating a stellar contribution to the spectrum.

Mrk 1066 was also studied by Afanas'ev, Lipovetskii, and Shapovalova (1981, hereafter ALS 81), using the same equipment. For this object they report 62 emission lines and blends of emission lines, including many iron lines as well as broad components in both Hα and Hβ. No absorption lines are noted in their paper.

We have obtained high signal-to-noise spectra of both Mrk 744 and Mrk 1066 using the image-dissector scanner in conjunction with the 3 m Shane telescope. The spectral region covered is roughly from 3500 Å to 8000 Å; § II of this paper more fully describes these observations. Preliminary visual comparison of our Mrk 744 and Mrk 1066 spectra with the spectra of "standard" (nonactive) galaxies revealed not only the Na i D absorption line reported by ALS 79 in Mrk 744, but also the same line in Mrk 1066, and in both active nuclei the Ca i H and K absorption lines (λλ3968, 3934), the G band (λ4302), the Mg i b blend (λ5175), the Fe i $E_2$ line (λ5269), and a wealth of other absorption features due to the underlying galaxies. Further detailed analysis has led to the decomposition of the active-galaxy spectra into three components: a galaxy component, a featureless continuum of power-law form, and an emission-line spectrum. This analysis is described in § III, which includes measurements of some of the more prominent absorption features. We have found no evidence for many of the fainter emission lines reported by ALS 79 and ALS 81. Section IV presents and discusses the measurements of the emission lines in our spectra that we do confidently detect. In § V the more general problem of the interpretation of Seyfert 1.8 galaxies such as Mrk 744, and of the closely related Seyfert 1.9 galaxies, is discussed.

II. OBSERVATIONS

The image-tube image-dissector scanner on the 3 m Shane reflector was used to obtain spectral scans of Mrk 744 on 1981 May 12/13, and of Mrk 1066 on 1981 October 5/6. A grating yielding a dispersion of 1.25 Å per channel and a resolution of ~ 10 Å was employed, along with a slit of projected size 2''7 × 4''0. Each scan covered roughly 2500 Å, so to span as wide a spectral range as possible, two scans of each active nucleus were
TABLE 1

<table>
<thead>
<tr>
<th>Object</th>
<th>Date</th>
<th>Spectral Region</th>
<th>Exposure Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mrk 744</td>
<td>1981 May 12/13</td>
<td>λ3410–5970</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>λ4640–7200</td>
<td>48</td>
</tr>
<tr>
<td>Mrk 1066</td>
<td>1981 Oct 5/6</td>
<td>λ3435–5995</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>λ4665–7225</td>
<td>32</td>
</tr>
</tbody>
</table>

taken. The exposure times and spectral ranges of each scan are given in Table 1.

The spectra were reduced by standard methods and the redshifts of the two objects with respect to the Sun were determined \( (z = 0.0090 \pm 0.0001 \text{ for Mrk 744 and } z = 0.0120 \pm 0.0001 \text{ for Mrk 1066}) \). Reddening due to our own galaxy was calculated using the Burstein-Heiles (1978) method, yielding \( E_{B-V} = 0.00 \) for Mrk 744 and \( E_{B-V} = 0.10 \) for Mrk 1066. For each object the red and blue scans were added together, dereddened using the above values of \( E_{B-V} \), and de-redshifted. The resultant spectra of Mrk 744 and Mrk 1066 are shown in Figure 1, along with the spectrum of a nonactive galaxy, which is included for comparison.

Several of the emission lines typical of active galactic nuclei are clearly visible and are labeled in Figure 1. Also labeled are some of the absorption features due to the stellar component of the galaxy. There are also numerous fainter features, which may be identified as faint absorption lines by comparing with the nonactive “standard” spectrum below. Care must be taken to be sure sections of continuum between two absorption lines are not misidentified as faint emission lines.

In Figure 2 is an expanded portion of the spectrum of Mrk 744, centered on Hβ. It provides an example of three components to the Balmer lines—a narrow emission line within a somewhat broader absorption line (the latter due to the stellar contribution), superposed on a broad emission component. In Figure 1 the broad component to Hα in Mrk 744 is easily visible, and because the Hβ broad component is so weak we would assign a Seyfert 1.8 classification to Mrk 744 (Osterbrock 1981).

