Covering factor in AGNs: evolution or selection

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Abstract

The covering factor (CF) for the AGN, is defined as the ratio of infrared (L_{ir}) and bolometric (L_{bol}) luminosities. The study of possible evolution of the CF was based on the newest SDSS data from DR16Q. To cover full spectrum from IR to UV the cross-match with WISE, GALEX and UKIDSS was performed. The sample of over 17,000 quasars was derived. Data was further divided into two redshift bins – low-z and high-z quasars. The calculated CF median values of $\log_{10} CF_{low-z}$ and $\log_{10} CF_{high-z}$ may be interpreted as an evolution of CF with redshift. To find out the cause of potential CF evolution the correlation with the AGN global parameters like accretion rate was checked. The L_{ir} vs accretion rate shows separation between low-z and high-z quasars. The possible selection effects, including different calculations of luminosities and the selection of objects with the best WISE S/N ratio, were checked.

Active Galactic Nuclei

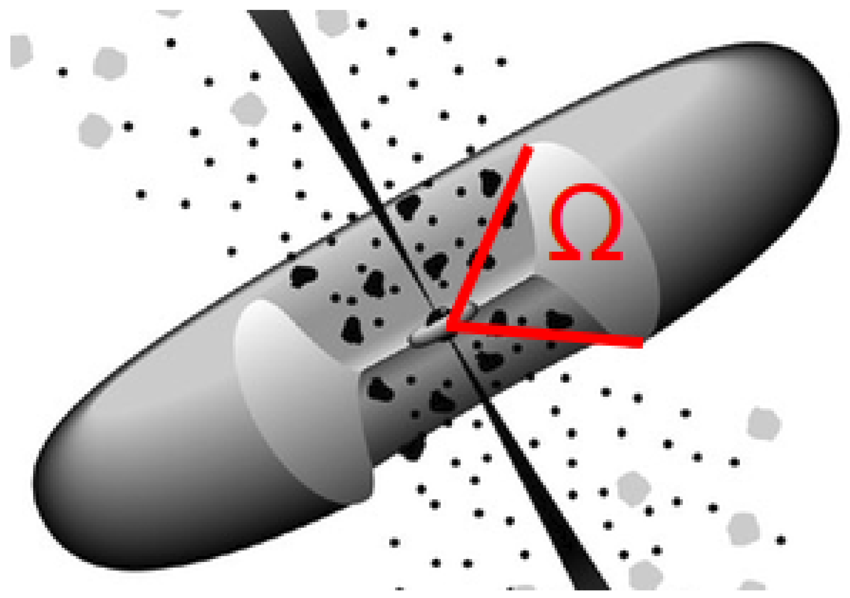


Figure 1. The schematic view of the AGN, based on the unification scheme (CREDIT: Torres & Anchordoqui 2004). In the presented analysis the most important component of AGN is **the dusty torus** - the donut-like shape around the black hole (BH). The solid angle **Ω** (marked with red lines) between the BH and the torus is used to **define the covering factor**.

References

[1] Gu, M. 2013, ApJ, 773, 176
[2] Lyke B. W., et al., 2020, ApJS, 250, 8

Covering Factor (CF)

The CF describes the fraction of **obscuration** of the quasar BH **by the dusty torus**. First studies defined it as the ratio of the solid angle between BH and torus to 4π ($CF = \Omega/4\pi$). Currently an estimation of the CF defined as **ratio between $\mathbf{L_{ir}}$ and $\mathbf{L_{bol}}$** is used. **Assumptions: 1)** L_{ir} is dominated by the hot dust emission from the torus and depends on the amount of captured radiation from the accretion disc. **2)** L_{bol} accounts for the majority of the disc luminosity. Thus its ratio is expected to be directly proportional to the CF.

