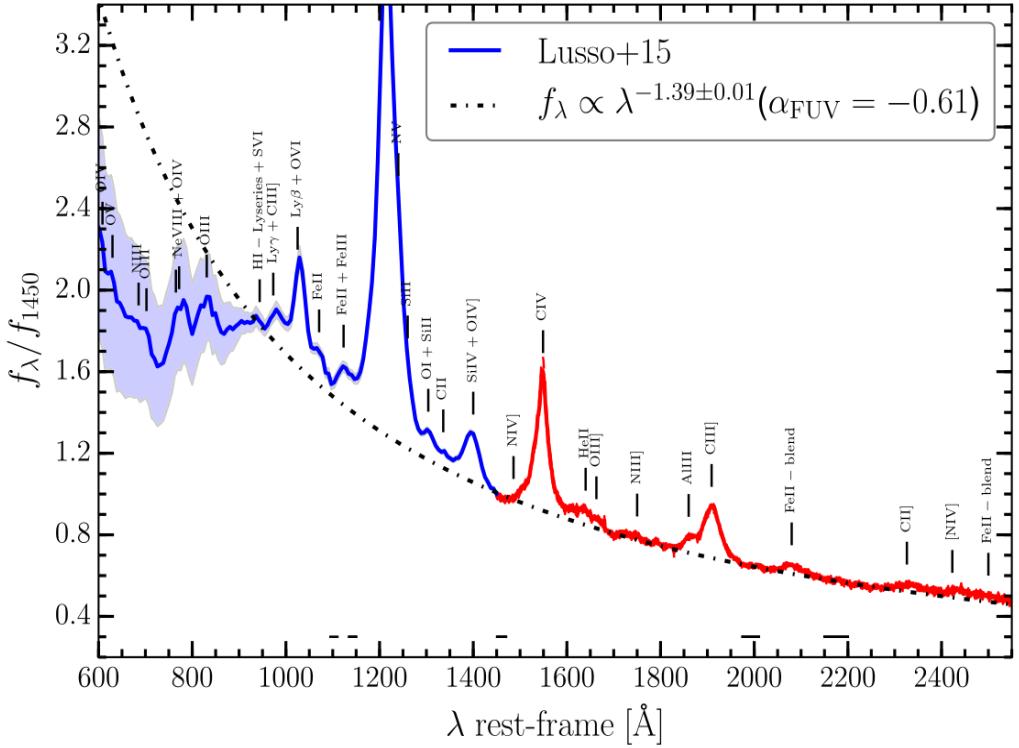
Average Spectral Energy Distribution of AGN by COSMOS and CHORUS Catalog

Tetsuya Ezaki
Waseda University M1

Introduction

- Spectral Energy Distribution（SED）
  →contain lots of information
  ex)emission lines , continuum,
  IGM absorption

Flux density :
$f_\lambda \propto \lambda^{-\alpha-2}$ [erg s^{-1} cm^{-2} Å^{-1}]



Lusso et al.2015

Purpose of Research

- SED by Different Features of AGNs

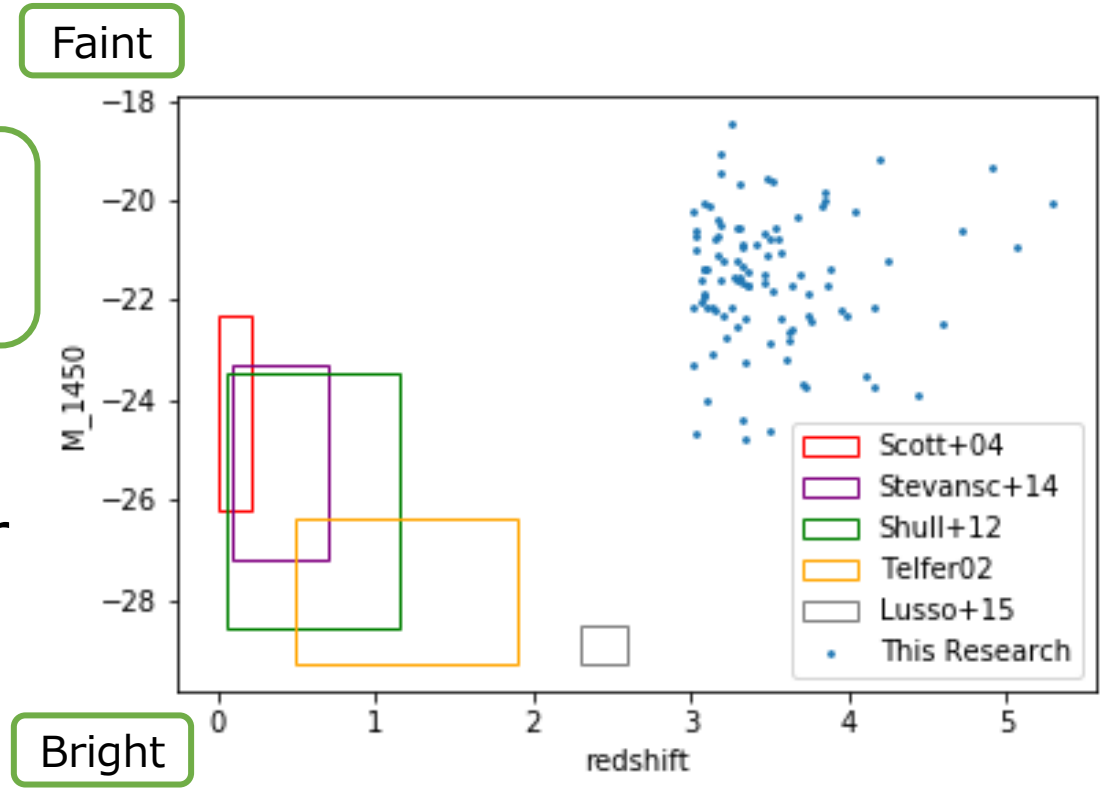
Previous research		This research
Bright	⇔	Faint
Low redshift		High redshift($z \geq 3$)

