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The nature of the intranight variability of radio-quiet quasars

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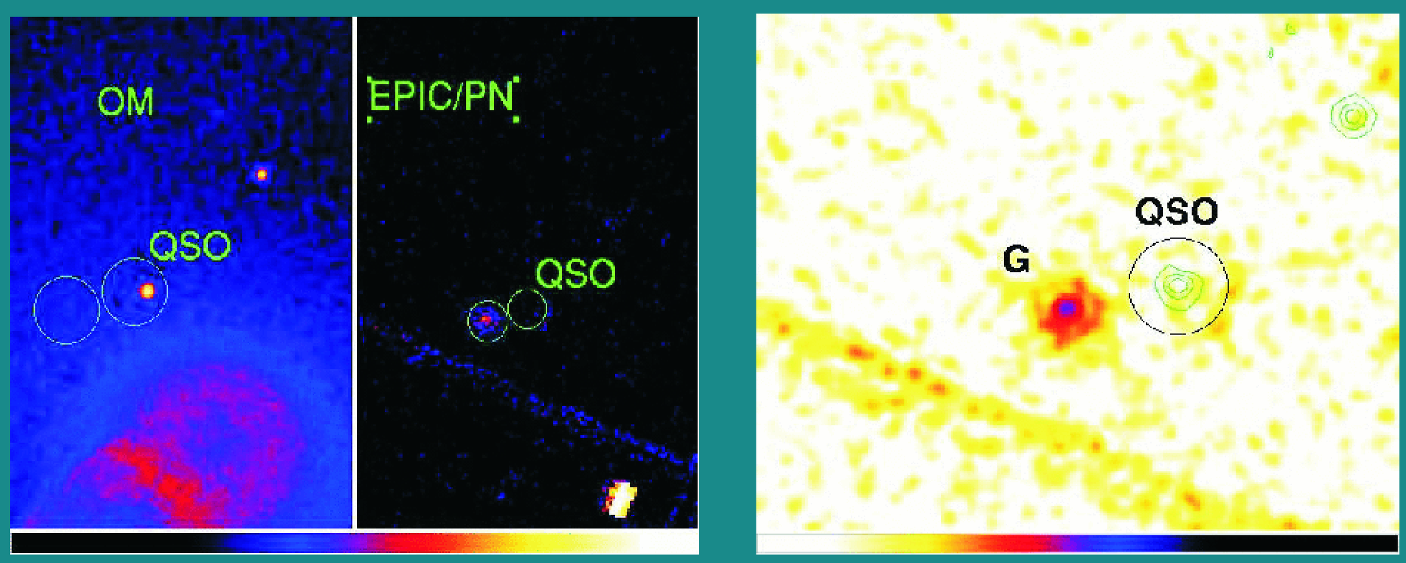
We select a sample of 10 radio-quiet quasars with confirmed intranight variability and with available X-ray data. We compare the variability properties and the broad band spectral constraints to the predictions of microvariability by three models: (i) irradiation of accretion disk by variable X-ray flux (ii) accretion disk instability (iii) the presence of a weak blazar component.

We concluded that the third model, i.e. the blazar component model, is the most promising if we adopt a cannonball model for the jet variable emission. In this case, the probability of detecting the microvariability is within 20-80%, depending on the ratio of the disk to the jet optical luminosity. Variable X-ray irradiation mechanism is also possible but only under additional requirement: either the source should have very narrow H-beta line or occasional extremely strong flares appear at very large disk radii.

Table 1. Micro-variable Radio-Quiet Quasars with available X-ray data[1]

source	RA(2000.0)	DEC(2000.0)	z	R	V	0.1-2.4 keV	Γ_X	α_{ox}
PG 0026+129	00 29 13.7	13 16 05	0.142	1.08	15.41	9.37	2.31 (ROSAT)	1.30
MKN 1014	01 59 50.1	00 23 41	0.163	2.12	15.69	4.03	2.82 (ROSAT)	1.52
PG 1116+215	11 19 08.7	21 19 18	0.177	0.72	14.73	12.00	2.62 (ROSAT)	1.43
1750+507	17 51 16.7	50 45 39	0.3	5.01	15.40	11.73	3.03 (ROSAT)	1.47
AKN 120	05 16 11.4	-00 08 59	0.032	1.03	14.1	3.6[3]	2.46 (XMM)	1.44
Q 1252+020	12 55 19.7	01 44 12	0.342	0.52	15.48	5.95	-	1.29
upper limits						flux at 1 keV		α_{ox}
0824+098	08 27 40.1	09 42 10	2.928	-	18.3	$< 8.83e-14$		> 1.35
PG 0832+251	08 35 35.9	24 59 41	0.331	1.26	16.1	$< 9.3e-14$		> 1.61
PG 0043+039	00 45 47.2	04 10 24	0.385	-	16.0 (B)	$< 8.6e-16$		> 2.3

[1] columns denote source name, redshift, radio loudness parameter, visual magnitude, X-ray flux in 1.e-14 ergs/s/cm^2 from Yuan et al. 1998, soft X-ray slope and broad-band optical/X-ray slope; [2] (0.5 - 2 keV) from Risaliti et al (2003); [3] from Vaughan et al (2004), in 1.e-11 erg/s/cm2 (2-10 keV) , with $\Gamma = 2.0$.



PG0043+039 in XMM-Newton. The EPIC-PN image has been smoothed. A nearby galaxy is marked and QSO is in the circle region.

