CHARACTERIZING RADIO GALAXY EVOLUTION USING THE K-Z RELATION

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ABSTRACT

Using data from the 3CRR, 6CE, 6C*, 7C I-III, SDSS, and 2MASS surveys, I analyzed the relationship between redhift (z) and luminosity (K) of radio galaxies, comparing my results to those of previous records in order to confirm the conclusions on the evolution of radio galaxies.

INTRODUCTION

Radio galaxies- radio loud (emits strong radio waves)

-Why radio? Radio waves pass through dust/obstacles

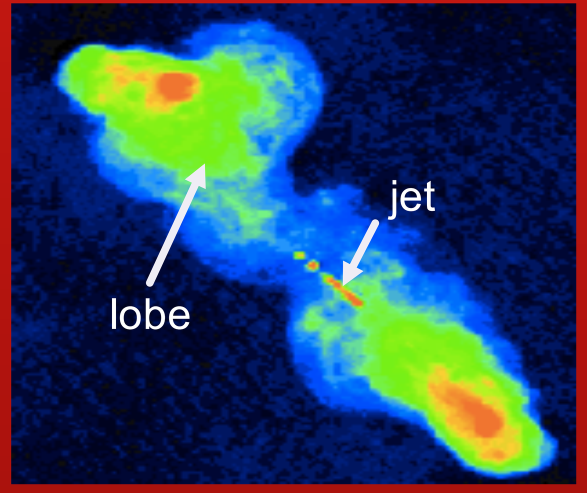


Figure 1.Radio image taken by NRAO [16]

-FRII Radio Galaxy (high luminosity)- most common type of radio galaxy; jets emit radio radiation and create double lobes

-Most of the luminosity is concentrated at the edges (hotspots)

K-magnitude-logarithmic measure of luminosity in K-band (20-40 GHz); larger K-magnitudes are fainter luminosity [13]

Redshift (z) –(similar to Doppler effect) expansion of universe shifts emitted light to redder spectrum; measure of distance and age (higher z = farther = older) [15]

K-z relation- the farther (large z), the fainter (large k)

Measurement of Redshift

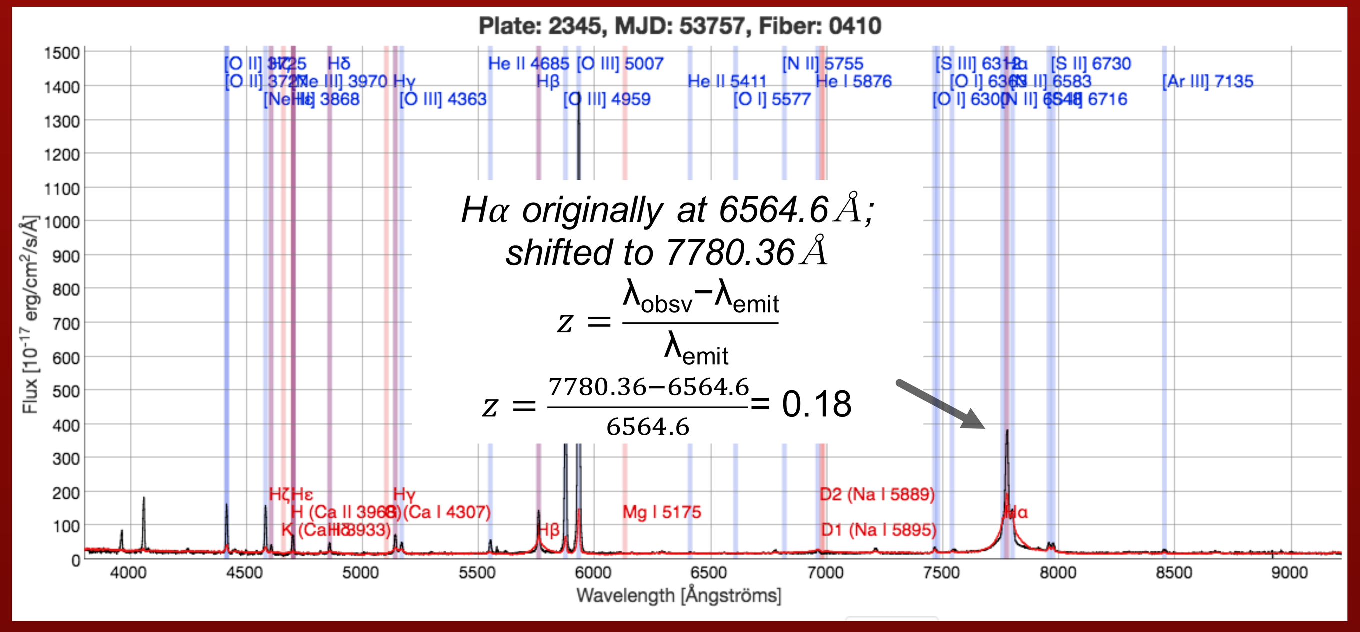


Figure 2. Taken from SDSS DR 12 [9]- optical electromagnetic spectrum of radio galaxy; redshifted 0.18