- SED of AGN is multi-wavelength

⇒Longer wavelength side than Balmer limit

- Subject of Study

100 AGNs in the COSMOS region



Data

- AGN in the COSMOS region
  Two AGN catalogs（Iwata et al.2021 & Kimura et al.2020）
  ⇒Detection of duplicate objects : within 1 arc second
  ⇒Redshift : $z \geq 3$

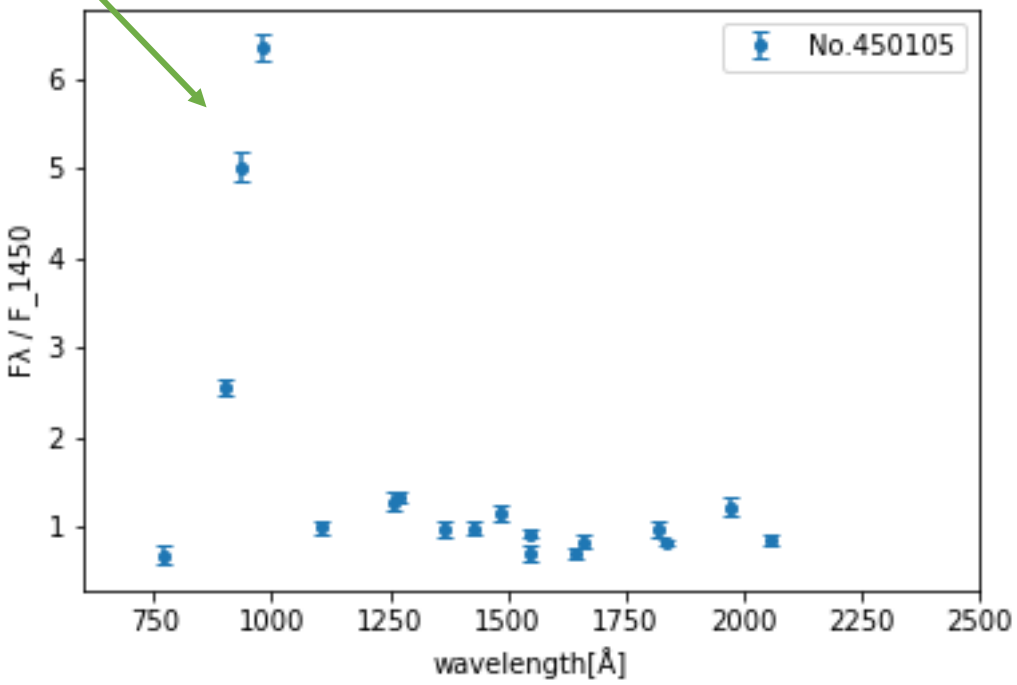
- Obtain data from COSMOS2015(Laigle et al.2016) and CHORUS catalog(Inoue et al.2020)
  ⇒Photometric data measured by 43 filters were used
  ⇒Flux density F&Flux density error δ_F
  ⇒Only data with S/N≧5

100 AGNs

Exclude 4 out of 100 AGNs

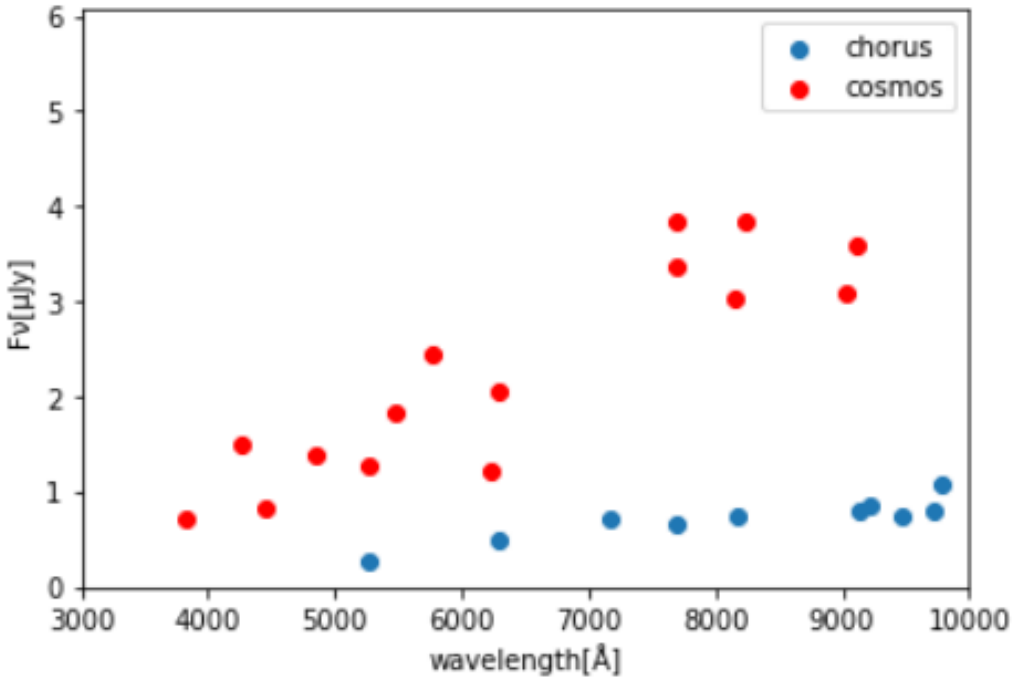
Lyα emission line?