$$\mathbf{CF = L_{ir}/L_{bol}}$$

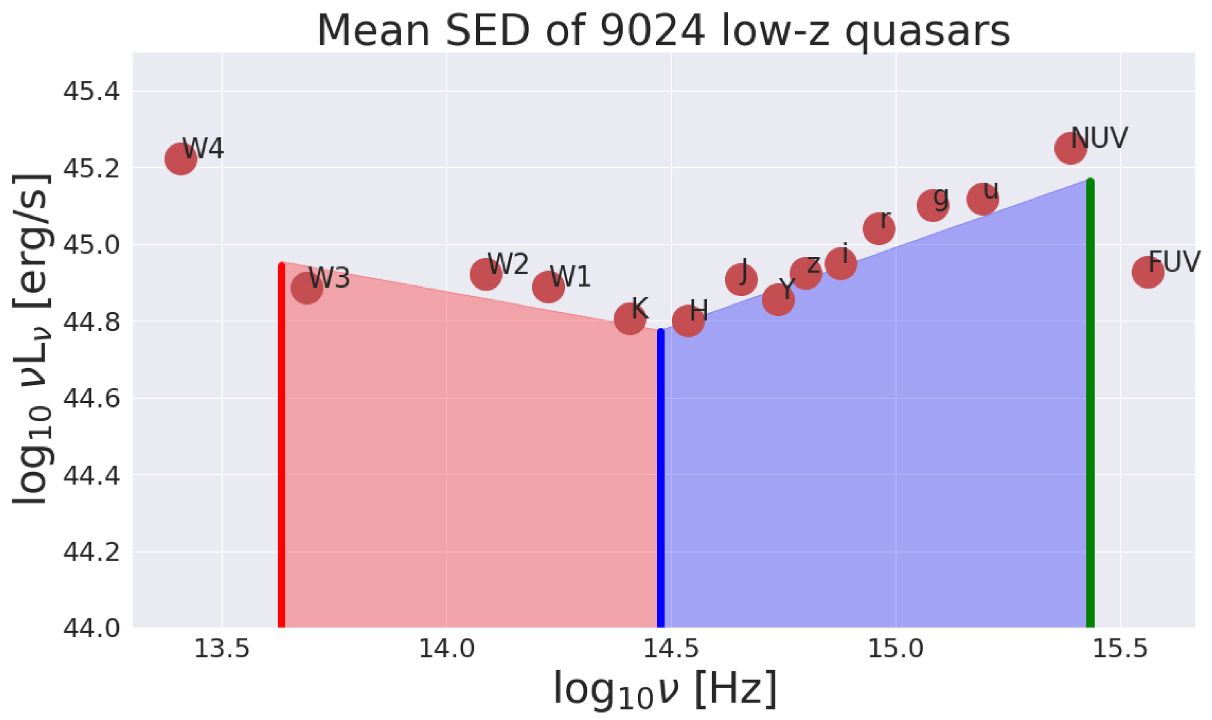
