THE REDSHIFT OF THE QSO PKS 1158 + 007

M. M. PHILLIPS AND STEVEN A. HAWLEY
Cerro Tololo Inter-American Observatory,* La Serena, Chile
Received 1978 August 31

We have obtained a spectrum of the QSO PKS 1158 + 007 from which we derive a redshift of 1.383 instead of the previously published value of 0.325. Our redshift removes the apparent anomaly of broad (5400 km sec^{-1}) forbidden-line emission.

Key words: quasi-stellar object—redshift

Wright et al. (1977) report a redshift $z = 0.325$ for the radio source PKS 1158 + 007 based on the identification of emission lines at $\lambda 6631$, $\lambda 4956$, and $\lambda 4525$ with [O III] $\lambda 5007$, [O II] $\lambda 3727$, and [Ne V] $\lambda 3426$, respectively. Additionally, they report a full width at half maximum intensity of 120 Å for the line identified as [O III] $\lambda 5007$. This would imply a velocity width of roughly 5400 km sec^{-1} making PKS 1158 + 007 an apparent exception to the rule that in Seyfert galaxies, radio galaxies, and QSOs the forbidden lines do not have the great breadths of the permitted lines.

The purpose of this note is to report on a spectrum of PKS 1158 + 007 we have recently obtained with the SIT vidicon spectrograph (Atwood et al. 1979) on the CTIO 4-m reflector in the wavelength region $\lambda\lambda 3300$–7200. This spectrum, representing a total integration time of 30 minutes, is presented in Figure 1. The continuum magnitude of this object is approximately 19th, and thus the signal-to-noise ratio of the spectrum is relatively poor. Nevertheless, two broad emission lines are clearly present, with centroids at observed wavelengths of approximately 6672 Å and 4549 Å. Shown under the spectrum are the positions and wavelengths of the lines observed and identified by Wright et al., as given above. Evidently the two strong lines visible in our spectrum are the ones identified by Wright et al. as [Ne V] $\lambda 3426$ and [O III] $\lambda 5007$. Below the spectrum we have also indicated the predicted positions of H$\gamma$ $\lambda 4340$, H$\beta$ $\lambda 4861$, and [O III] $\lambda 4959$ if the redshift of $z = 0.325$ is correct.

There are several reasons why we believe that the redshift of PKS 1158 + 007 is not $z = 0.325$. First, there is no evidence in our spectrum of H$\gamma$, H$\beta$, or [O III] $\lambda 4959$ emission. In particular, the latter line should be present at one-third of the strength of [O III] $\lambda 5007$. The absence of Balmer-line emission would also make the spectrum of this object unlike that of any other known QSO. A further difficulty is the intensity ratio of [Ne V] $\lambda 3426$ to [O III] $\lambda 5007$, which would be much larger than that observed for other low-redshift QSOs (Baldwin 1975). Finally, we measure a full width at half-maximum in excess of 140 Å for the line identified as [O III] $\lambda 5007$. As mentioned previously, such a large width for a forbidden line has never before been encountered.

We believe that our spectrum is more consistent with a redshift of $z = 1.383$. The two strong lines are then identified with C IV $\lambda 1909$ and Mg II $\lambda 2798$. Not only do these identifications give better agreement for the redshift than do those of Wright et al., but the problems mentioned in the previous paragraph are also avoided. A similar confusion of redshift occurred for the QSO 4C 55.27, where lines identified with [Ne V] $\lambda 3426$ and [O III] $\lambda 5007$ were subsequently shown to be C IV $\lambda 1909$ and Mg II $\lambda 2798$ emission (Hawley, Miller, and Weymann 1977).

Observations of PKS 1158 + 007 in the blue should reveal C IV $\lambda 1549$ emission at an observed wavelength of approximately 3700 Å if our redshift of $z = 1.383$ is correct. P. Osmer of CTIO recently obtained a low-resolution (~ 40 Å) spectrogram of PKS 1158 + 007 for us with the SIT-vidicon on the 4-m telescope. The spectrum covers the wavelength range $\lambda\lambda 3200$–6000, and shows the predicted C IV $\lambda 1549$ line to be strongly in emission at an observed wavelength of 3693 Å. The previously identified C IV $\lambda 1909$ line is weakly evident in this spectrogram, and He II $\lambda 1640$ emission may also be present.

One aspect of the spectrum of PKS 1158 + 007 which is interesting is the existence of an emission line at $\lambda 4956$ seen by Wright et al. which they identified as [O II] $\lambda 3727$. We see a very weak, broad emission feature at $\lambda 4930$ which with $z = 1.383$ corresponds to rest wavelength $\sim \lambda 2070$. So far as we are aware no one has called attention to an emission line at this wavelength in moderate-redshift QSOs. However, our reconnaissance of the literature reveals a small number of published spectra of moderate redshift QSOs in which a line near $\lambda 2070$ is present (e.g., Burbidge 1977; Baldwin and Netzer 1978). We searched the UH-
Fig. 1—SIT vidicon spectrum of PKS 1158 + 007. The data are plotted on a relative $F_x$ scale versus observed wavelength. Below the spectrum are shown the positions, wavelengths, and proposed identifications of the three emission features observed by Wright et al. Also plotted are the positions of the $\text{H}_\gamma$, $\text{H}_\beta$, and $[\text{O} \text{III}] \lambda 4959$ lines if their redshift of $z = 0.325$ is correct. Above the spectrum are the identifications we suggest in this paper, which lead to a redshift of $z = 1.383$. Incomplete cancellations of night sky lines are marked NS.

traviolet Multiplet Table (Moore 1962) but were unable to find a satisfactory identification for this line. The observational data are meager at this time and a positive identification may have to wait for a more accurate wavelength and perhaps a better idea of whether this emission line is generally present.

REFERENCES

Moore, C. 1962, An Ultraviolet Multiplet Table, Circular of the National Bureau of Standards 488, Section 4.