PREVIOUS STUDIES

Eales et. al 1997- found increased dispersion of K in high redshifts; concluded radio galaxies must form at z=2

Bryant et al. 2009- found no increase in dispersion of K

-(σ = 0.7 at all redshifts)

Willott et al. 2003- found no increase in dispersion; thus radio galaxies formed at high redshift (z>3) and passively evolved

RADIO GALAXY SURVEYS

3CRR: 178 MHz; flux density limit- $S_{178} > 10.9$ Jy

6CE/6C*: 151 MHz; flux density limit- $.96 < S_{151} < 3.93$ Jy

7C (I-III):151 MHZ; flux density limits of $S_{151} > 0.5$ Jy

SDSS/2MASS: FR-II galaxies corroborated by multiple sources (taken from 3C-7C surveys)

** Reliability: surveys all used in multiple papers/studies

ANALYSIS

-Compiled data: K-magnitudes are corrected for instrument aperture and emission lines (3CRR, 6CE/6C*, 7C)

**Use of 2MASS K-magnitudes with SDSS redshifts (instead of SDSS magnitudes) because 2MASS data is more suitable for radio (SDSS filters are only accurate until infrared)

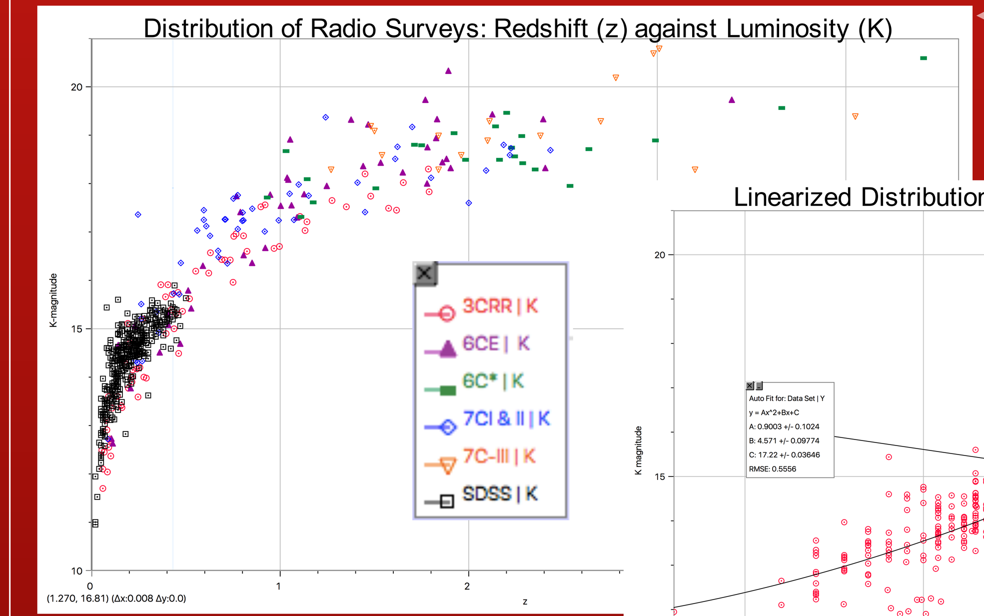


Figure 3. Distribution of all data; graphed redshift against K-magnitude; adjusted scale, starting from origin.