Mrk 1066, on the other hand, appears to have no broad Balmer components, and hence would be classified by us as a Seyfert 2. (Note that this is contrary to...
the classification as a Seyfert 1.8 by ALS 81.) It is a
definite Seyfert 2, but just barely, for the [O III] \(\lambda5007/\text{H}\beta\) ratio is only \(\approx 4\) (Shuder and Osterbrock
1981). The narrow emission lines in Mrk 1066 and
Mrk 744 have comparable widths, but there is a small
extended blue wing in the lines of Mrk 1066. The
emission spectrum of Mrk 1066 is stronger than that of
Mrk 744.

III. DECOMPOSITION OF THE SPECTRA

The decomposition of the spectra of Mrk 744 and
Mrk 1066 into galaxy and featureless continuum com-
ponents was performed using a least squares fitting routine
written by B. F. Hatfield and modified by J. M. Shuder
(1981). The technique assumes a power law for the
featureless continuum \((F_c \propto \nu^{-\alpha})\) and requires a “nor-
mal” galaxy spectrum to be used as one of the compo-
nents to the fit. A range of values for the power-law
index \(\alpha\) is provided as input by the user, and for each
value the program finds the fraction \(f_{FC}\) of the observed
spectrum at 4800 Å that is due to the featureless con-
tinuum, and the sum of the residuals to this best fit.
Hence by comparing the residuals for a range of values
of \(\alpha\), one may determine the value of \(\alpha\) and \(f_{FC}\) for
the overall best fit—the fraction of light at 4800 Å due
to the overlying galaxy is then \(f_{GC} = 1 - f_{FC}\).

Since not all “normal” galaxies have identical spectra,
there is another parameter that affects the fits—which
galaxy to use as the “normal” galaxy. As we are fitting a
spectrum, the characteristic of the galaxy in which we
are interested is not the morphological type but rather
the spectral type (to the extent it can be defined). We
have done least squares fits for four different “normal”
spectra: a sum of the spectra of NGCs 6482 and 6702,
and individual spectra of NGC 2681, NGC 7331, and
NGC 4736. In the classification system of Humason,
Mayall, and Sandage (1956) these spectra are types G2,
F8, G8, and G0, respectively.

For a given “normal” galaxy spectrum the best fit
parameters \(\alpha\) and \(f_{FC}\) also are dependent on what part
of the spectrum we fit. With a view toward checking the
consistency of our results, we determined the best fit \(\alpha\)
and \(f_{FC}\) several times for each “normal” galaxy, each
time using slightly different limits on the continuum
fitted. Specifically we found that including the small
section of continuum in the ultraviolet below [O III]
\(\lambda3727\) significantly altered the best fits for some of the
galaxy spectra. (The fits for the other spectra were
unchanged.) The response curve of the image tube below
3700 Å is somewhat suspect, and hence the fits includ-
ing the continuum below this point were also considered
suspect and are not used in Table 2, which lists the best
fit parameters for each of the four spectral types and for
both active galaxies. But these fits do point out the
necessity for careful consideration of which portions of
the continuum to include in the fitting process.

All of the fits with the lower limit of the continuum
placed just redward of the [O III] \(\lambda3727\) emission line,
where the response curve is well determined, were mutu-
ally consistent with each other—at most \(\alpha\) varied by
\(\pm 0.1\) and \(f_{FC}\) by \(\pm 0.07\), within the uncertainties due to
the unknown spectral type of the active galaxy.

Examination of the subtractions of the best fits from
the active galaxy under consideration allowed a qualita-
tive estimate of which “normal” galaxy had the most
similar continuum to the stellar component of the active
galaxy. It was found for both Mrk 744 and Mrk 1066
that while the F8 spectrum could be ruled out the G0,
G2, and G8 subtractions were almost identically good,
with the G0 spectrum providing a marginally superior
fit in both cases.