z=3.96



①z might be wrong

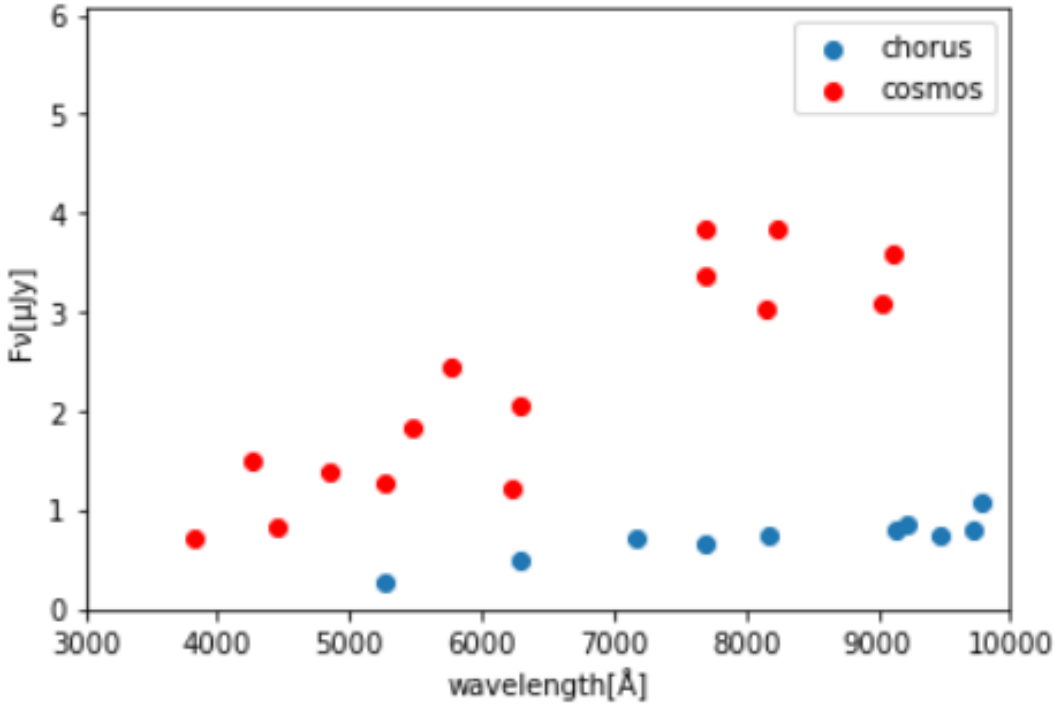
z=3.949



②0.751 arc second away

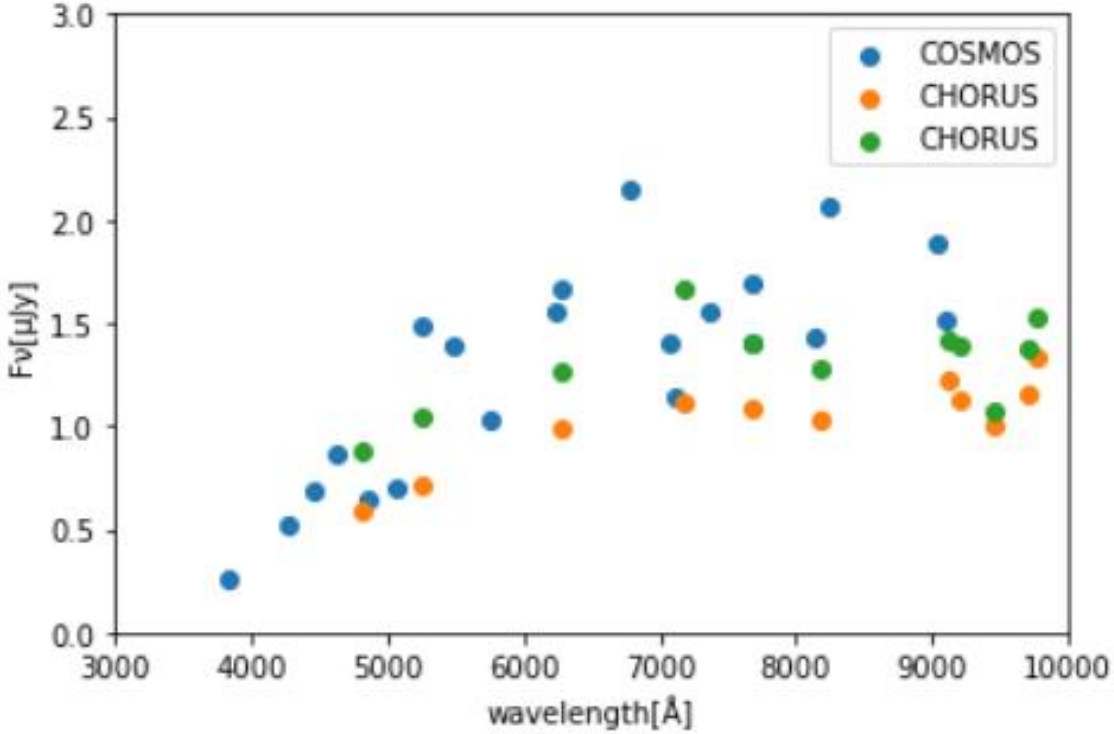
Exclude 4 out of 100 AGNs

z=3.754



③AGN which does not fit the shape of SED

z=3.36



④two detected within 1 arc second

SED with 96 AGNs

Data Analysis

- Normalization

$$F_{norm} = \frac{F_\lambda}{F_{1450}}$$

- Weighted Average

Flux Density :

