Polarimetric Method of Determining Magnetic Fields in Accretion Discs around Black Holes

Gnedin Yu.N., Silant'ev N.A., Piotrovich M.Yu., Natsvlishvili T.M., Buliga S.D.
Central Astronomical Observatory at Pulkovo, Saint-Petersburg

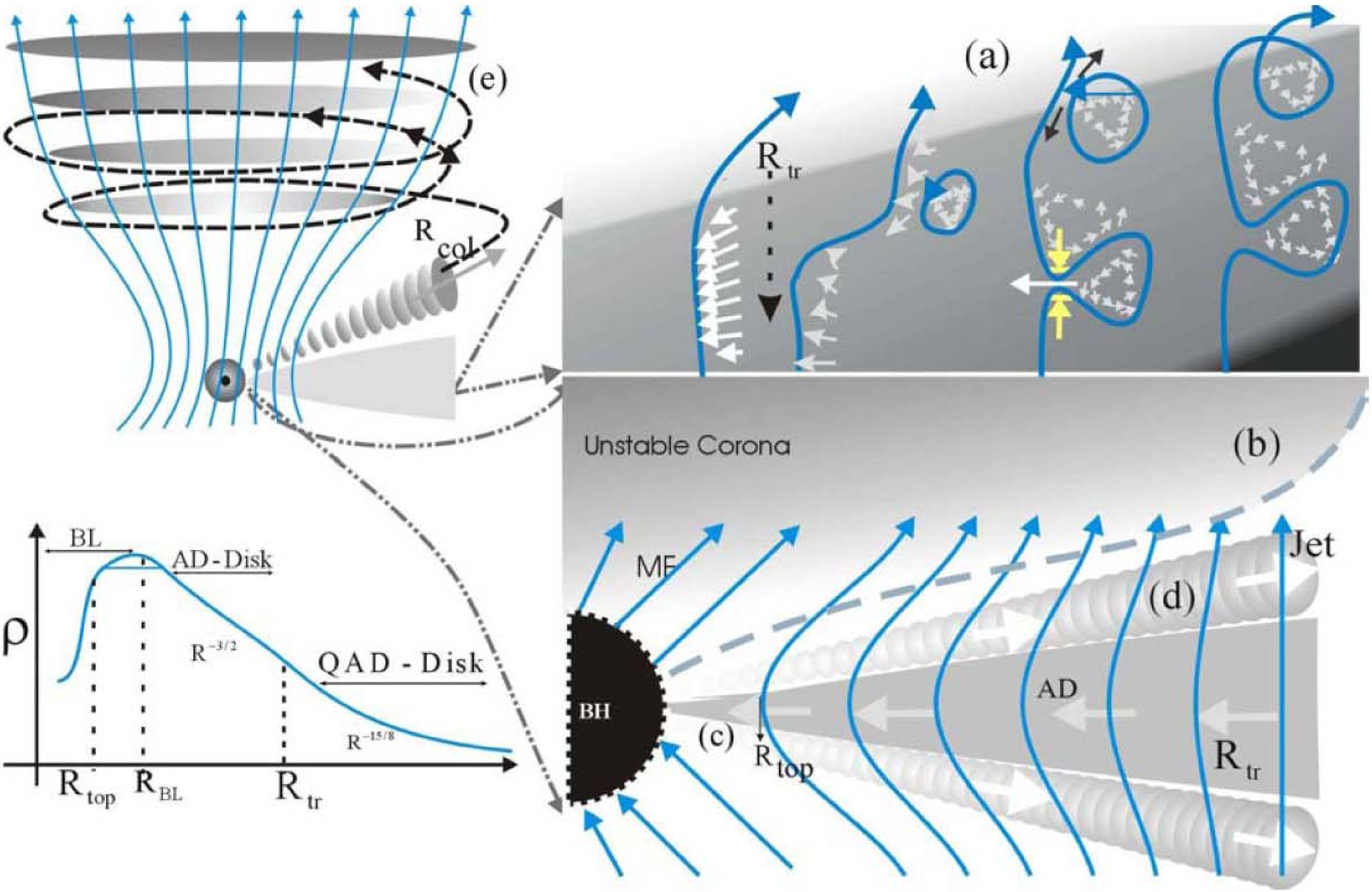
Abstract

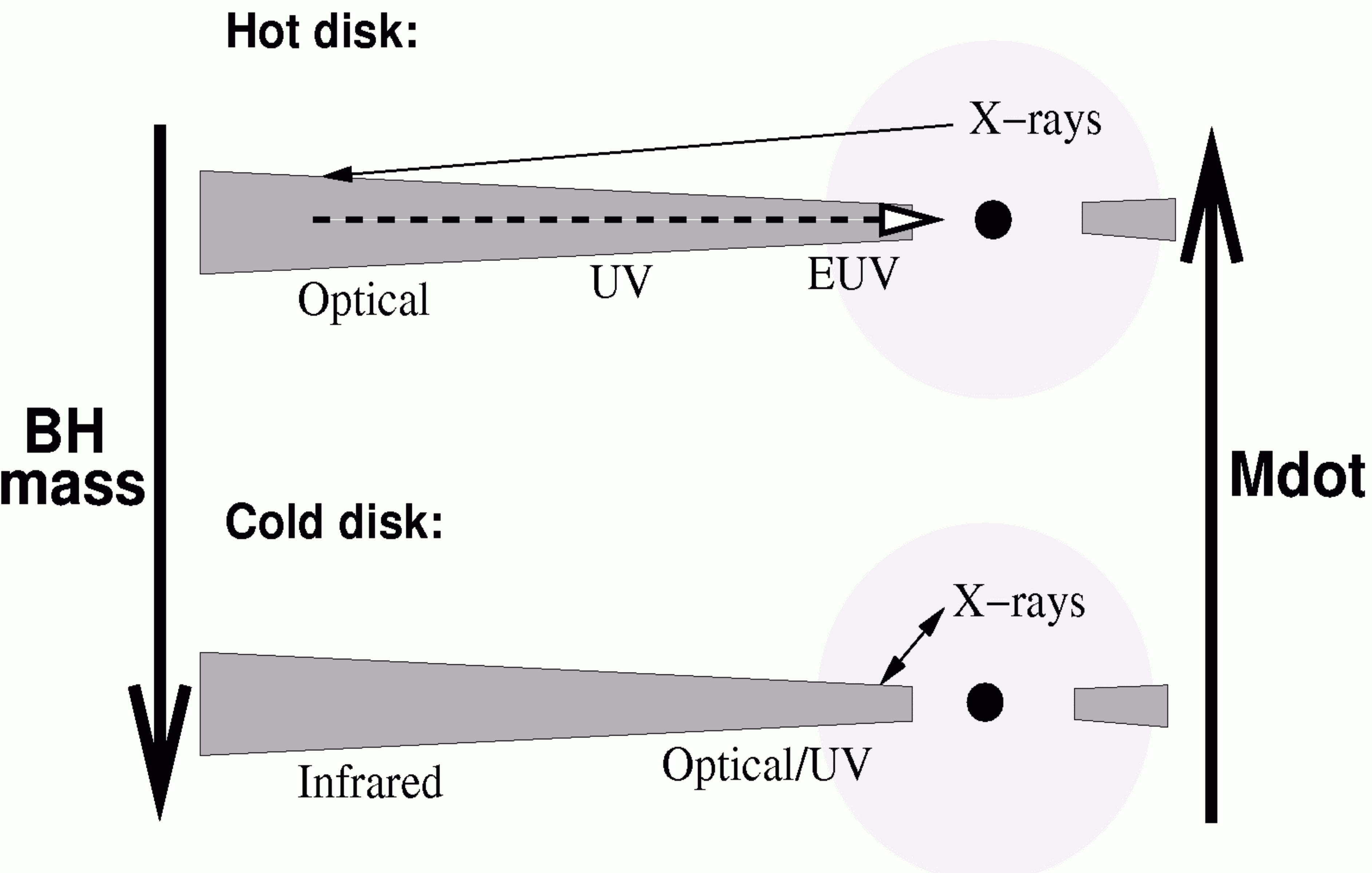
We present the review of basic methods of measurements of magnetic fields with application to accreting supermassive black holes. The problem of the connection between jet and accretion disk is discussed. The results of polarimetric radio and optical observations of QSOs and AGNs are presented in this talk.