We note that over the range of spectral types investi-
gated the best fit spectral index for Mrk 744 is remark-
ably constant, \(\alpha = 1.0 \pm 0.1\), while the fraction of
featureless continuum at 4800 Å, \(f_{FC}\), varies from 0.23
in the F8 fit to 0.47 in the G8. Qualitatively the trend in
the latter is easy to understand. As the spectral type of
the “normal” galaxy becomes later and the galaxy spec-
trum redder, a larger power-law contribution is required
to bring the intensity in the blue up to the level of the
Mrk 774 spectrum, and \(f_{FC}\) increases. Unfortunately this
indicates that the fits may be unable to tell us very
accurately how much of the light at 4800 Å is power-law
and how much is galaxy, even though the spectral index
of the power-law may be well-determined. On the other
hand, in Mrk 1066 both the power-law slope and frac-
tion depend on the spectral type of the “normal” galaxy
— \(\alpha\) varying from 2.75 to 2.2 and \(f_{FC}\) from 0.40 to 0.57.

A second method of estimating the amount of power-
law contribution in the spectrum of an active galaxy is
to measure the equivalent widths of absorption features
due to the stellar component in the spectrum. By mea-
suring the equivalent width of a given line in both the
active galaxy and a “normal” galaxy it is straightforward
to calculate the amount of dilution the “normal”
line would have to undergo to match the equivalent
width of the same line in the active galaxy. If we denote

TABLE 2

<table>
<thead>
<tr>
<th>Active Galaxy</th>
<th>“Normal” Galaxy</th>
<th>Power-Law Slope, (\alpha)</th>
<th>Fraction of Power Law, (f_{FC})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mrk 744</td>
<td>F8</td>
<td>1.0</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>G0</td>
<td>0.9</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>1.1</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>G8</td>
<td>1.0</td>
<td>0.47</td>
</tr>
<tr>
<td>Mrk 1066</td>
<td>F8</td>
<td>2.75</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>G0</td>
<td>2.6</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>2.35</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>G8</td>
<td>2.2</td>
<td>0.57</td>
</tr>
</tbody>
</table>
the equivalent width of a line at wavelength $\lambda$ by $W_\lambda$ and denote the ratio of power-law to galaxy contribution at this wavelength by $R_\lambda$ we have the relationship

$$R_\lambda = \frac{W_\lambda(\text{normal})}{W_\lambda(\text{active})} = 1.$$  

By measuring the continuum strengths in the "normal" galaxy at $\lambda$ and at 4800 Å and by using the power-law index $\alpha$ given in Table 2, this ratio may be converted to the ratio of featureless continuum to galaxy contribution at 4800 Å, $R_{H\beta}$, and hence to the parameter $f_{FC}$:

$$R_{H\beta} = R_\lambda \left(\frac{4800 \text{ Å}}{\lambda}\right)^{\alpha - 2} \left(\frac{F_\lambda(\lambda)}{F_\lambda(4800 \text{ Å})}\right)_{\text{normal galaxy}}.$$  

$$f_{FC} = \frac{R_{H\beta}}{1 + R_{H\beta}}.$$  

We have noted the existence of many of the strongest absorption lines in the spectra of Mrk 744 and Mrk 1066. Of these Ca II H is partially filled in by an unknown amount of emission of [Ne III] $\lambda$3967 and H$\beta$ $\lambda$3970, and hence cannot be used in an analysis such as has been described. In any case both it and the K line are in a region of the spectrum where crowded absorption lines make the definition of a continuum very ambiguous. Ca II H and K and Na I D may also be ruled out, as these absorption lines are formed not only in stars but also in interstellar gas, and thus may vary radically from one galaxy to the next. After consideration of a number of factors including the definition of the neighboring continuum, the freedom from interference with emission lines, and the characteristic of arising exclusively in stars, we decided to measure the G and b bands and the Fe I $E_2$ line $\lambda$5269. The equivalent width measurements are given in Table 3 and the resulting calculated values of $f_{FC}$ are given in Table 4. Several comments are in order about these numbers. First, the Mg I b feature may be partially filled in by [Ni I] $\lambda$5199 in emission, clearly visible in our spectra in Figure 1. In Mrk 744 the great breadth of the b feature and the large separation of its center from the [Ni I] line argue for this effect being very slight, 5% at most. In Mrk 1066, however, the [Ni I] line not only has an extended blue wing (as noted in § II) but is also stronger than in Mrk 744, and the effect here is probably quite substantial. The filling-in of the b line will result in an underestimate of $W_\lambda$ (active) and hence an overestimate of $f_{FC}$.