$$\bar{F} = \frac{\sum_{i=1}^{n} w_i F_i}{\sum_{i=1}^{n} w_i} \quad \left(w_i = \frac{1}{\delta_{F_i}^2} \right)$$

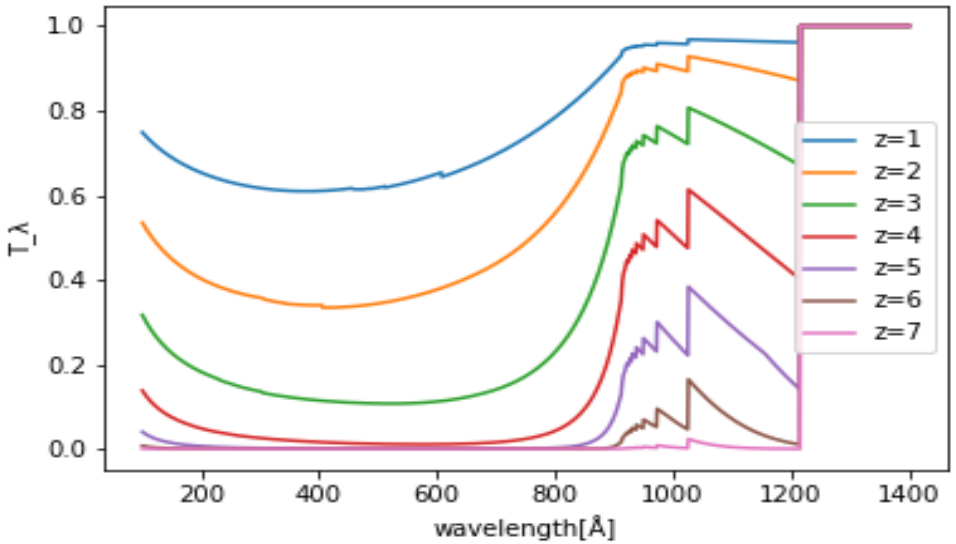
Flux Density error :

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} w_i (F_i - \bar{F})^2}{(n-1)\sum_{i=1}^{n} w_i}}$$

- IGM Correction

⇒Shorter wavelength side than Lyα emission line

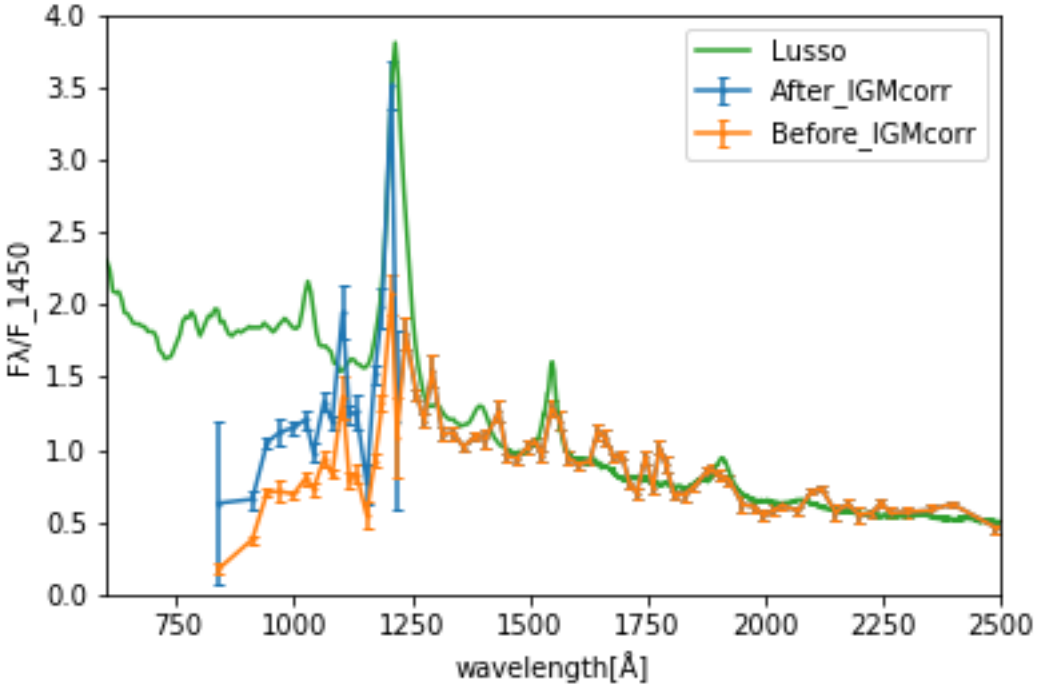
$$F_{correction} = \frac{F_\lambda}{T_\lambda}$$