Table 1 Characteristic scales in the nuclear regions in active galaxies

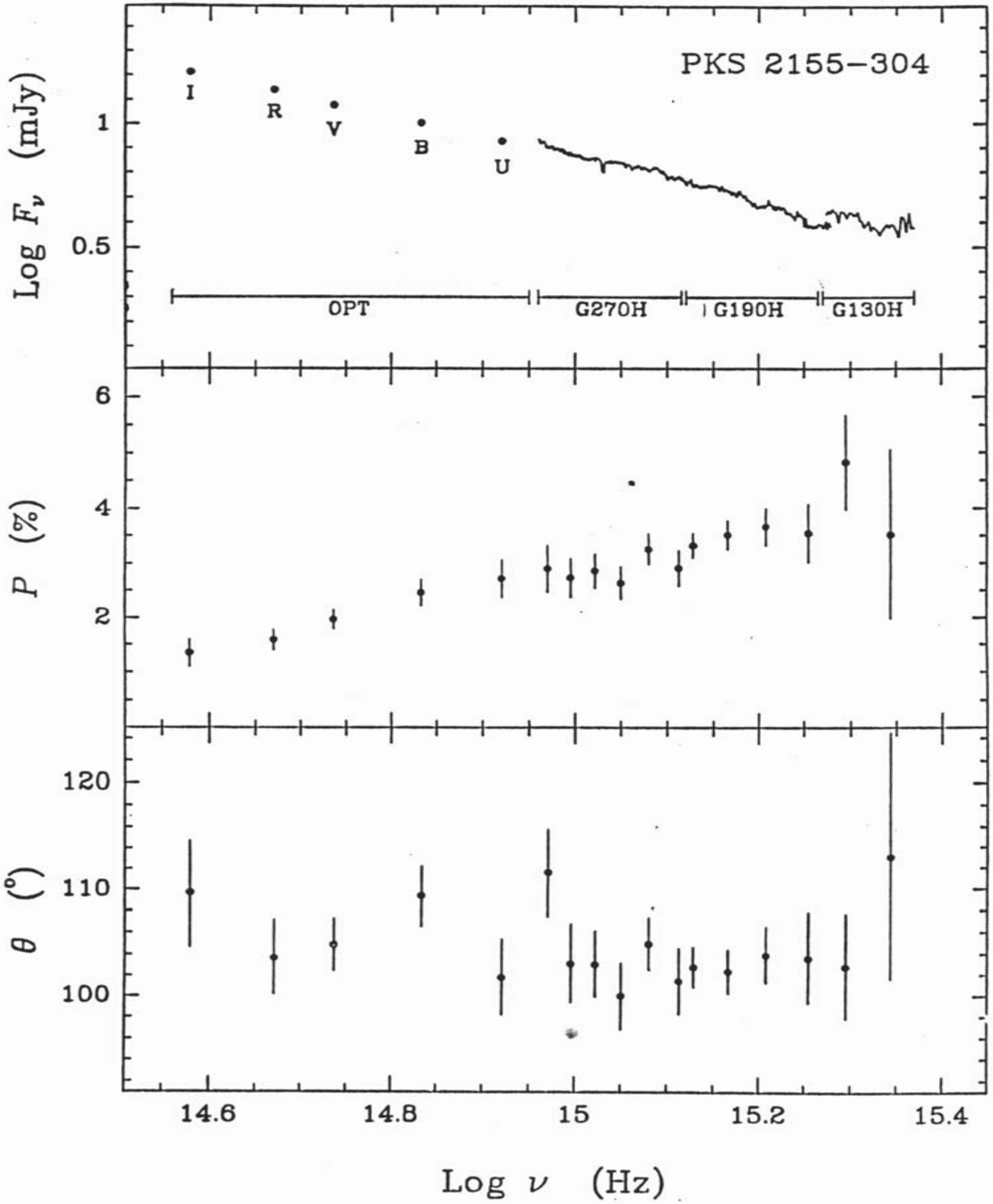
	l $[R_g]$	l_8 [pc]	θ_{Gpc} [mas]	τ_c [yr]	τ_{orb} [yr]
Event horizon:	1–2	10^{-5}	5×10^{-6}	0.0001	0.001
Ergosphere:	1–2	10^{-5}	5×10^{-6}	0.0001	0.001
Corona:	10^1–10^2	10^{-4}–10^{-3}	5×10^{-4}	0.001–0.01	0.2–0.5
Accretion disk:	10^1–10^3	10^{-4}–10^{-2}	0.005	0.001–0.1	0.2–15
Jet formation:	$>10^2$	$>10^{-3}$	$>5 \times 10^{-4}$	>0.01	>0.5
Jet visible in the radio:	$>10^3$	$>10^{-2}$	>0.005	>0.1	>15
Broad line region:	10^2–10^5	10^{-3}–1	0.05	0.01–10	0.5–15000
Molecular torus:	$>10^5$	>1	>0.5	>10	>15000
Narrow line region:	$>10^6$	>10	>5	>100	>500000