Another point to keep in mind is that because we are dealing with a difference in equivalent widths the uncertainties become disproportionately large as the strength of the line decreases. For example, if the equivalent width measurements of the G, b, and $E_2$ features of the G8 spectrum were increased by 0.05 each, the corresponding calculated values of $f_{FC}$ for Mrk 744 would increase by $\sim 0.02$ for the relatively strong G and b features, but by 7% for the weaker $E_2$ line. (For the G8 spectrum $E_2$ is only 40% as strong as the b feature.)

Keeping these two important points in mind and considering the resulting values of $f_{FC}$ we find that for Mrk 744 both the b and $E_2$ measurements tend to rule out the F8 spectrum, and the b measurement of the G8 spectrum indicates a poor fit there. However the G8 spectrum indicates a poor fit there. However the G8 spectrum should not be ruled out because we recall that a slight filling-in of the b line with [Ni I] emission will bring the value of $f_{FC}$ down, closer to the least squares value. We recall that the least squares fits also indicated a spectral type later than F8.

For Mrk 1066 all of the b feature measurements indicate that there is some filling-in by the [Ni I] $\lambda$5199 emission line. The G band measurements do not allow easy discrimination, although the G2 and G8 spectra do not fit as well as could be expected. The $E_2$ measurements, as noted, are subject to large uncertainties, but they would tend to rule out the F8 spectrum. Overall the best fit to the stellar component of Mrk 1066 appears to be the G0 spectrum.

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These measurements of the equivalent widths of strong absorption lines in the two active galaxies we are considering in this paper provide important confirmation of the least squares fitting technique described in the first part of this section. They also provide some supplementary information in the case of Mrk 1066—indicating that the G2 and G8 spectra may not match as well as the G0 spectrum. If we only rule out the F8 spectrum fits for both Mrk 744 and Mrk 1066, however, we find that our spectrum of Mrk 744 consists of a power-law featureless continuum of spectral index $\alpha = 1.0 \pm 0.1$, contributing $0.41 \pm 0.08$ of the light at 4800 Å, a galaxy of spectral type G0 or later contributing the remainder of the continuum light, and a typical Seyfert emission-line spectrum. Our spectrum of Mrk 1066 consists of a power law with index $\alpha = 2.4 \pm 0.2$ contributing $0.55 \pm 0.02$ of the light at 4800 Å, a G0 or later galaxy spectrum, and again a typical Seyfert emission-line spectrum. In the next section we discuss the emission-line contribution to the spectra of Mrk 744 and Mrk 1066.

IV. THE EMISSION-LINE SPECTRUM

In Table 5 we present our measurements of the equivalent widths and fluxes of the emission lines in the two galaxies. Line fluxes are presented as a ratio with respect to [O III] $\lambda 5007$—the measured flux in this line was $4.0 \times 10^{-13}$ ergs cm$^{-2}$ s$^{-1}$ Å$^{-1}$ in Mrk 744 and $3.1 \times 10^{-13}$ ergs cm$^{-2}$ s$^{-1}$ Å$^{-1}$ in Mrk 1066, through a slit $2.7 \times 4.0$ centered on the respective nuclei.

The line profiles of strong individual lines in each object ([O III] $\lambda 5007$ for Mrk 744 and [O II] $\lambda 3727$ for Mrk 1066) were used as models in order to deblend [Ne II] $\lambda\lambda 6548, 6583$, and [H$\alpha$] $\lambda 6563$, as well as the [S II] $\lambda\lambda 6717, 6731$ lines. For each line in the blend the model line was appropriately scaled and broadened, until the blend itself was matched as well as possible. The resulting fluxes for the individual lines are the values tabulated in Table 5. Note that in the case of Mrk 744 this left an excess flux due to the broad component of H$\alpha$. A similar deblending procedure allowed an estimate of the H$\beta$ broad component in Mrk 744. There was no evidence for broad Balmer components in the spectrum of Mrk 1066.