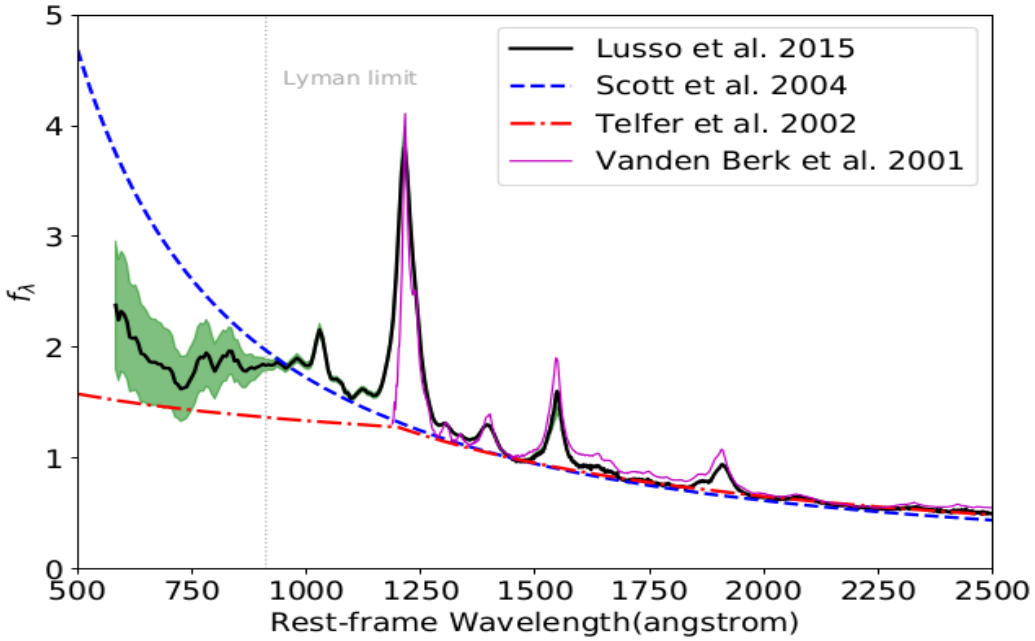


Inoue et al.2014

Comparison with Previous Studies

each bin:40 data





Lusso et al.2015

Lower flux at shorter wavelength side than Lyα

Caused by differences of magnitude?

Magnitude Dependence of Average SED①

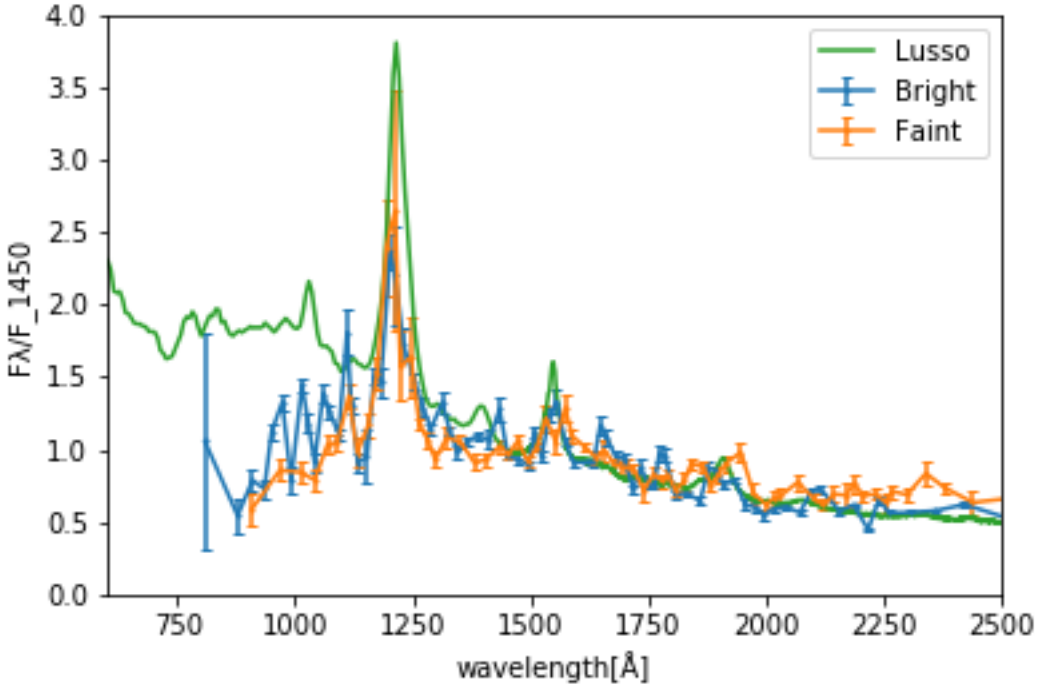
Table 1: Classification of AGNs

Classification	Quantity	Average M_{1450}
Blighter AGN	48	-23.50
Fainter AGN	48	-21.41

