ANALYSIS OF THE OBSERVED APPARENT CORRELATION OF LINE LUMINOSITY WITH REDSHIFT FOR FR TYPE II AGNs

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ABSTRACT

We investigate the reported correlation of emission line luminosity with redshift in radio-loud FR II elliptical galaxies. This is with a view to testing if this relationship is real or merely an artefact of luminosity selection effects, since the condition is ubiquitously absent in the lower redshift, FR I elliptical galaxies.

1. INTRODUCTION

Most classes of Active Galactic Nuclei (AGNs) exhibit strong emission lines which are photonoized by the UV continuum of the central continuum source which is probably powered by accretion of matter into a massive balckhole. Current classification groups objects with strong broad permitted lines as belonging to type I AGNs while those with narrow emission lines are designated as type II AGNs. While the type I AGNs have both broad permitted and narrow forbidden lines, type II AGNs have only narrow forbidden lines in their spectra. The emission line width is also used to classify these objects into broad line radio galaxies (BLRGs) and narrow line radio galaxies (NLRGs). The radio loud type II AGNs (i.e. NLRGs) include two distinct morphological types: the low luminosity FR I (Fanaroff and Riley, 1974) type radio galaxies and their high luminosity FR II counterparts. Generally, there exists a strong correlation between luminosity (P) and redshift (z) in extragalactic sources at both high and low z. However, for the emission-line luminosity (L_{line}) data, while the P-z correlationship is observed for the high luminosity FR II radio-loud elliptical galaxies, it is absent in the low z, FR I counterparts. In the subsequent analysis, we estimate the contribution of luminosity selection effects to the observed strong L_{line}-z correlation for the FR II galaxies in our sample to check if this correlation is significant or merely artificial. Our data is taken from Zirbel and Baum (1995) and contains 136 FR II galaxies but we excluded those sources without spectral index (α) and/or L_{line} values in our analysis.

2. ANALYSIS AND RESULT

Previous investigations of radio loud objects have revealed a flattening of their spectral slopes with increasing z for both radio-loud and radio-quiet types up to $z \leq 2$ (Schartel et al.,1996). Studies of the variation of α with z independent of P is normally performed using samples of sources which have approximately the same median P but a wide range in z (Ubachukwu et al., 1996). This arrangement will enable some quantitative assessments to be provided for the contribution of luminosity selection effects in the observed α-z relationship. Ubachukwu et al. (1996) have shown that if α correlates with both z and P (here emission-line luminosity, L_{line}) the functional relationship can be parametized respectively as,

$$\alpha(z) = a_1 + m \log(1+z) \quad (1)$$

$$\alpha(L_{line}) = a_2 + n \log(L_{line}) \quad (2)$$

However, it has further been shown that a power-law variation of P with z exists (which is only applicable above some z cut-off; Ubachukwu et al. (1993)) of the sort,

$$L_{line} = L_{line(o)} (1+z)^{\beta} \quad (3)$$

where β is a constant arising largely as a consequences of luminosity selection effects (if the P-z relation is entirely attributable to it). Hence, incorporating Eq. (3) into Eq. (2) we have,

$$\alpha(L_{line}, z) = a_2 + n\beta \log(1+z) + n \log_{line\ (o)} \quad (4)$$

$$= a_3 + n\beta \log(1+z) \quad (5)$$

where $L_{line(o)} = L_{line}$ (z = 0) and $a_3 = a_2 + n\log L_{line(o)}$.
Eqs. (1) and (2) will enable us to estimate the contribution of luminosity selection effects in the source sample since if the observed L_{line}-z correlation is attributable to it, then $m \approx n\beta$; else the residual z dependence, x can be estimated as

$$x = m - n\beta \quad (6)$$

We analyze the emission-line fluxes for a large sample of radio-loud, high z ($z > 0.5$) type II AGNs as compiled by Zirbel and Baum (1995). The sample consists of narrow emission-line luminosities measured in Hα + (N II) $\lambda\lambda$ 6584, 6548 and excludes all measurements of broad emission-lines. This implies that for the BLRGs we only considered their narrow emission fluxes and for those sources measured at (O II) λ 3727 or in (O III) λ 4959/λ5005 their fluxes were converted to Hα flux by using the empirical relation Hα/(O II) = 4.0 and Hα(O III) = 1.1 (McCarthy, 1987). Our analysis is carried out using the steep radio spectra (α > 0.5) components since inclusion of the flat spectra (α<0.5) components is likely to complicate interpretation of the resultant numerical results (Kapahi and Kulkari ,1990). We have adopted H_o = 50 Km/h/Mpc, q_o = 0.0 and $S_\nu = S_o \nu^{-\alpha}$ where S_o is the monochromatic flux. We shall first investigate the dependence of α on z and L_{line} independent of each other by fitting the observed data to Eqs. (1) and (2). This produced the following empirical relationships,

$$\alpha (z) = - 0.17 + 0.26 \log (1+z) \quad (7)$$

$$\alpha (L_{Line}) = 0.26 + 0.06 \log L_{line} \quad (8)$$

with correlation coefficients, γ = 0.6 and 0.66, respectively. These correlations are significant. However, to investigate the effect of luminosity, on the above relationships we fitted the observed log L_{line} – log (1+z) data into Eq. (3) and obtained,

$$\alpha(z) = 34.2 + 3.80 \log (1+z) \quad (9)$$

Eq.(9) implies that β = 3.8, agreeing closely with β 4.0 found by Ubachukwu et al. (1996). Therefore, using β = 3.8 plus m = 0.26 and n = 0.06 (from Eqs. (8) and (9) respectively) Eq. (6) which expresses the expected redshift dependence, x yields,

$$x = 0.26-0.06 \times 3.80 \sim 0.032 \quad (10)$$

Equation (10) is expected to give a null result if m = n β. This condition is virtually true here as the difference is negligible and indicates that only ~12% of the observed α - z correlation is intrinsic with the rest contributed by luminosity selection effects.

In conclusion, we have demonstrated in the foregoing analysis that the reported (artificial) correlation in emission-line luminosity with redshift for FR II radio-loud elliptical galaxies is not true but is merely an artefact induced by luminosity selection effects in the sample. It seems rather more correct that there is no correlation in the emission-line luminosity with z for both the FR II and FR I radio-loud elliptical galaxy types.

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