If we assume that the narrow Balmer lines are due to case B recombination (Brocklehurst 1971) affected by reddening, and further assume a reddening law similar to that in our own galaxy (Miller and Mathews 1972) we may deduce the amount of reddening in each active nucleus from the Balmer decrements. In Mrk 744 we find that no reddening is present, and in Mrk 1066 we find $E_{B-V} = 0.93$. Some complication is involved in the case of Mrk 744 because the narrow component of H$\beta$
is within a broader Hβ absorption line in the galaxy spectrum. In Mrk 744 we used the [O iii] ratio (λ4959 + 5007)/λ4636 to determine an approximate temperature of 21,000 K for the O^+ -forming region. The [S ii] λ6716/λ6731 ratio indicates N_e/T_e^{-1/2} = 10.2, yielding an electron density of N_e = 1.5 × 10^3 cm^{-3} for T_e = 21,000 K. Because the [S ii] lines are generally formed at a lower temperature than the [O iii] lines this should be construed as an upper limit to the density in the S^+ region.

In the last column of Table 5 are presented the line fluxes in Mrk 1066, corrected for E(B-V) = 0.93. The corrected [O iii] ratio (λλ4959 + 5007)/λ4636 then yields a temperature of 16,500 K for the O^+ -region, while the [N ii] ratio (λλ6548 + 6583)/λλ5755 indicates a temperature for the N^+ -forming region of 10,600 K, somewhat cooler. The [S ii] λ6716 to λ6731 ratio then indicates a density of 1.1 × 10^3 cm^{-3} (using T_e = 10,600 K, [S ii] is expected to be found at even cooler temperatures than [N ii]).

The temperatures and densities found for Mrk 744 and Mrk 1066 are typical values for Seyfert narrow-line regions. We note that the Balmer decrement in the broad-line region of Mrk 744 is Hα/Hβ = 8.4, typical of many Seyfert 1.8 broad-line regions. The broad-line decrement is fairly uncertain, however, due to the confused nature of the multiple contributions to the Hβ profile already discussed.

By convolving the measured instrumental profile of the scanner with gaussians of various full widths at half-maximum (FWHM) and comparing the results with the [O iii] line profiles λ5007 lines in Mrk 744 and Mrk 1066, we determined the intrinsic narrow-line broadening in each object. In both cases the [O iii] λ5007 profiles had a FWHM of 450 ± 110 km s^{-1}. As noted above, the Mrk 1066 narrow-line profiles have an extended blue wing.

We do not confirm the other emission lines, not listed in Table 5, that were reported as present in Mrk 744 (ALS 79) or in Mrk 1066 (ALS 81). Very probably what were identified as emission lines were actually fragments of continuum between neighboring pairs of absorption lines in the galaxy spectra, or in some cases possibly even peaks in the statistical noise of the spectra, which were taken with a photographic image-tube system.

V. SEYFERT 1.8 AND 1.9 GALAXIES

Mrk 744 is an example of the class of Seyfert galaxies which have a composite Hα emission-line profile, consisting of a weak broad component, similar to the H i Balmer-line profile in a Seyfert 1 galaxy, superposed on a fairly strong narrow component, similar to the Balmer-line profile in a Seyfert 2 galaxy. Such objects which also have a weak broad Hβ emission-line component, as Mrk 744 does, have been called Seyfert 1.8 galaxies, while those in which broad Hβ cannot be detected with certainty have been called Seyfert 1.9 galaxies (Osterbrock 1981). Both of these types can only be recognized on scans taken with very high signal-to-noise ratio, in which the weak, broad components can be detected. In addition to the five Seyfert 1.8 and Seyfert 1.9 galaxies listed by Osterbrock (1981), and Mrk 744, described in the present paper, three other objects of this type have been identified in the continuing Lick Observatory spectral survey of known and suspected Seyfert galaxies. They are listed in Table 6. With nine Seyfert 1.8 and 1.9 galaxies known, in spite of the severe observational problems of recognizing them, compared with roughly 120 Seyfert 1 and 1.5 galaxies and 50 Seyfert 2 galaxies carefully surveyed, the population of this group is by no means negligible.