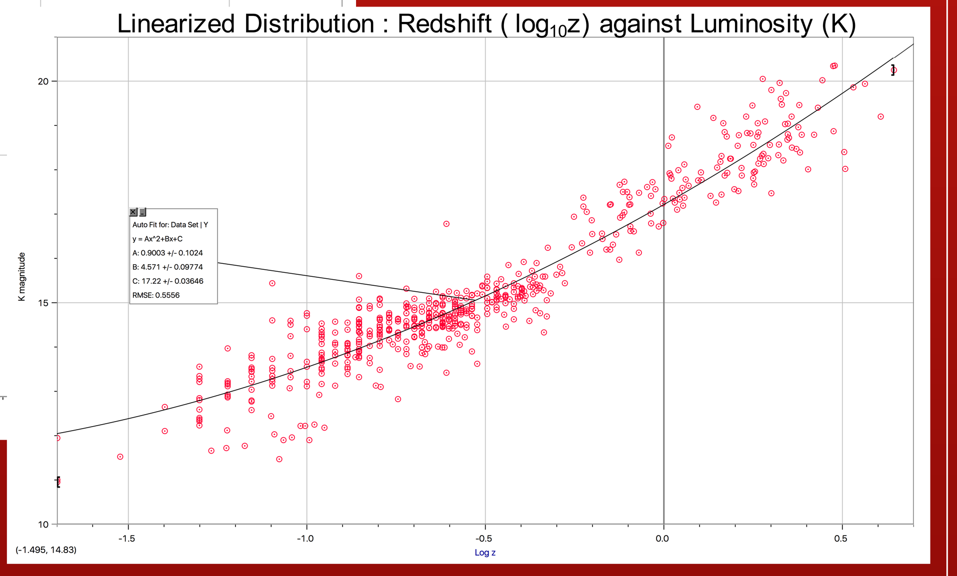


Figure 4. Distribution of all data; $\log_{10}$ (redshift) against K-magnitude; fitted with best curve fit.

Figure 4: Linearized model (log z) is fitted to an quadratic equation which had the lowest RMSE of 0.5556

$$K(z) = C + B \log_{10} z + A(\log_{10} z)^2$$

A = 0.9003 +/- 0.1024

B = 4.571 +/- 0.09774

C = 17.22 +/- 0.03646

-My model is similar to previous models (especially Willott et al 2003), but has a positive A coefficient because of more faint galaxies at lower redshifts make the model curve upwards. ** Note that SDSS compiled data covers various frequencies/flux limits

Sample	Flux limit	Frequency	Best fit to $K - z$	References
3CRR	10.9 Jy	178 MHz		
6C	2.0 Jy	151 MHz	$K(z) = 17.37 + 4.53 \log_{10} z - 0.31(\log_{10} z)^2$	Willott et al. (2003)
7CRS	0.5 Jy	151 MHz		
NVSS-EIS	7.2 mJy	1.4 GHz	$K(z) = 17.62 + 4.04 \log_{10} z - 1.39(\log_{10} z)^2$	Brookes et al. (2006)
FIRST-Boötes	1.0 mJy	1.4 GHz	$K(z) = 17.90 + 4.30 \log_{10} z$	EL Bouchefry & Cress 2007
FIRST-Boötes/Cetus	1.0 mJy	1.4 GHz	$K(z) = 17.50 + 4.13 \log_{10} z - 0.30(\log_{10} z)^2$	This work
	—	874 MHz	$K(z) = 17.75 + 3.64 \log_{10} z$ at all redshift	Bryant et al. (2009)
MRCR-SUMSS	—	874 MHz	$K(z) = 17.76 + 3.45 \log_{10} z$ at $z > 0.6$	Bryant et al. (2009)
	—	874 MHz	$K(z) = 17.89 + 3.11 \log_{10} z$ at $z > 1$	Bryant et al. (2009)