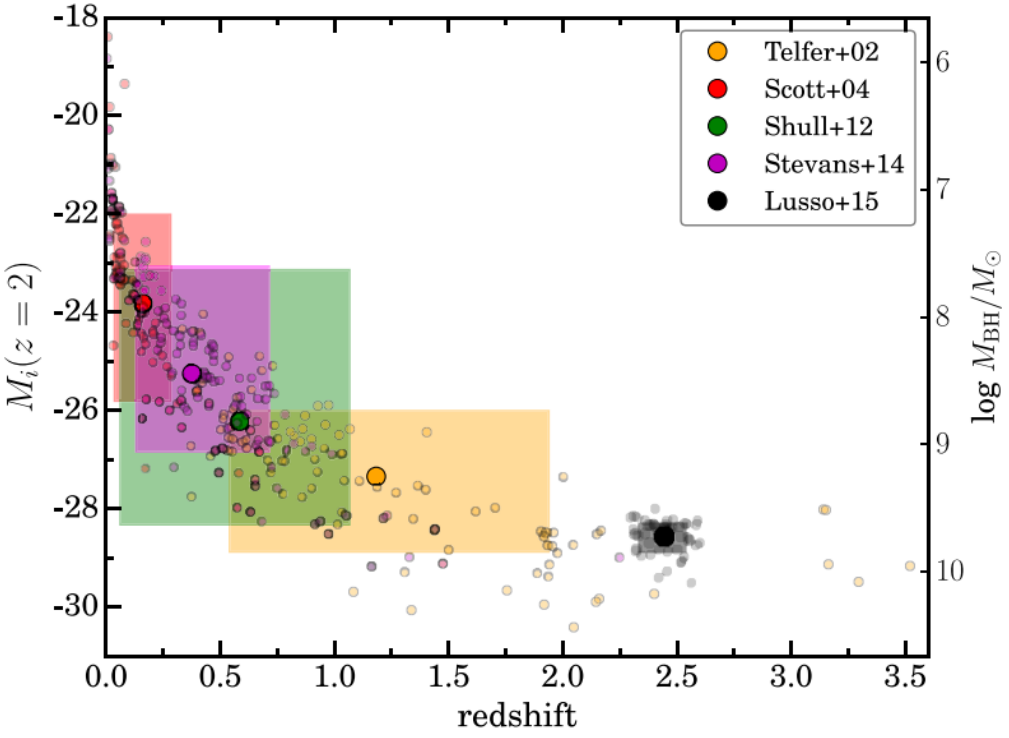
Median : -22.38

- Brighter groups have slightly larger flux density values
- Possibly due to the use of different magnitudes

