Seeking the Epoch of Maximum Luminosity for Dusty Quasars

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In collaboration with D. Weedman and L. Sargsyan
Under review at ApJ
Reminder: what is quasar?

- Quasi Stellar Radio Source, discovered in 1950s
- Maarten Schmidt explained the spectrum in 1963
  =>$\Rightarrow$ very distant objects
- From the high variability
  =>$\Rightarrow$ very compact objects
- Supermassive black hole with accretion disc around.
  Yakov Zeldovich, Igor Novikov and Edwin Salpeter
Accepted Model of the Quasar
Our Fundamental Questions

- When and How did the First SMBHs of $10^9$ Solar Masses Form?
- When and How did the Dust Form in the Universe?
Currently Accepted Evolutionary Scenario

- Galaxies form
- Gather mass
- Merge (starburst triggering, bigger BH)
- Reach the activity peak at $z$ of $\sim 2-3$ (based on UV luminosity)

- Will There be Such a Peak When Looking in IR?
Galaxy Merging and Dust
Dust in Quasar

**Hot Dust Visible**

**Silicate Emission**

**No Hot Dust Visible**

**Silicate Absorption**
Dust Luminosities of Quasars and Ultraluminous Infrared AGN determined from Spitzer spectroscopy and SDSS/WISE
Data Sources

SDSS
Telescope in New Mexico
SDSS compilation from - Shen et. al., 2011, ApJS 194, 45

WISE – launched in 2009 captures the sky in IR
IR Template (Spitzer Spectra of optically discovered SDSS quasars).

IR Distribution

![Graph showing the distribution of some parameter over a range of values on the x-axis and log νLν on the y-axis.]
Luminosity Functions
IR Luminosity Evolution
The difference between $z = 2$ and $z = 4$ halves the time available for massive galaxy and black hole formation (down to 1.5 Gyr from the beginning of the Universe at $z = 4$ from 3.2 Gyr at $z = 2$).
Comparisons With UV

\[ \log \nu L_\nu(0.25\,\mu m)/\nu L_\nu(7.8\,\mu m) \]

vs

\[ z \]

1.5 - 4.0

-0.5 - 1.5
Comparisons With UV

Narayanan et. al., 2010, MNRAS 407, 1701
Dust in Quasar

Hot Dust Visible
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Average BOOTES Spectrum

![Graph showing normalized $f_\nu$ against rest wavelength (\mu m)]
Lfs of Obscured and Unobscured Quasars

\[ \log \rho(\nu L^\nu) \]

\[ \log \nu L^\nu \]

\[ z = 2.1 \]
Summary

- No Luminosity Peak in IR up to at least $z \sim 5$.
  - Comparisons with UV do not show any significant trend with redshift in dust content.
- There are as many obscured quasars out there as the unobscured ones.