Column designation: l – dimensionless scale in units of the gravitational radius, GM/c^2; l_8 – corresponding linear scale, for a black hole with a mass of $5 \times 10^8\, M_\odot$; θ_{Gpc} – corresponding largest angular scale at 1 Gpc distance; τ_c – rest frame light crossing time; τ_{orb} – rest frame orbital period, for a circular Keplerian orbit. Adapted from (Lobanov & Zensus 2006)

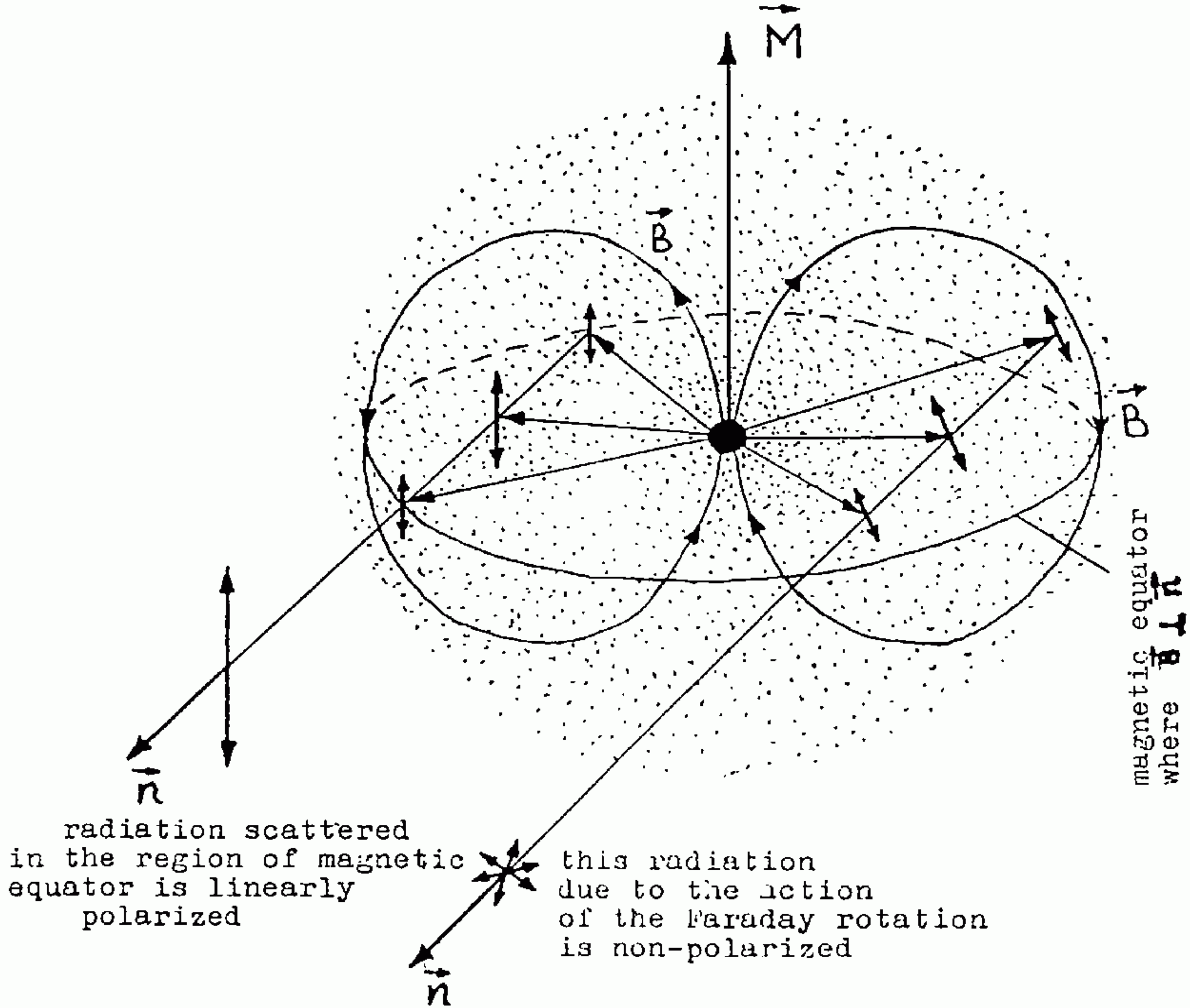

(e)
R_{col}
(a)
R_{tr}
Unstable Corona
(b)
ME
Jet
(d)
BH
AD
(c)
R_{top}
R_{tr}
BL
AD - Disk
ρ
$R^{-3/2}$
QAD - Disk
$R^{-15/8}$
R_{top}
R_{BL}
R_{tr}