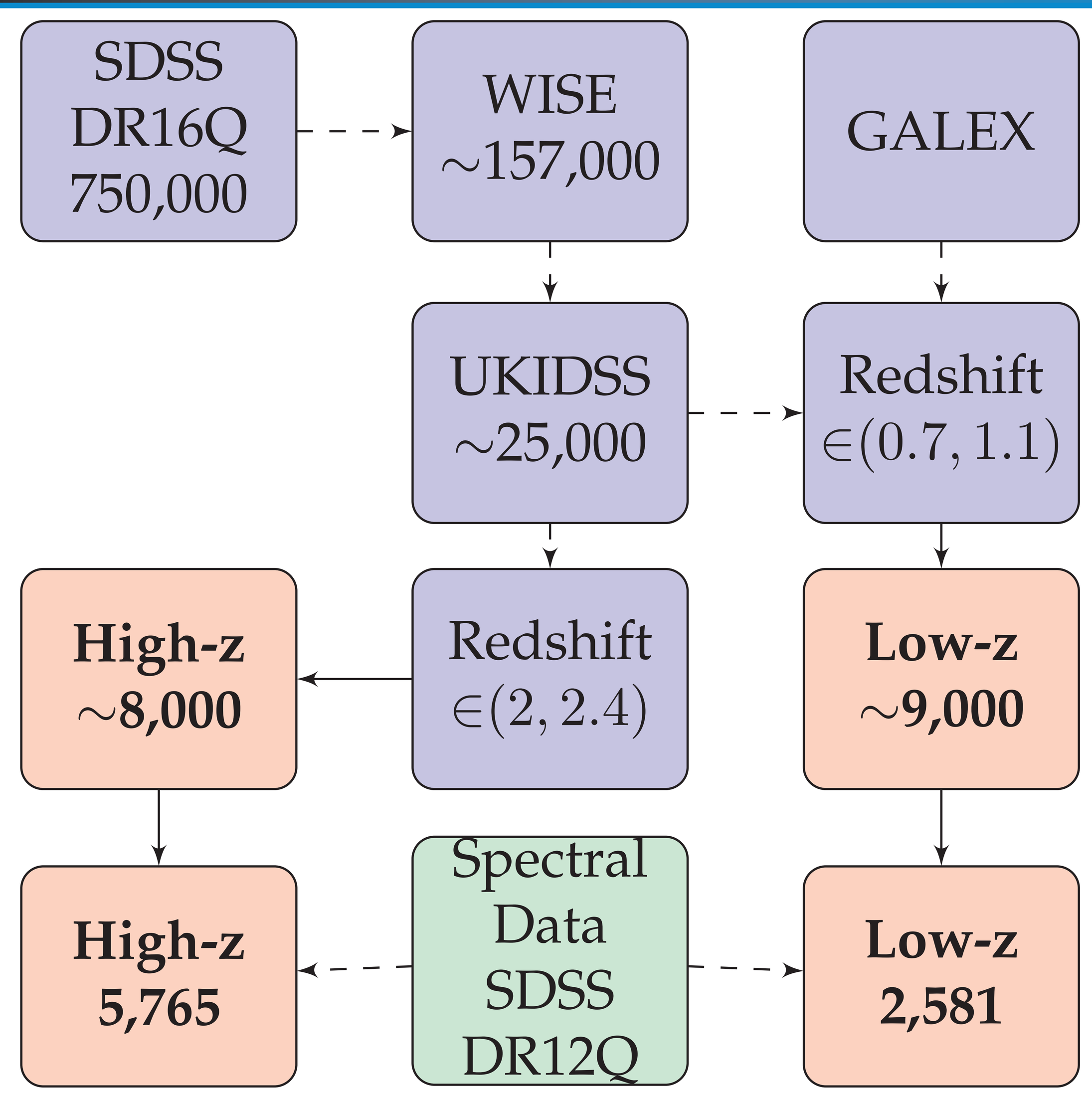