Microvariability Models

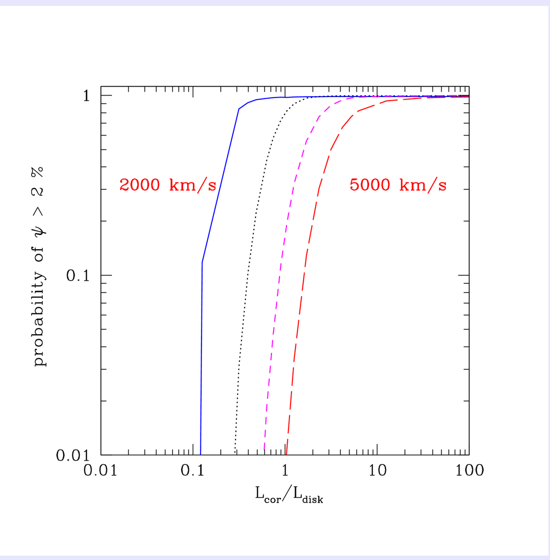
- **X-ray irradiation of an accretion disk**
  We consider a strongly variable X-ray emission from a hot plasma above the disk. The X-rays can be partially intercepted by the disk and thermalized, leading to the variable Opt/UV emission.
- **Disk instability**
  - **Radiation pressure instability**
    We compute the time-dependent disk evolution using the code of Janiuk & Czerny (2005), with a viscosity law $\alpha(P_{gas} P_{tot})^{1/2}$. This leads to the periodic disk outbursts on the timescales $\gg$1day.
  - **Magnetorotational instability**

Local development of the MRI is modeled using the Markoff chain (King et al. 2004), using the scheme as in Janiuk & Czeny (2007). The strength of the variability is determined by the number of magnetic cells.

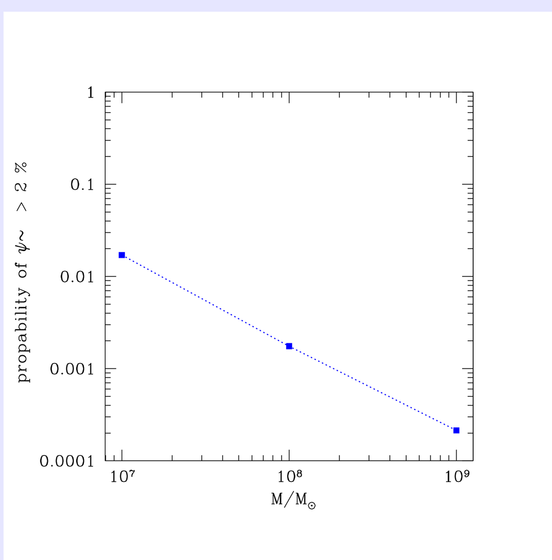
- **Blazar component**
  We use the cannonball model of the variability implemented by Janiuk et al. (2006) to model gamma ray bursts. The model can be applied however to all types of unstable jet-like outflow, with a suitable choice of parameters: emission radius, jet Lorentz factor, opening angle, observer's inclination.

Table 2. Hβ line properties and black hole mass determination for SDSS sources

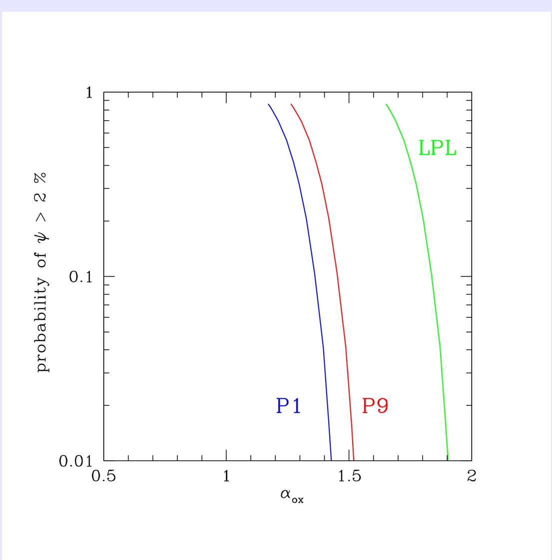
source	EW(Hβ) [Å]	FWHM(Hβ) [km s^{-1}]	$\lambda L_\lambda(5100)$ [10^{44} erg s^{-1} cm^{-2}]	log M	log L/L_{Edd}
MKN 1014	-37±3	2230±110	10.8	8.1	-0.27
1422+424	-82±4	3380±140	54.7	8.8	-0.28
Q 1252+020	-60±3	4100±140	101.0	9.1	-0.32
PG 0832+251	-74±4	3380±90	51.8	8.8	-0.29



Predicted probability of the INV exceeding 2%, for the X-ray irradiation model, as a function of the corona to disk luminosity ratio, and for 4 values of Hβ line FWHM



Predicted probability of the INV exceeding 2%, for the MRI caused variability, for 3 values of the BH mass: 10^7, 10^8 and 10^9 M_{Sun} (corresponding bolometric luminosities were 10^{45}, 10^{46} and 10^{47} erg s^{-1}).



Predicted probability of the INV exceeding 2%, for the blazar model, as a function of the broad band spectral slope. The BH mass is 10^8 M_{Sun}, and models are blazar states, P1 and P3, (3C 273 source; Hartman et al. 2001) and low frequency peak BL spectral shape, LPL (Becker 2007).

References

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