All the more recently identified Seyfert 1.8 and Seyfert 1.9 galaxies, like the earlier cases, have very large broad-line F(Hα)/F(Hβ) emission-line flux ratios. For instance, in Mrk 744 the broad-component ratio is F(Hα)/F(Hβ) = 8.4, much larger than the observed ratio 3.5 in typical Seyfert 1 galaxies, with a range from about 2.7 to 5.0. As Osterbrock (1981) suggested, although collisional excitation and line radiative-transfer effects do not play a considerable role in determining the broad-line flux ratios, the very large F(Hα)/F(Hβ) ratios in these objects suggest that interstellar reddening is also quite important in them. If the broad-line region has a disklke form, as several authors have suggested, perhaps the Seyfert 1.8 and 1.9 galaxies are cases in which this region is seen nearly edge-on, and there is considerable dust in its plane, much of it surrounding the ionized gas. On this interpretation normal Seyfert 1 and 1.5 galaxies would be similar objects, in which the equatorial plane of the broad-line disk is sensibly inclined to the line of sight from the Sun, rather than nearly parallel to it. Ulvested, Wilson, and Sramek (1981) and Tohline and Osterbrock (1982) have emphasized that if the broad-line region is disklke, it may well be tipped at a rather considerable angle to the overall plane of the galaxy in which it occurs. These objects are therefore different from a Seyfert 1 galaxy seen nearly edge-on, of which the best example is NGC 4235 (Abell, Eastmond, and Jenner 1978). In it, not only the broad emission lines but the narrow lines as well show evidence of very great interstellar extinction, no
doubt resulting from dust in the plane of the galaxy. This agrees with the idea, derived mostly from high-resolution radio maps and the strong correlation of the narrow emission lines with radio emission, that the narrow-line region does lie closely in the plane of the overall galaxy (Wilson and Willis 1980; Booler, Pedlar, and Davies 1982).

These ideas are somewhat speculative but may provide a conceptual framework for interpreting Seyfert-galaxy observational data. Note that they predict that Seyfert 1.8 and 1.9 nuclei would not have larger infrared excesses than Seyfert 1 or 1.5 objects, since they are the same type of objects, seen in different orientations. Sharper tests than this, however, will be necessary to prove or disprove this hypothesis.

VI. SUMMARY

In summary, we have found that the spectrum of Mrk 744 is composed of a featureless continuum of form $F \propto \nu^{-\alpha}$ with power-law index $\alpha = 1.0 \pm 0.1$, contributing $0.41 \pm 0.08$ of the light at 4800 Å, a galaxy of spectral type G0 or later contributing the remainder, and a typical Seyfert 1.8 emission-line spectrum. The [O III] temperature is 21,000 K, and the density from [S II] is $1.5 \times 10^3$ cm$^{-3}$ or less. We classify Mrk 744 as a Seyfert 1.8, taking into consideration the broad Hα component and the weaker broad Hβ component.

Our spectrum of Mrk 1066 consists of an $\alpha = 2.4 \pm 0.2$ power law contributing $0.55 \pm 0.02$ of the light at 4800 Å, a spectral type G0 or later galaxy contributing the rest, and a typical Seyfert 2 emission-line spectrum. From the Balmer decrement the internal reddening in Mrk 1066 is $E_{B-V} = 0.93$. The [O III] temperature is 16,500 K, the [N II] temperature is 10,600 K, and the density from [S II] roughly $1.1 \times 10^3$ cm$^{-3}$. No broad-line Balmer components are visible, and hence we classify Mrk 1066 as a Seyfert 2 galaxy.

The very rich emission-line spectra of Mrk 744 and Mrk 1066 reported by ALS 79 and ALS 81 respectively are not confirmed. We feel that many of their fainter line identifications are fragments of continuum between neighboring pairs of absorption lines, or in some cases possibly even peaks in the statistical noise of the spectra.

The authors wish to thank O. Dahari and J. M. Shuder for their invaluable assistance in obtaining, reducing, and analyzing the data presented in this paper. W. C. Keel made available two of the “normal” galaxy spectra in advance of publication. D. E. O. also wishes to thank the National Science Foundation for their partial support of this research under grant AST 79-19277.

REFERENCES


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