Figure 2. The mean SED of the low-z QSO. Coloured regions mark **areas integrated** for $\mathbf{L_{ir}}$ (red) and $\mathbf{L_{bol}}$ (blue). Red, blue and green lines stand for wavelengths at $7\mu m$, $1\mu m$, $0.11\mu m$.

Data



Steps of analysis

- Cross-match of photometric data and selection of redshift bins,
- Extrapolation/interpolation of luminosities at $1\mu m$, $7\mu m$ and $0.11\mu m$ from neighbouring filters, (consecutively L_1, L_7 and $L_{0.11}$),
- Fitting the power law between L_7 - L_1 and L_1 - $L_{0.11}$,
- Integrating fitted power-laws as L_{bol} between L_1 and $L_{0.11}$, L_{ir} integrated between L_7 and L_1 (Fig. 2, blue and red area consecutively),
- Calculating the $\log_{10} CF$,
- Computing the accretion rate defined as T_{acc}=$1.62 L_{bol}/L_{Edd}$, where L_{Edd} is the Eddington luminosity.

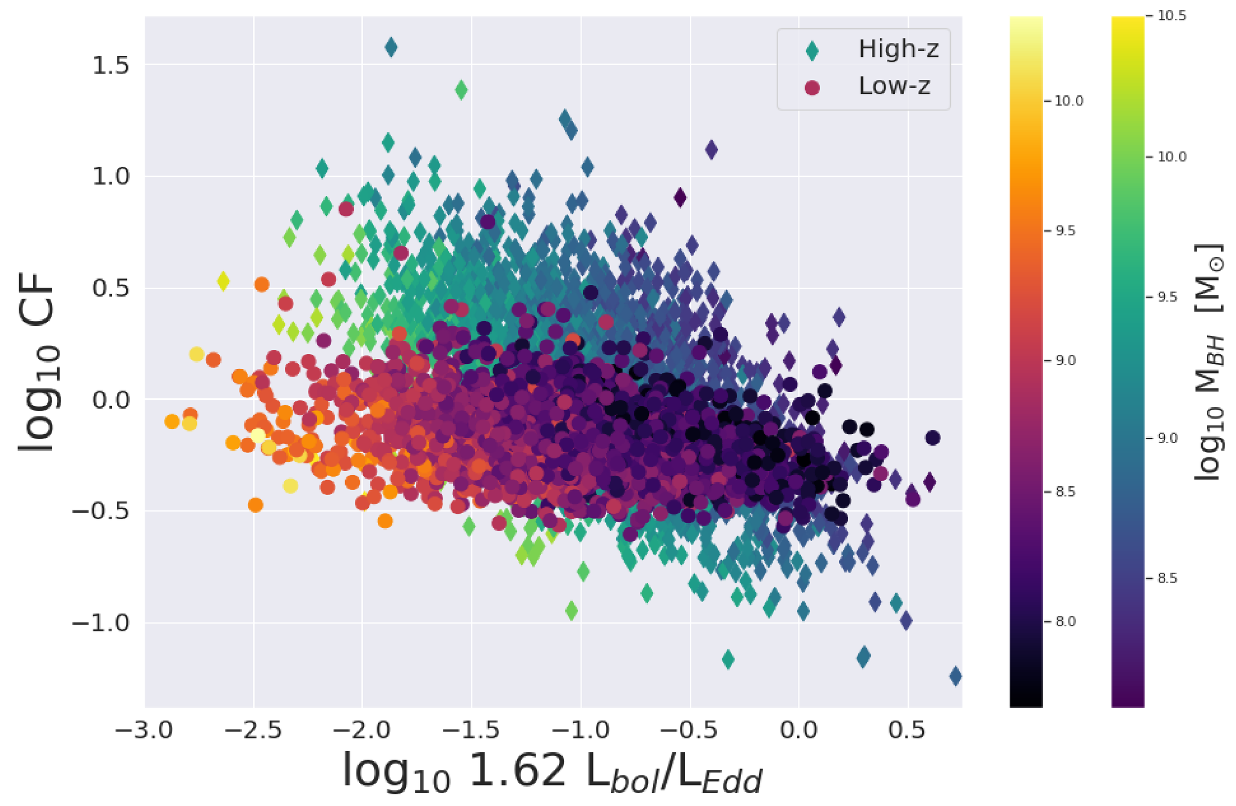


Figure 3. The relation between the $\log_{10}$ CF vs $\log_{10}$ accretion rate. High-z QSO have higher dispersion. By inferring relation of CF with accretion rate we are looking for the physical driver behind torus thickness. The CF have higher values for high-z, quasars with smaller T_{acc}, which means that more dust is present in high-z objects.

Results

The calculated CF median values are $\log_{10} CF_{low-z}$=-0.14 ± 0.13 and $\log_{10} CF_{high-z}$= 0.10 ± 0.22. This values may be interpreted as an **evolution of CF with redshift**.

To study whether the CF evolution is real the influence of the following **possible selection effects** was checked:

- The influence of WISE W3 and W4 errors in observation close to detection limit (SNR>3).
- Other definitions of luminosities leading to the L_{ir} and L_{bol}, especially the wavelengths of L_1, L_7 and $L_{0.11}$.

