Waveband Luminosity Correlations in Flux-Limited Multiwavelength Data

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Introduction

• Knowing the intrinsic correlations between different waveband emissions is important in many astronomical questions e.g.
  • Radio-far IR correlation
  • Accretion disk vs. jet vs. torus emission in AGN

• Let’s focus on quasars as an example...
Do you see any correlation?

- **Real optical-mid-infrared (SDSS x WISE)**
  - No intrinsic correlation!

- **Real optical-radio (SDSS x FIRST)**

- **Simulated optical-radio**
  - No intrinsic correlation!
How Did That Observed Correlation Get Induced? (SDSS x WISE Dataset)
Correlational Techniques in Bins

• We use the Pearson correlation coefficient (PCC) as a measure of the linear luminosity-luminosity and luminosity-redshift correlations:

\[
r_{xy} = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{N \sigma_x \sigma_y}
\]

• We use the Pearson partial correlation coefficient (PPCC) as a measure of the luminosity-luminosity correlation minus their mutual dependence on redshift:

\[
r_{xy,z} = \frac{r_{xy} - r_{xz} r_{yz}}{\sqrt{(1 - r_{xz}^2)(1 - r_{yz}^2)}}.
\]
Redshift Evolutions & Local Luminosities

- We can determine the “local luminosities” for our data by removing the best-fit redshift evolution from the “raw” luminosities.

- Local luminosity is defined by

\[ L'_a = \frac{L_a}{g_a(z)} , \]

where the best-fit luminosity-redshift correlation is

\[ g_a(z) = \frac{(1+z)^{k_a}}{1+(\frac{1+z}{Z_{cr}})^{k_a}} , \]

Simulated Data (No Intrinsic Correlation)

10 Bins

- Raw luminosities
- Local luminosities

20 Bins

- Raw luminosities
- Local luminosities
Simulated Data (With Intrinsic Correlation)

20 Bins

Raw luminosities

Local luminosities
Real Optical x Mid-IR Data (SDSS x WISE)

20 Bins

Raw luminosities

Local luminosities
Real Optical x Radio Data (SDSS x FIRST)

20 Bins

Pearson Correlation Coefficient

Raw luminosities

Local luminosities
Conclusions

• The observed correlation between two waveband luminosities is not necessarily the intrinsic correlation!
  → Correlations can be induced by flux limits and similar luminosity evolutions with redshift

• Using PCCs and PPCCs in bins of redshift can access whether the observed correlations between two waveband luminosities are intrinsic
  → We’ve shown this with simulated observed data with known degrees of intrinsic luminosity correlation

• We find that in quasars the optical and mid-infrared luminosities are very highly intrinsically correlated, while optical and radio luminosities are less highly intrinsically correlated
  → Supports general picture where accretion disk luminosity is directly responsible for torus luminosity, while jet strength is a function of both black hole size and black hole spin
  → Reminder: Degree of correlation does not indicate functional form of correlation – that can be investigated with different methods