Dust and the far-UV break observed in the energy distributions of Quasars

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connection between far-UV and X-rays?

• Are soft-X rays a simple extrapolation of the far-UV powerlaw?
  – Haro-Corzo et al. (2007)
  – this afternoon

• “Composite” spectra are not always an ideal tool what about individual spectra?
  – in the X-rays?
  – in the far-UV
1. BELR sees a different SED?
2. a bump is hidden in the EE--UV
3. UV-break due to absorption
   • recovery at high energy

**BELR:**
- photoionization models favor a much harder SED
- example: “Locally optimally emitting Clouds” models of Baldwin et al.
- Korista et al.
- Casebeer et al.
- Divorce between models and observations

**far-UV index of ~1.7**
- much too soft SED!
- EW of HeII, CIV, NV hard to reproduce

(Korista et al. 1997)
spectral index $\alpha$

$$F_\nu \propto \nu^{\alpha}$$

$$\nu F_\nu \propto \nu^{\alpha+1}$$

$$\lambda F_\lambda \propto \lambda^{-(\alpha+1)}$$

Telfer's composite SED

same composite SED
spectral indices from individual quasars

- Telfer’s sample,
  - UV break \( \sim 1100\text{Å} \)
  - mean indices:
    - \( \alpha_{\text{NUV}} \approx -0.7 \)
    - \( \alpha_{\text{FUV}} \approx -1.7 \)
- Ton 34
  - extremely UV deficient
    - \( \alpha_{\text{NUV}} = -0.3 \)
    - \( \alpha_{\text{FUV}} = -5.3 \)
extreme UV deficiency of Ton 34

1. IUE SWP
2. IUE LWP
3. HST-FOS
4. Palomar
   (Sargent et al.)
   - normal near-UV line spectrum
   - very unusual in the extreme UV
   - better data needed

(paper with Y. Krongold submitted)
solution: existence of a flux rise or recovery in the extreme-UV?

- maybe continuum picks up in the extreme-UV?
- could the UV break be a localized feature?
- which mechanisms may cause such a localized UV trough?
HI : Lyα … + Lyman continuum

intergalactic absorption

intrinsic screen

disk photosphere

accelerated outflow

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HI : Lyα … + Lyman continuum

dust absorption

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1. jump not seen
2. too sharp edge
3. fit so-so
4. too much dust?

Eastman, MacAlpine, Richstone

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A. too much dust
B. IR emission?
C. dust destroyed?
D. not needed

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not useful
conclusions

1. intrinsic crystalline C dust, promising:
   - infrared re-emission
     • rules out meteoritic flavor
     • compute bulk impurities of N, O
       – in progress: Anja Andersen
   - polarization vs lambda
     • model scattering using proper transfer code?

2. accretion disk photosphere
   • cooler emission from line driven wind

3. accelerated outflow?
   - speculative but tantalizing

GOAL: reconcile line emission spectrum with observed SED
1- extragalactic HI absorption (WHIM)


predicted jump is NOT observed

predicted jump is NOT observed
A-intergalactic dust


- requires too much dust
- carbon crystallites only

\[ \alpha_{\text{EUV}} \text{ vs. redshift } z \]

\[ \alpha_{\text{FUV}} \]

rest-frame

redshift
3- problem of SEDs from current accretion disk models

• photospheric models
  – Hubeny et al.
• accretion disks do predict break near Lyman limit
  – does not fit too well observed break
  – too soft an SED to account for high ionization emission lines

Hubeny et al. (2000)
line driven wind
launched wind may induce a cooler emission gas component
4-accelerated outflow

- gas condensations accelerated up to 0.8 c
- model could be modified so that
  - break could be blueshifted by 0.1c
  - determine where the flux recovery occurs in the extreme-UV
B-crystalline carbon extinction

- Shang et al. (2005) explored SMC-like and ISM dust
  - such dust does NOT fit UV break
- crystalline carbon grains
  - extinction very “peaky” in the far-UV
  - can fit UV break (see later)
  - was found in 3 stellar disks around emission line stars
- formation processes:
  - nucleation of organic ice mixtures by UV photolysis (Kouchi et al. 2005)
  - UV conversion of PAH clusters (Duley & Grishko 2001).
dust model based on carbon crystallites

- small size regime
  - grain radii 2.5–25 Å
- 2 types of crystallite diamonds
  - terrestrial cubic diamond
  - nanodiamonds from meteorite Allende
examples of quasars with evidence of far-UV recovery at 18.5eV (670Å)

- PG 1008+1319  \( z_q = 1.287 \)
- Pks 0232-04  \( z_q = 1.45 \)
- HS 1307+4617  \( z_q = 2.129 \)

extinction predicts a flux recovery in the extreme UV

where is energy re-emitted?

- Feature not observed in 3C298 (Spitzer data)
- Rules out meteoritic type of carbon crystallites

\[ \log \nu L_\nu \]

\[ \log \nu \]

\[ \text{where is energy re-emitted?} \]

- Meteoritic nanodiamonds

\[ \text{de Diego et al. 2007} \]

\[ \text{Flux (10}^{-19} \text{W cm}^{-2} \mu \text{m}^{-1}) \]

\[ \lambda (\mu \text{m}) \]

3C 298
Must use then cubic type only, but wider range of grain sizes

- curve D3
  - grain size range must extend from 3 to 200 Å to fit the UV break

\[ \text{crystalline C} \]
\[ \text{size 3–200 Å} \]
dust abs. fits UV break in individual quasar spectra

- example: PG1148+459
- assuming curve D3
  - cubic nanodiamond grains only
  - size distr. ($a^{-3.5}$)
    - range 3–200 Å
    - Haro-Corzo et al. (2007)