The above effects influence the values of CF (the difference between low-z and high-z is smaller), but **none** of them **neglected the evolution**. The Spitzer photometry was used to check the WISE data, but it was possible only for 21 QSO.

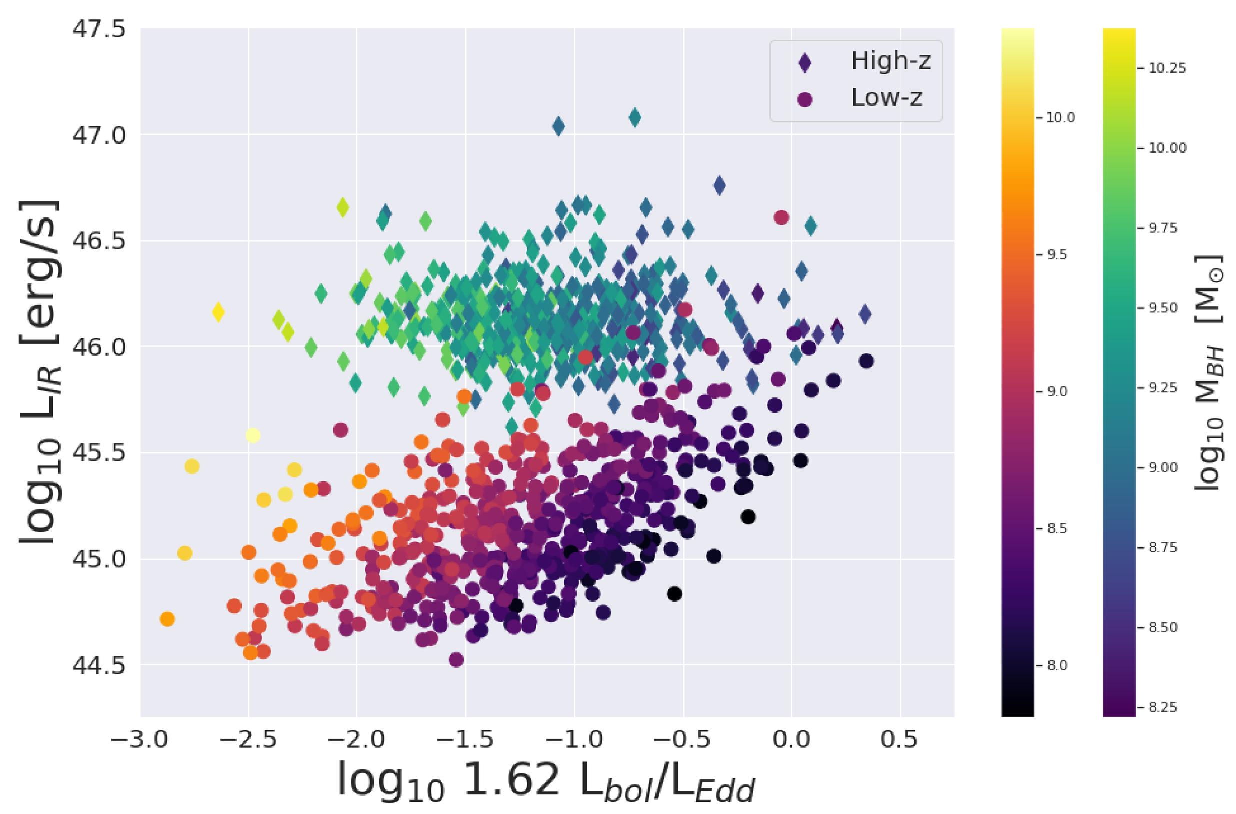


Figure 4. The relation $\log_{10} L_{ir}$ vs $\log_{10} T_{acc}$, with color the M_{BH} are marked for low-z (purple), high-z (green). Only the sub-sample with $WISE_{SNR} > 3$ is shown. Low-z and high-z are clearly separated, with low-z having lower L_{ir}.

Future Research

- Study of Type I and Type II QSO,
- Machine learning.

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