Reddening in the Narrow-Line Region of Active Galactic Nuclei

I.M.Yancoulova[1] and Z.I.Tsvetanov[2,3]

[1]*Dept. Astronomy, University of Sofia, 5 Anton Ivanov Str., 1126 Sofia, Bulgaria*
[2]*Dept. Astronomy, Bulgarian Acad. Sci., 72 Lenin Blvd., 1784 Sofia, Bulgaria*
[3]*ESO, Karl-Schwarzschild-Str. 2, D-8046 Garching bei München, FRG*

1 Introduction

The best indicators of the reddening in the narrow-line regions of AGN are ratios of pairs of forbidden lines arising from a common upper level. The ratios of [SII] $\lambda 4072/\lambda 10320$ and [OII] $\lambda 7325/\lambda 2470$ are good examples, but they include lines in the far ultraviolet and infrared regions which are difficult to observe.

Another possibility is to use line-ratios in a more accessable optical region. Allen (1979) suggested a combination of [OII] $\lambda 7325/\lambda 3727$ (or R_O) and [SII] $\lambda 4072/\lambda 6725$ (or R_S) ratios ($R_O \times R_S$ *vs* R_O/R_S diagram) as a reddening indicator in the NLR. This method was later used in reduced form by Malkan (1983) (R_O/R_S diagram) to estimate reddening in a number of AGN he had observed. The main assumpion of both Allen (1979) and Malkan (1983) is that the narrow emission-line region is homogeneous in density and temperature.

There are two arguments against this assumption. First, it was shown that a correlation between FWHM and N_{cr} (critical density) existed in a number of objects. The general conclusion is that there are probably clouds of a range of densities (10^2 - 10^7 cm^{-3}) in most AGN narrow-line regions. Second, it can be shown that most of the emission in a given line comes from the region where $N_e \approx N_{cr}$, consequently, the suggestion in the Allen and Malkan papers that [SII] $\lambda 4072, \lambda 6725$ and [OII] $\lambda 3727, \lambda 7325$ lines were formed under the same conditions (densities and temperatures) is not correct. It is prefarable that the ratio of lines of equal or similar critical densities should be used in determining the reddening in the NLR and therefore we suggest that the following line ratios could be used:

$$\frac{[SII](\lambda 6717 + \lambda 6731)}{[OII](\lambda 3726 + \lambda 3729)} = \frac{N(S)}{N(O)} R_3 \frac{X(S^+)}{X(O^+)}, N_{cr} \approx 10^3 cm^{-3}$$

$$\frac{[SII](\lambda 4069 + \lambda 4076)}{[OII](\lambda 7320 + \lambda 7330)} = \frac{N(S)}{N(O)} R_6 \frac{X(S^+)}{X(O^+)}, N_{cr} \approx 10^6 cm^{-3}$$

where $N(S)$ and $N(O)$ are S and O relative abundances, $X(S^+)$ and $X(O^+)$ — the degree of ionization of S and O, and R_3 and R_6 are functions only of N_e, T_e and atomic pameters.

D. E. Osterbrock and J. S. Miller (eds.), Active Galactic Nuclei, 329–330.

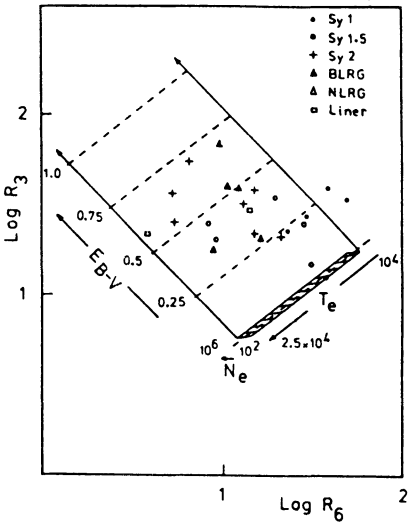

Fig. 1. R_3/R_6 diagram. The hatched area is the zero reddening range where $10^2 \leq N_E \leq 10^6 cm^{-3}$ and $10000 \leq T_e \leq 25000K$. The objects are plotted assuming $N(S)/N(O) = 0.34/8.3$ and $X(S^+)/X(O^+) = 1$.

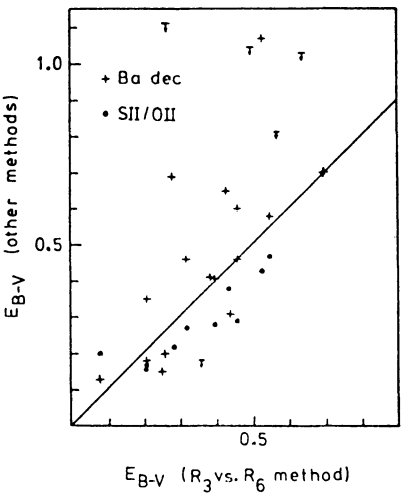

Fig. 2. Comparison of reddening estimated via the SII/OII method (all data taken from Malkan (1983)) - • (filed circles); via the Balmer decrement - + (crosses) and via the R_3/R_6 method.

2 Results

The equilibrium equations for 5-level approximation of S^+ and O^+ are solved numerically and results are shown in Fig. 1. In order to use the R_3/R_6 diagram for reddening determination it is necessary to know $N(S)/N(O)$ and $X(S^+)/X(O^+)$. Different values of those ratios would shift an arbitrary point on Fig. 1 along the 45° line which is almost parallel to the constant reddening line. For this reason it is not necessary to know the precise values of $N(S)/N(O)$ and $X(S^+)/X(O^+)$, but only whether those two ratios are changed when going from low- to high density clouds. Reasonable first approximation is that $N(S)/N(O)$ and $X(S^+)/X(O^+)$ ratios remain constant throughout NLR.

The data for 25 objects taken from the literature are plotted in Fig. 1. Despite the small number of objects a slight tendency is present for the Sy1 galaxies to have smaller reddening compared to that of type 2 galaxies.

Fig. 2 shows the comparison of the reddening estimated by the three methods. An intrinsic value of $H_\alpha/H_\beta = 3.0$ was used. It is clearly seen that Malkan's method gives lower reddening comparing with the R_3/R_6 method while the values determined by the hydrogen lines are higher.

References

Allen, D.A., 1979. *Mon. Not. R. astr. Soc.*, **186**, 1P.
Malkan, M.A., 1983. *Astrophys. J.*, **264**, L1.

https://doi.org/10.1017/S0074180900141245 Published online by Cambridge University Press