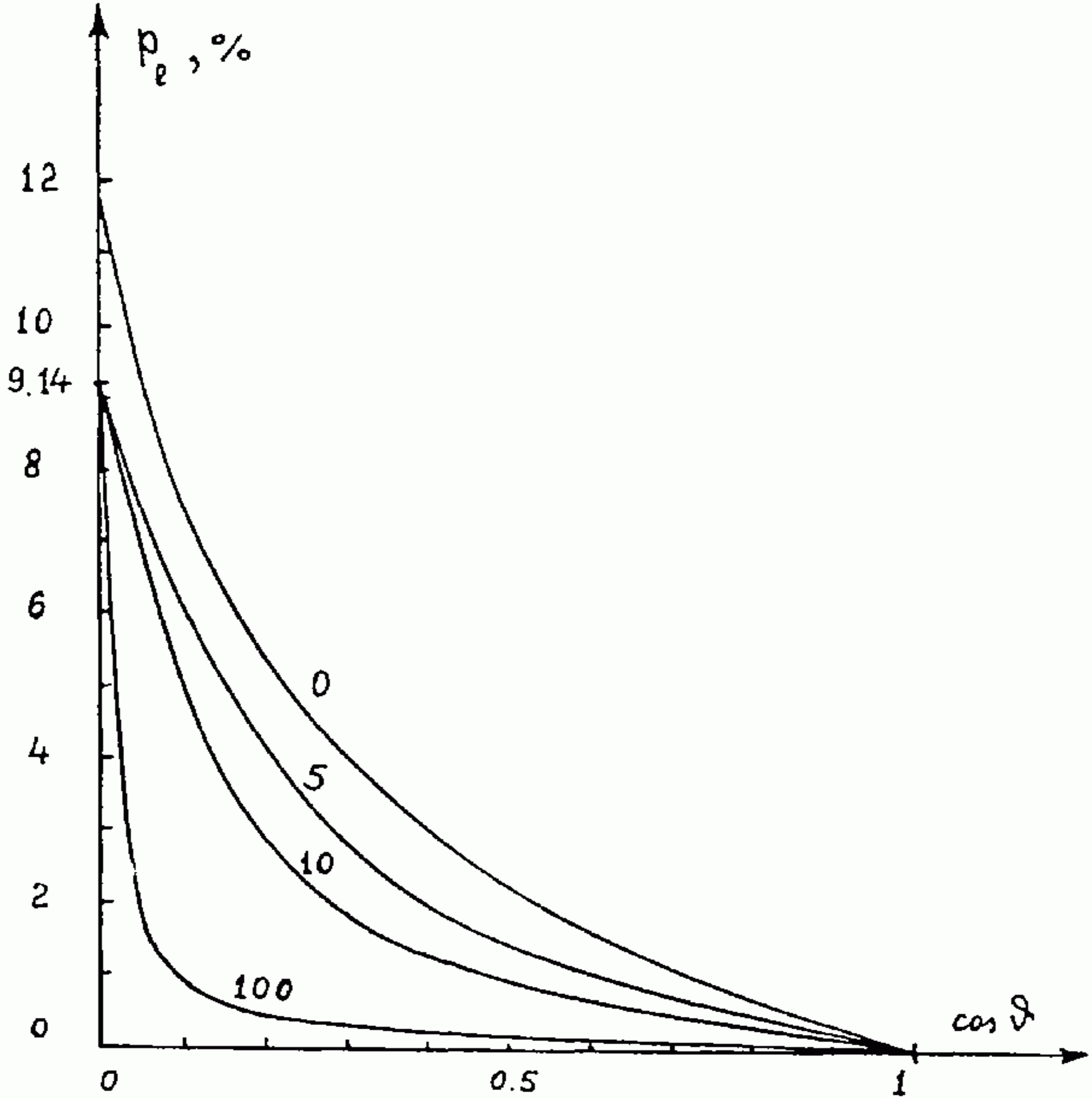


Hot disk:
X–rays
Optical
UV
EUV
BH mass
Mdot
Cold disk:
X–rays
Infrared
Optical/UV



PKS 2155−304
Log F_ν (mJy)
I
R
V
B
U
OPT
G270H
G190H
G130H
P (%)
θ (°)
Log ν (Hz)


$\vec{M}$
$\vec{B}$
$\vec{B}$
magnetic equator
where $\vec{B} \perp \vec{n}$
$\vec{n}$
radiation scattered
in the region of magnetic
equator is linearly
polarized
this radiation
due to the action
of the Faraday rotation
is non-polarized
$\vec{n}$



p_ℓ , %
12
10
9.14
8
6
4
2
0
0
0.5
1
cos ϑ
0
5
10
100

Three basic regions of Magnetic Fields:

(a) Accretion Disk

(b) Relativistic Jet

(c) Accretion Disk Wind and Outflow

$$P_l\left(\vec{B},\vec{n}\right)=\frac{P_l\left(0,\mu\right)}{\sqrt{1+\delta^2\cos^2\theta}}\ ;\quad \tan 2\chi=\delta\cos\theta$$

$$\delta=0.8\lambda_{rest}^2\left(\mu m\right)B$$ - depolarization parameter

For an accretion disk: $\delta=\delta_\perp\sqrt{1-\mu^2}+\delta_{||}\mu\ ;\quad \mu=\cos i$

$$\delta_\perp=0.8\lambda_{rest}^2\left(\mu m\right)B_\perp\ ,\quad \delta_{||}=0.8\lambda_{rest}^2\left(\mu m\right)B_{||}$$

$$B_\perp\left(R\right)=B_H\left(\frac{R_H}{R}\right)^n\ ,\quad n=\frac{5}{4}$$ - Pariev et al., 2003.

$$B_{||}=B_j=B_\perp\left(\frac{L_j}{L_d}\frac{H}{R}\right)^{1/2}\approx B_\perp\frac{L_j}{L_d}$$

Magnetic Equipartition

R.-Y. Ma, F. Yuan, arXiv:0706.0124.

$$B_H = k\sqrt{2L_{bol}/\varepsilon c}\,/\,R_H, \quad k \approx 1$$

$$L_{bol} = \varepsilon \dot{M} c^2, \quad R_H = \frac{GM}{c^2}\left(1 + \sqrt{1 - \left(\frac{a}{M}\right)^2}\right)$$

a/M	ϵ_M	Spin Equilibrium?	Characterization
0.0	0.057	no	standard thin disk; nonspinning BH
0.95	0.19	yes	turbulent MHD disk
0.998	0.32	yes	standard thin disk; photon recapture
1.0	0.42	yes	standard thin disk; max spin BH

$$B_{Ed} = 6.2\times10^8 \left(\frac{M_\odot}{M_{BH}}\right)^{1/2} \left(\frac{\eta}{\varepsilon}\right)^{1/2} \frac{1}{1 + \sqrt{1 - \left(\frac{a}{M}\right)^2}}, \quad \eta = \frac{L_{bol}}{L_{Ed}}$$

Magnetic Field of QSOs in the Epoch of Reionization

QSO	z	L_{bol}/L_{Ed}	a/M = 0, ε = 0.057	a/M = 0.95, ε = 0.19	a/M = 0.998, ε = 0.32	a/M = 1.0, ε = 0.42
J0836+0054	5.810	0.44	$9.0x10^3$ G	$7.5x10^3$ G	$7.15x10^3$ G	$6.6x10^3$ G
J1030+0524	6.309	0.50	$1.5x10^4$ G	$1.22x10^4$ G	$1.16x10^4$ G	$1.0x10^4$ G
J1044-0125	5.778	0.31	$7.1x10^3$ G	$6.0x10^3$ G	$5.7x10^3$ G	$5.3x10^3$ G
J1306+0356	6.016	0.61	$1.8x10^4$ G	$1.5x10^4$ G	$1.43x10^4$ G	$1.4x10^4$ G
J1411+1217	5.927	0.94	$3.5x10^4$ G	$2.93x10^4$ G	$2.8x10^4$ G	$2.7x10^4$ G
J1623+312	6.247	1.11	$3.5x10^4$ G	$2.93x10^4$ G	$2.8x10^4$ G	$2.7x10^4$ G

The Magnetic Flux Conservation in Accretion Disk:

$$a \sim \frac{1}{\lambda^{2/3}}, b \sim \lambda^{2/3}, B_z \sim R_\lambda^{-2}, B_\perp \sim R_\lambda^{-1}$$

$$\lambda_{res} \to a = b, \lambda_{res} = f\left(M_{BH}, L_{bol}/L_{Edd}, a_*\right)$$

$a_* = 0$ - Schwarzschild BH, $a_* = 1$ - Kerr BH.

$$P_{rel} = \frac{P_l\left(B, \mu\right)}{P_l\left(0, \mu\right)}$$

$$a = b = 4, P_{rel} = 0.3522, \chi = 20^\circ.7$$

$$a = 8, b = 2, P_{rel} = 0.1279, \chi = 41^\circ.2$$

$$a = 2, b = 8, P_{rel} = 0.1279, \chi = 0^\circ.9$$

Estimation of Magnetic Field Strength at the Event Horizon of SMBH by Optical Polarization in Continuum.

