Combined X-Ray and mm-Wave Observations of Radio Quiet Quasars

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Collaborators on this work

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Radio Quiet PG Quasars

\[ L_R = (0.6 \pm 0.1) \times 10^{-5} L_X^{1.08 \pm 0.15} \]

\[ R_s = 0.71 \quad P_r = 6.5 \times 10^{-9} \]
The Big (Scale) News

\[ \log L_R \text{ (erg s}^{-1} ) \]

\[ \log L_X \text{ (erg s}^{-1} ) \]

\[ L_R/L_X = 10^{-5} \]
The Big News

\[ \log L_R (\text{erg s}^{-1}) \]

\[ \log L_X (\text{erg s}^{-1}) \]

\[ L_R / L_X = 10^{-5} \]

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Maybe Radio Emission is also from X-Ray Corona?

![Graph showing relationship between Log L_R/L_X and Log L_X (erg s^-1).]

- Jets
- Not jets
- Cool Stars
- ULX Seyfert RQQ
Like AGN (in X-rays)
Stellar Coronae are Dynamic

Hot
Mass
Ejection

Flaring
Magnetic
(not much) Radio Variability

- X-Ray: factor few over days
- Radio at 5 GHz: Maybe 10% over month
The Explanation for No Variability: Opaque Radio-Sphere

- Synchrotron self absorbed source

\[ \frac{L_\nu}{4\pi d^2} = S_\nu \Omega R^2/d^2 \]

\[
R_{ssa} = 0.1 \left( \frac{vL_\nu}{10^{40} \text{ erg s}^{-1}} \right)^{1/2} \left( \frac{B_\perp}{\text{Gauss}} \right)^{1/4} \left( \frac{v}{5 \text{GHz}} \right)^{-7/4} \text{ pc}
\]

- At 5 GHz \( R_{ssa} = 0.1 \text{ pc} \)
- Light crossing times of 100 days
- For rapid variability, want to OBSERVE AT HIGHER FREQUENCIES namely in the mm-band
Schematic AGN Spectrum

$T_{\text{dust}} > 30K$

30 - 300 GHz

1 - 0.1 mm
(unexplored)
sweet spot

Radio

Alloin+95
• All detected at 95 GHz
• Above the low-ν slope. High-ν excess
• Implied self-absorbed 95 GHz synchrotron size 
  \( R = 0.1L_{40}B^{1/4}v_5^{-7/4} \text{ pc} \)
  is < 10^{-3} \text{ pc (}<\text{mas})
  - of order of X-ray variability time < light day
• But do they vary?
Measuring Variability
NGC 7469 - CARMA’s Swan Song

\[ \chi^2 \text{ variability test} \]

99.9817% confidence

\[ F_{VAR} = \sqrt{\frac{std^2 - \sigma^2_{\text{measure}}}{\langle F_v \rangle^2}} \]

Over 36 days
- \( F_{VAR} = 12.8 \pm 2.5 \% \)
- X-rays* 16.0 \( \pm \) 0.4 \%

Over 6 day periods
- \( \langle F_{VAR} \rangle = 12.5 \pm 6.3 \% \)
- X-rays* 12.3 \( \pm \) 0.4 \%

But is it the X-ray corona?
Need simultaneous observations

*RXTE (2-12 keV)
Markowitz & Edelson 2004
NGC 7469 w/ Swift and IRAM

Photometric stability of single dish is questionable. Need to go for shorter times with interferometers.
Conclusions

• mm-Wave Observations could be another way to study the inner-most high-energy AGN accretion component that we observe regularly in X-rays (Corona)

• We have detected many sources, possibly one that varies, but what we really need ...

• Simultaneous monitoring of XMM-Newton and ALMA (or IRAM/PdB) - the only way to conclusively verify this connection
THANK YOU FOR YOUR ATTENTION