Figure 5. From Bouchefry 2008 [2]- Compilation of models over 5 sources

CONCLUSION

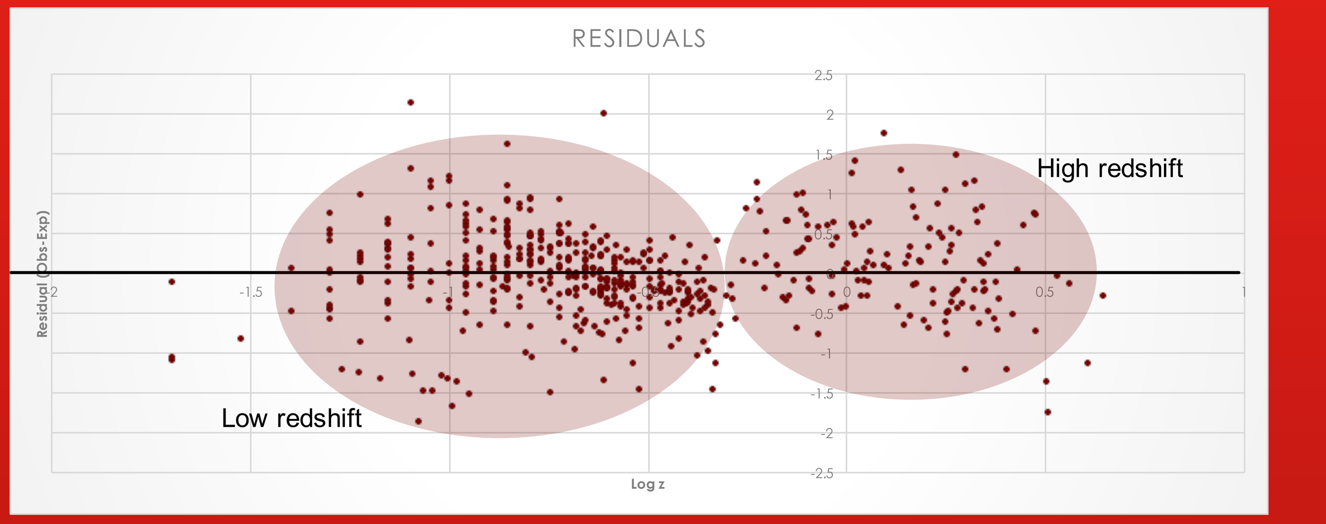


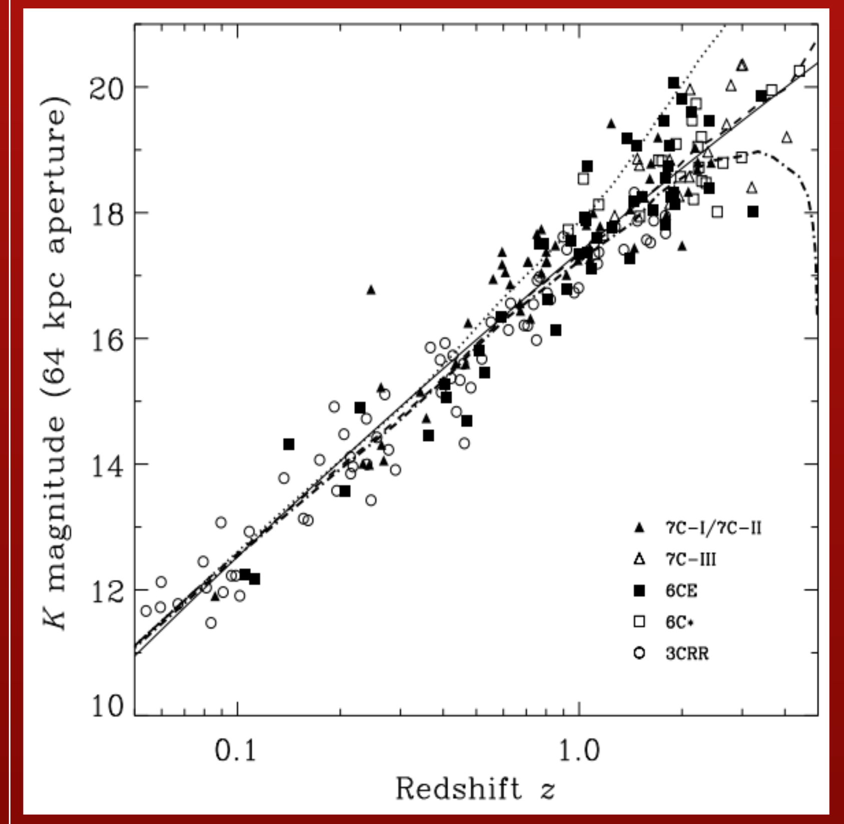
Figure 6. Residuals for data and equation of Figure 4; log z plotted against residuals

-Dispersion: σ=0.5569 (there are separate dispersions for low/high redshift residuals)

-low redshift (z<.5): σ=0.537; high redshift (z>.5): σ=0.613

-Slight increased dispersion at high redshifts is possibly accounted for by fewer points from high redshift surveys

Model follows passively evolving instantaneous burst model (galaxies form at high redshift and passively evolve until present day) [1]



-Upper dotted line is a model for galaxies with no stellar evolution

-At high redshift (3CRR, 6CE/6C, 7C), data diverges from this dotted line, suggesting stellar formation must be at high redshift.*

-But lower values follow the dotted line suggesting no stellar formation after (ie. passive evolution)

Figure 7. From Willott et al. 2003 [1]- Distribution of 3CRR, 6CE/6C*, and 7C (I-III) based on relativistic Doppler effect and graphed with model curves for non-stellar evolution and passive.

My model curves upwards at lower redshifts and shows fainter luminosity than the expected linear pattern, thus more powerful radio sources at high redshift/ earlier epochs. This suggests a decline in formation of powerful radio galaxy in present day. [1]

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ACKNOWLEDGEMENTS

1. Jeremy Smith
2. Dr. Morris Swartz
3. Kevin Martz
4. Johns Hopkins University Physics Department
5. Quarknet
6. National Science Foundation
7. Dr. Chris Willott
8. Dr. Matt Jarvis