NGC 4258: $i = 83^\circ \pm 4^\circ$

$$P_l\left(\lambda\lambda 4000 - 4800\dot{A}\right) = \left(0.38 \pm 0.03\right)\%, \chi = 12^\circ \pm 2^\circ$$

$$P_l\left(\lambda\lambda 5100 - 6100\dot{A}\right) = \left(0.35 \pm 0.01\right)\%, \chi = 7^\circ \pm 1^\circ$$

$$P_l\left(\lambda\lambda 7500 - 8000\dot{A}\right) = \left(0.29 \pm 0.02\right)\%, \chi = 8^\circ \pm 2^\circ$$

The classical result (Chandrasekhar-Sobolev Theory):

$$P_l = 6.9\% \ (\mu = \cos i = 0.122)$$

$$R_\lambda = 0.95 \times 10^{10} \left(\frac{\lambda_{rest}}{\mu m}\right)^{4/3} \left(\frac{M_{BH}}{M_\odot}\right)^{2/3} \left(\frac{L_{bol}}{\varepsilon L_{Edd}}\right)^{1/3} \quad \text{(Poindexter et al., 2007)}$$

The faraday Depolarization Factor: $\delta = 0.8\lambda_{rest}^2 B\left(R_\lambda\right)$

$$B_H = B\left(R_\lambda\right)\left(\frac{R_\lambda}{R_H}\right)^n, \quad n = \frac{5}{4}$$ - the standard Shakura-Sunyaev Disk

$$B_H = 2.5 \times 10^4 G$$

NGC 4258

Zeeman Spectropolarimetry 18cm OH Megamaser Emission

(Modjaz et al., 2005)

1σ upper limit: 30mG at 0.14pc.

$$B_H = 2.5\times10^4 G \;,\; n = \frac{5}{4}$$

$$B_{mas}\left(0.14\,pc\right) = 20mG \text{ for } \frac{a}{M_{BH}} \approx 1$$

NGC 3516 (Smith et al., 2002)

$$M_{BH} = 10^{7.36} M_\odot \ , \ L_{bol} = 10^{44.9} \ erg/s \ , \ i = 38^\circ.3$$

$$P_l\left(\lambda\lambda 6500 - 6740\dot{\mathrm{A}}\right) = \left(0.15 \pm 0.04\right)\%, \chi = 30^\circ.1 \pm 8^\circ$$

$$P_l\left(theory\right) = 0.83\% \ ; \ B_H = 10^4 G \ (\varepsilon = 0.32 \ , \ a_* = 0.998)$$

$a_* = a/M_{BH}$ - Kerr parameter.

NGC 4151

$$M_{BH} = \left(1.53^{+1.06}_{-0.89}\right) M_\odot \ , \ L_{bol} = 10^{43.73} \ erg/s \ , \ i = 60^\circ$$

$$P_l\left(\lambda\lambda 3800 - 5300\dot{\mathrm{A}}\right) = 0.26\% \ , \ P_l\left(theory\right) = 2.257\%$$

(Chandrasekhar, 1950) $B_H = 1.5 \times 10^4 G \ , \ \varepsilon = 0.32$

NGC 5548

$$M_{BH} = 10^{8.05} M_\odot \ , \ L_{bol} = 10^{44.83} \ erg/s \ , \ i = 45^\circ$$

The classical Thomson limit: $P_l = 1.115\%$

$$P_l\left(\lambda\lambda 6520 - 6860\dot{\mathrm{A}}\right) = \left(0.69 \pm 0.01\right)\% \ , \ B_H = 720G \ , \ \varepsilon = 0.32$$

Model	$B_{eq}(R)$	$P_l(\lambda)$	Refs.
Accretion disk with ion supported flows.	$\sim R^{-5/4}$	$\sim \lambda^{-1/3}$	Begelman, 1988
Sunayev-Shakura disk Region (a), $P_r >> P_g$	$\sim R^{-3/4}$	$\sim \lambda^{-1}$	Shakura-Sunayev, 1973
Shakura-Sunayev disk (b) $P_g >> P_r$	$\sim R^{-9/8}$	$\sim \lambda^{-1/2}$	Shakura-Sunayev, 1973
Shakura-Sunayev disk (c) $P_g >> P_r$	$\sim R^{-21/16}$	$\sim \lambda^{-1/4}$	Shakura-Sunayev, 1973
Hot Accretion Disk with Plasma Viscosity	$\sim R^{-15/28}$	$\sim \lambda^{-9/7}$	Kafatos, 1988
Payne-Eardley Disk $P = P_g$, $\alpha = 1$	$\sim R^{-21/8}$	$\sim \lambda^{-1/8}$	Shapiro-Teukolsky
Magnetic Accretion-Jet Ejection Disk without equipartition	$\sim R^{-5/2}$	$\sim \lambda^{4/3}$	Case and Keppens, 2002
Accretion disk with non-zero torque on its inner edge	$\sim R^{-15/16}$	$\sim \lambda^{-1}$	Agol, Krolik, 2000
Disk with reprocessing	$\sim R^{-7/4}$	$\sim \lambda^{-1/8}$	

Магнитный диск: $B^2/8\pi = \alpha\sqrt{P_{gas}P_{rod}}$, $P_l \sim \lambda^{-15/16}$.