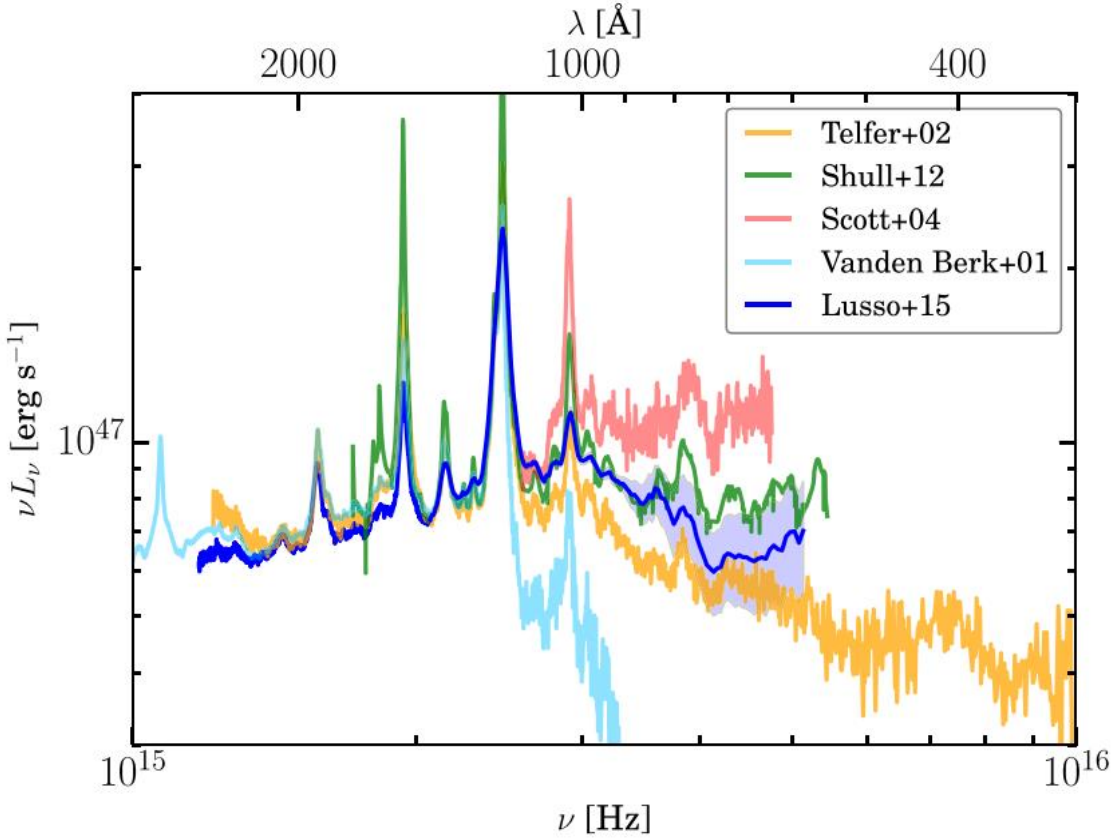
each bin:20 data



Previous Studies



Lusso et al.2015



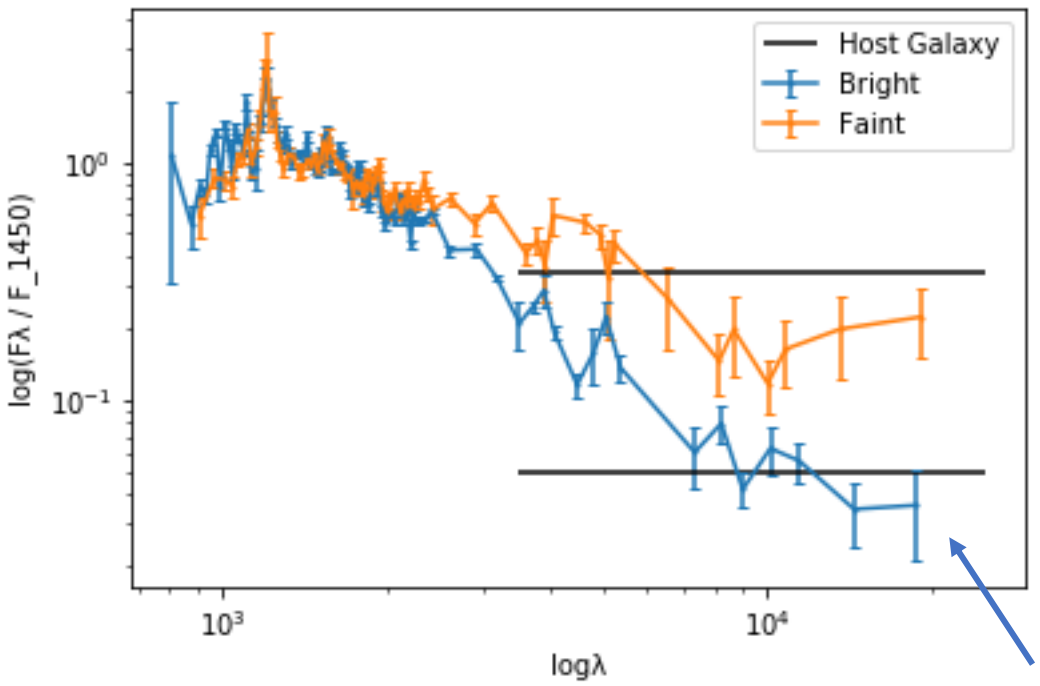
Lusso et al.2015

Magnitude Dependence of Average SED ②

- Upper solid black line:

Weighted average of values than the Balmer Limit

- Differences were observed between bright and faint AGNs



※upper value

Faint AGNs show contributions from the host galaxy

Future Prospect

- Use data of COSMOS2020
- Obtain AGNs with various redshifts and magnitudes
- Unify AGN correction for each previous research

Summary

- Depending on the magnitude of AGNs, flux density differs at shorter wavelengths than Lyα emission lines
- Host galaxy effects dominate at long wavelengths in fainter AGNs
- It would be meaningful to study how the SED changes with AGN of various redshifts and magnitudes

参考文献

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- [4] Kimura et al.2020, 'Properties of AGN Multiband Optical Variability in the HSC SSP Transient Survey',
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- [6] Inoue et al.2014, 'An updated analytic model for attenuation by the intergalactic medium', Monthly Notices of the Royal Astronomical Society, Vol.442, Issue 2, pp.1805, (https://academic.oup.com/mnras/article/442/2/1805/985753)

補足スライド

- 母銀河の明るさは一定と仮定

$$\frac{\tilde{F}_{Gal}}{\tilde{F}_{AGN}} = \frac{\frac{F_{Gal}}{\tilde{F}_{faint}}}{\frac{F_{Gal}}{\tilde{F}_{bright}}} = \frac{\tilde{F}_{bright}}{\tilde{F}_{faint}}$$