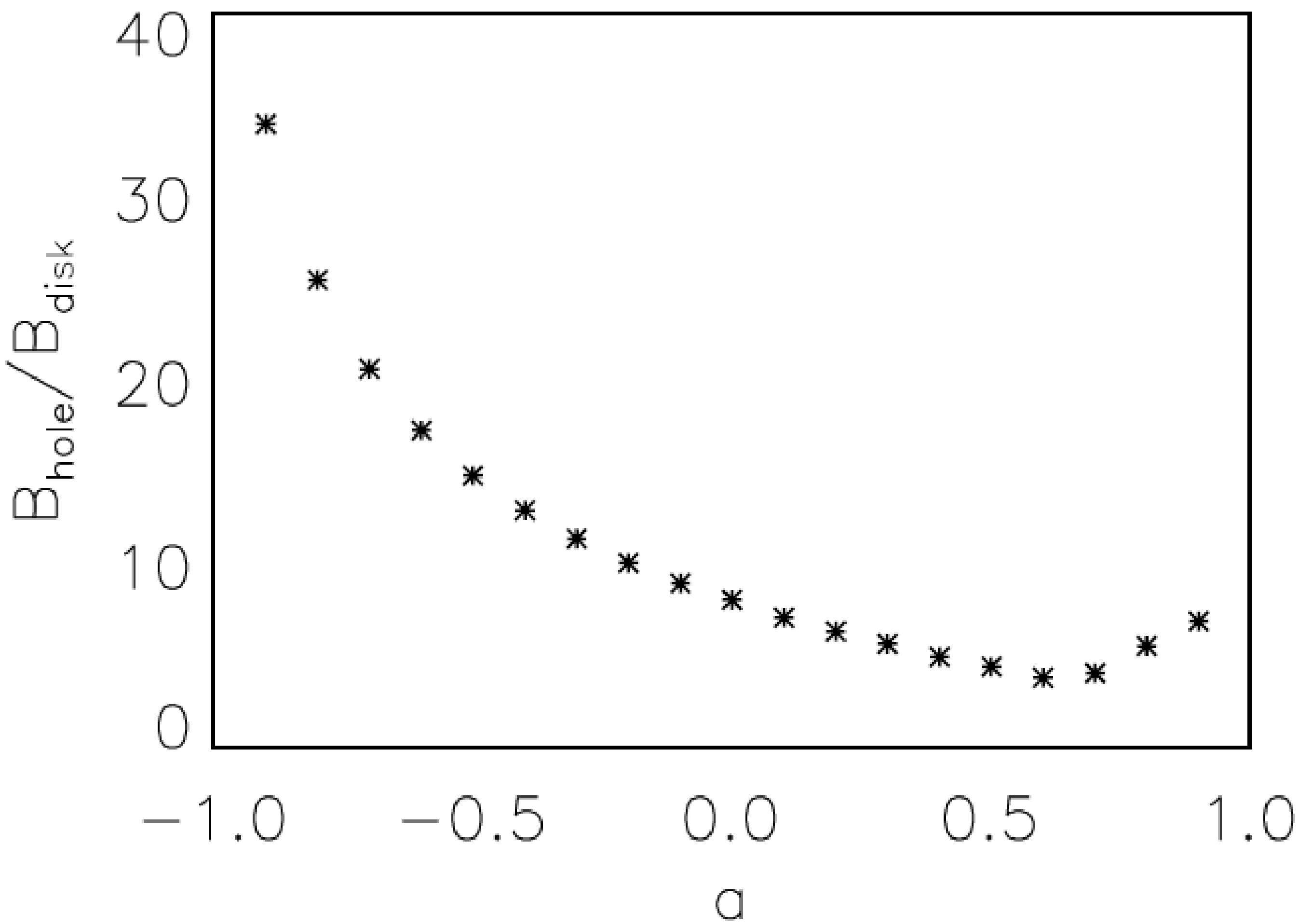


Figure 7. Ratio of horizon-threading magnetic field as measured by ZAMO observers and magnetic field strength in the accretion disk as a function of spin.

(D. Garofalo, The Astrophysical Journal, 699:400–408, 2009 July 1)

Table 2. New circular polarization measurements of quasars

Object	z	$p_{\rm lin}$ (%)	$\theta_{\rm lin}$ (°)	$p_{\rm circ}$ (%)
1120+019	1.465	1.95 ± 0.27	9 ± 4^c	−0.02 ± 0.05
1124−186	1.048	11.68 ± 0.36	37 ± 1^g	−0.04 ± 0.08
1127−145	1.187	1.30 ± 0.40 [w]	23 ± 10^a	−0.05 ± 0.05
1157+014	1.990	0.76 ± 0.18	39 ± 7^f	−0.10 ± 0.08
1205+146	1.640	0.83 ± 0.18	161 ± 6^f	−0.10 ± 0.09
1212+147	1.621	1.45 ± 0.30	24 ± 6^c	0.15 ± 0.09
1215−002⋆	0.420	23.94 ± 0.70	91 ± 1^g	−0.42 ± 0.40
1216−010	0.415	11.20 ± 0.17	100 ± 1^g	−0.01 ± 0.07
1222+228	2.058	0.92 ± 0.14	169 ± 4^g	0.01 ± 0.10
1244−255	0.633	8.40 ± 0.20 [w]	110 ± 1^a	−0.23 ± 0.20
1246−057	2.236	1.96 ± 0.18 [w]	149 ± 3^e	0.01 ± 0.03
1254+047	1.024	1.22 ± 0.15 [w]	165 ± 3^b	−0.02 ± 0.04
1256−229⋆	0.481	22.32 ± 0.15	157 ± 1^g	0.18 ± 0.04
1309−056	2.212	0.78 ± 0.28	179 ± 11^c	−0.08 ± 0.06
1331−011	1.867	1.88 ± 0.31	29 ± 5^c	−0.04 ± 0.06
1339−180	2.210	0.83 ± 0.15	20 ± 5^g	−0.01 ± 0.07
1416−129	0.129	1.63 ± 0.15 [w]	44 ± 3^b	0.05 ± 0.06
1429−008	2.084	1.00 ± 0.29	9 ± 9^c	0.02 ± 0.08
2121+050	1.878	10.70 ± 2.90 [w]	68 ± 6^a	0.02 ± 0.15
2128−123	0.501	1.90 ± 0.40 [w]	64 ± 6^d	−0.04 ± 0.03
2155−152	0.672	22.60 ± 1.10 [w]	7 ± 2^a	−0.35 ± 0.10

Notes: Linear and circular polarizations were measured in the V filter except a series of linear polarization data from the literature measured in white light and noted [w]; (⋆) 1215−002 is classified as a BL Lac by Collinge et al. 2005; Sbarufatti et al. 2005 re-determined the redshift of 1256−229 (z=0.481) and considered this object as a BL Lac. References for linear polarization: (a) Impey & Tapia 1990; (b) Berriman et al. 1990; (c) Hutsemékers et al. 1998; (d) Visvanathan & Wills 1998; (e) Schmidt & Hines 1999; (f) Lamy & Hutsemékers 2000; (g) Sluse et al. 2005.

D. Hutsemekers et al.

Table 1. FR II Quasars with Super Eddington Jets

Source	z	$\overline{Q}$ 10^{45}ergs/s	L_{bol} 10^{45}ergs/s	$\overline{R}$	freq (10^{15} Hz)	L_{bol}/L_{Edd}	$\overline{Q}_{Edd}$	ref
3C 216	0.670	15.1/14.1	≈ 0.12	≈ 120	0.71/1.16	$0.05 - 0.1$	$3.3 - 10$	1
3C 455	0.543	7.13/5.04	0.38	18.7/13.3	0.94	1.42	26.7/18.9	2
		7.13/5.04	0.38	18.7/13.3	0.94	0.07	1.33/0.94	3
3C 82	2.878	155.4/183.8	14.5	10.7/12.7	0.014	0.106	1.14/1.35	4
		155.4/183.8	25.0	6.22/7.35	1.67	0.245	1.52/1.80	4
3C 9	2.009	148.3/174	25.0	5.93/6.96	1.67	0.264	1.57/1.85	5
		148.3/174	38.8	3.82/4.49	0.0078	0.324	1.24/1.46	6
4C 25.21	2.686	59.3/59.7	11.6	5.11/5.15	1.14	0.198	1.02/1.02	5
PKS 1018-42	1.28	63.9/65.2	19.3	3.31/3.38	1.37	0.428	1.42/1.45	7
		63.9/65.2	14.7	4.35/4.45	1.37	0.326	1.42/1.45	7
4C 04.81	2.594	103.8/148	35.8	2.90/4.13	2.30	0.459	1.33/1.90	5
3C 196	0.871	73.5/87.0	31.6	2.33/2.76	1.53	3.04	7.10/8.41	8
		73.5/87.0	31.6	2.33/2.76	1.53	0.238	0.66/0.56	9
3C 14	1.469	52.38/51.68	32.6	1.61/1.59	1.00	0.604	1.05/1.03	10
3C 270.1	1.519	65.1/66.6	48.2	1.35/1.38	2.07	0.844	1.14/1.17	5

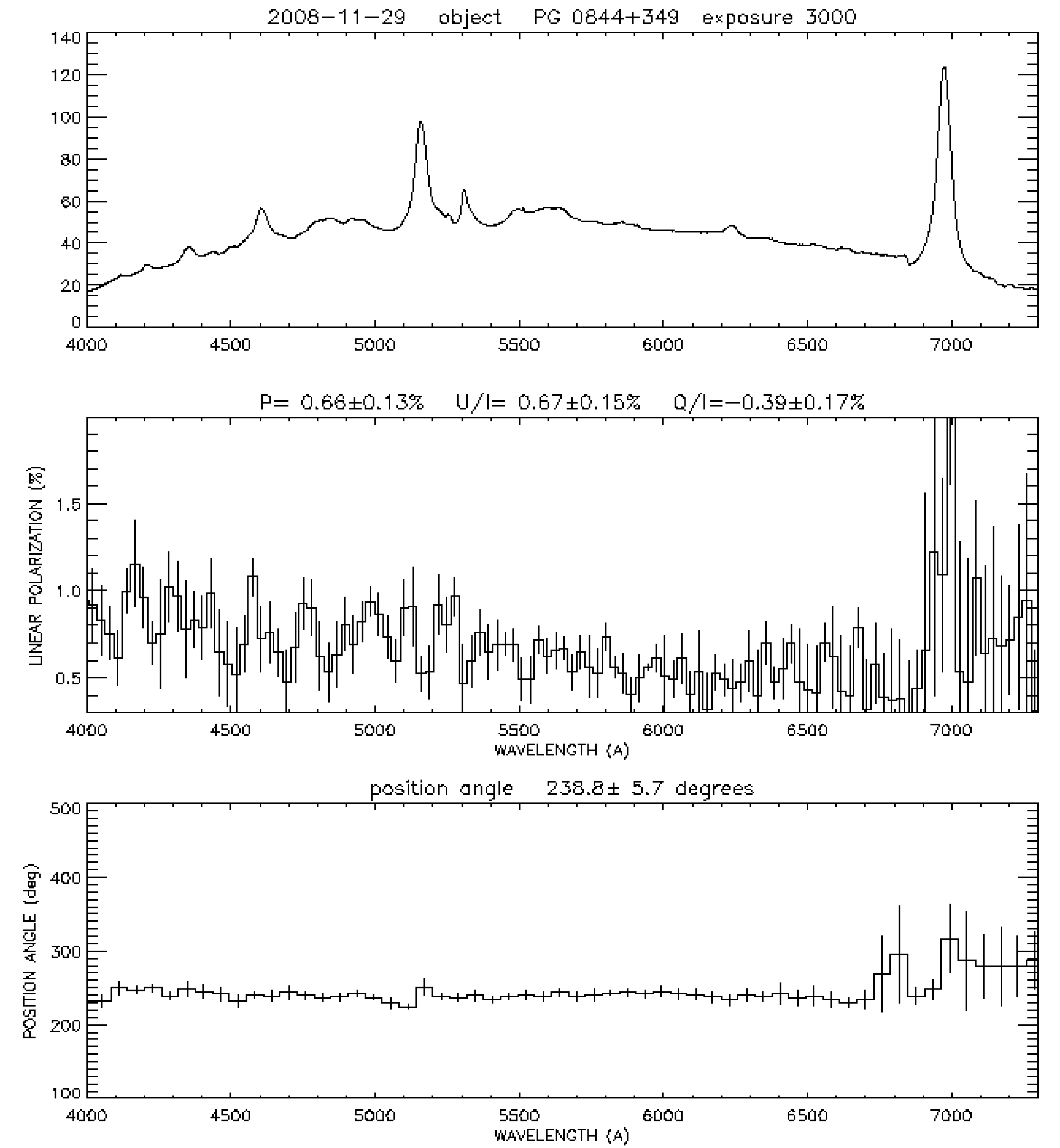
1. see Punsly (2007), 2. continuum and FWHM from Gelderman and Whittle (1994), M_{bh} from eqn (5), 3. M_{bh} from bulge luminosity estimate in eqn (8), 4. L_{bol} and FWHM raw data from Semenov et al. (2004), M_{bh} from eqn (6), 5. L_{bol} and FWHM from Barthel et al. (1990), M_{bh} from eqn (6), 6. continuum from Meisenheimer et al. (2001), FWHM from Barthel et al. (1990), M_{bh} from eqn(6), 7. Punsly and Tingay (2006), M_{bh} from eqn(7), 8. continuum and FWHM from Lawrence et al. (1996), M_{bh} from eqn (5), 9. continuum and FWHM from Lawrence et al. (1996), M_{bh} from eqn (7), 10. continuum and FWHM from Aars et al (2005), M_{bh} from eqn (7)

(Brian Punsly, arXiv:0610042v1)

Table 1: Recent Radio continuum observations on globular clusters

Cluster name	Distance (kpc)	n_{H} ($\mathrm{H\,cm^{-3}}$)	T_{gas} (Kelvin)	$F_{\mathrm{R,5GHz}}$ (μJy)	$M_{\mathrm{BH,rad}}$ ($M_\odot$)	$M_{\mathrm{BH,dyn}}$ ($M_\odot$)
ω Cen	5.3	0.044	10^4	20	5200/1100	12000
47 Tuc	4.5	0.28/0.07	10^4	40	4900/520	1500
NGC 6388	10.0	0.1	10^4	81	1500/735	5700
NGC 2808	9.5	0.26	10^4	162	8500/1800	2700
M15	10.3	0.42/0.2	10^4	25	4900/700	1000
M62	6.9	0.41	10^4	36	2900/600	3000
M80	10.0	0.21	10^4	36	5300/1100	1600
NGC 6397	2.7	0.16	10^4	216	4300/900	50
G1	780	$\sim$1	10^4	28	4500	18000