- フラックス密度差から等級差を求める

$$M_{faint} - M_{bright} = 1.72$$

- 明暗で分類したときの等級差

$$\Delta M = 2.07$$

補足スライド

$$F_\lambda = C'\lambda^{\alpha-2}$$

$$F_{norm} = C'1450^{\alpha-2}$$

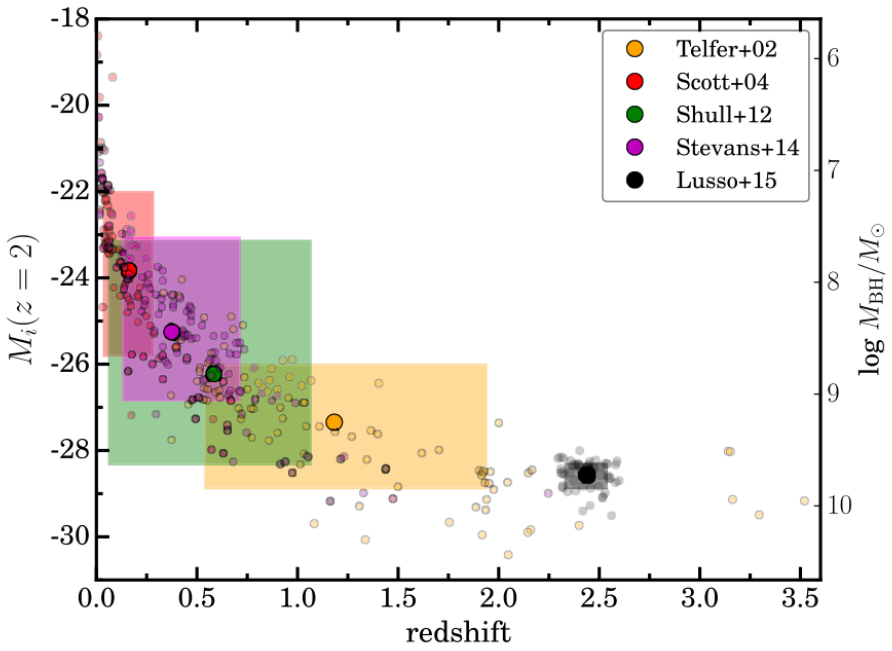
$$F_{norm} = \left(\frac{1450}{\lambda}\right)^{\alpha-2} F_\lambda$$

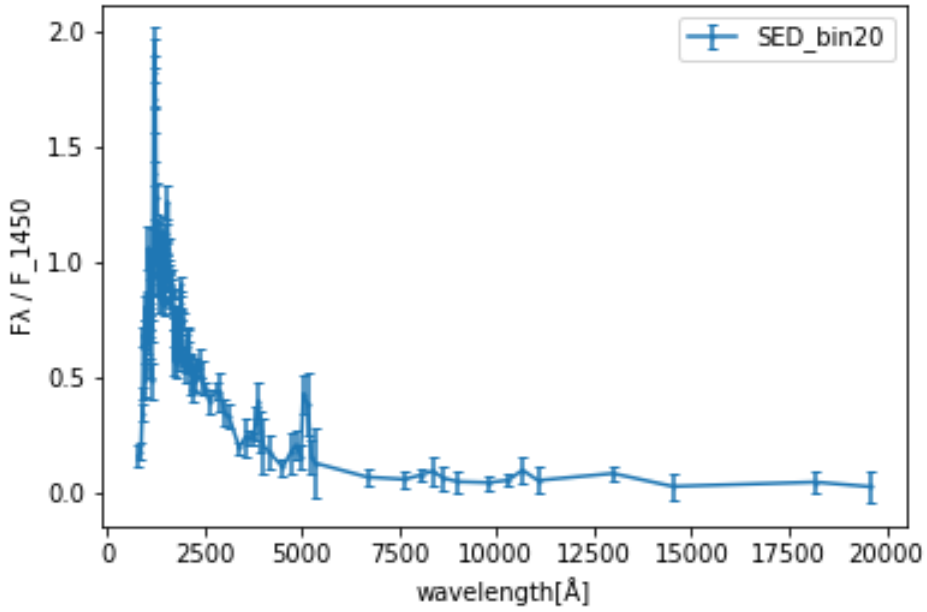
$$\delta_M^2 = \frac{2.5^2}{F_\nu^2\left(\ln 10\right)^2}\delta_{F_\nu}^2 = \frac{6.25}{\left(\mathrm{SN}\right)^2\delta_{F_\nu}^2\left(\ln 10\right)^2}\delta_{F_\nu}^2 = \frac{6.25}{\left(\mathrm{SN}\right)^2\left(\ln 10\right)^2}$$

$$F_\nu = 10^{\left(-\frac{M+48.6}{2.5}\right)}$$

$$\delta_{F_\lambda}^2 = \left(\frac{\partial F_\lambda}{\partial F_\nu}\right)^2 \delta_{F_\nu}^2 = \left(\frac{c}{\lambda^2}\right)\delta_{F_\nu}^2 = \left(\frac{c}{\lambda^2}\right)\delta_M^2 \times \frac{F_\nu^2\left(\ln 10\right)^2}{2.5^2} = \delta_M^2 \times \frac{F_\lambda^2\left(\ln 10\right)^2}{2.5^2}$$

補足スライド


Telfer+02
Scott+04
Shull+12
Stevans+14
Lusso+15
$M_i(z=2)$
$\log M_{\rm BH}/M_\odot$
redshift


SED_bin20
Fλ / F_1450
wavelength[Å]