(Ting-Ni Lu, Albert K.H. Kong arXiv:1102.1668v1)


2008-11-29 object PG 0844+349 exposure 3000
P= 0.66±0.13% U/I= 0.67±0.15% Q/I=-0.39±0.17%
LINEAR POLARIZATION (%)
WAVELENGTH (A)
position angle 238.8± 5.7 degrees
POSITION ANGLE (deg)
WAVELENGTH (A)

QSO B2112+059 Illuminated Disk: $T_e \sim R^{-\frac{1}{2}},\ a_* = 0.5$

PG 2112+059

$$n = \frac{5}{4},\ B(R_\lambda) = 50G,\ B_H = 4.5\times10^3 G,\ \frac{p_{kin}}{p_{magn}} = 1$$

PG 0026+129 Illuminated Disk: $a_* = 0.5$

$$n = \frac{5}{4},\ B(R_\lambda) = 55G,\ B_H = 2\times10^4 G,\ \frac{p_{kin}}{p_{magn}} = 1$$

PG 0844+349 Illuminated Disk: $a_* = 1$

Ton 951

$$n = 1,\ B(R_\lambda) = 33.7G,\ B_H = 1.7\times10^4 G,\ \frac{p_{kin}}{p_{magn}} = 50$$

3C390.3 Illuminated Disk: $a_* = 1$

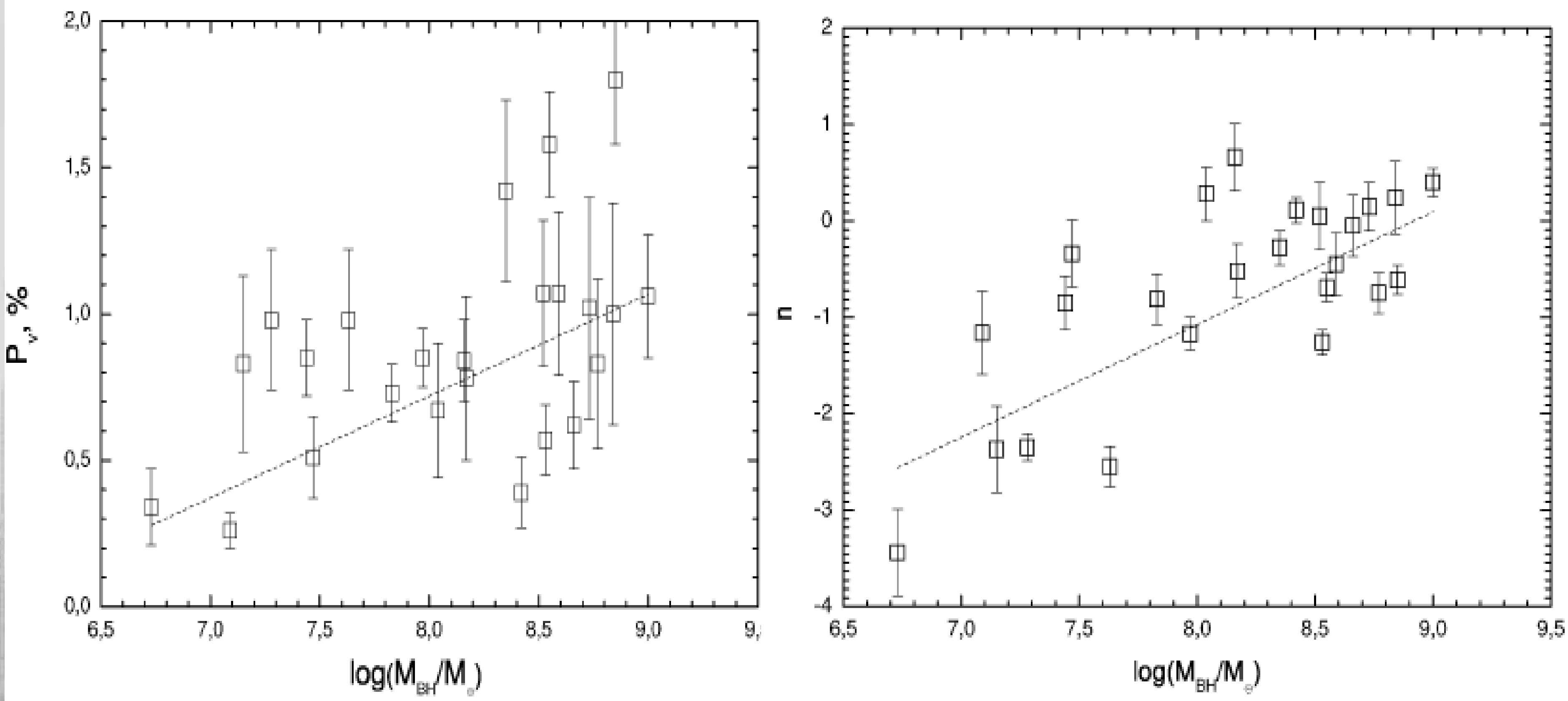
$$n = 1,\ B(R_\lambda) = 39.3G,\ B_H = 3.8\times10^3 G,\ \frac{p_{kin}}{p_{magn}} = 10^2$$

Table 2: Masses of the central black holes and polarization in continuum

Object	Type	$\log \lambda L_\lambda$ [erg/s] (opt.)	$\log \frac{M_{BH}}{M_\odot}$	Ref.	P_V [%]	n	Ref.
PG 0007+106	Sy1	44.82	$8.73^{+0.08}_{-0.10}$	6	1.02±0.38	0.15±0.25	1
PG 0026+129	QSO	45.02	$8.59^{+0.07}_{-0.12}$	7	1.07±0.28	-0.45±0.33	1
PG 0049+171	Sy1.5	44.00	$8.35^{+0.08}_{-0.10}$	6	1.42±0.31	-0.28±0.18	1
PG 0157+001	Sy1.5	44.98	$8.17^{+0.08}_{-0.10}$	6	0.78±0.28	-0.52±0.28	1
PG 0804+761	QSO	44.94	$8.84^{+0.05}_{-0.06}$	7	1.00±0.38	0.24±0.38	1
PG 0844+349	Sy1	44.35	$7.97^{+0.15}_{-0.23}$	7	0.85±0.10	-1.17±0.17	1
PG 0953+414	QSO	45.40	$8.42^{+0.08}_{-0.10}$	6	0.39±0.12	0.11±0.13	1
PG 1022+519	Sy1	43.70	$7.15^{+0.09}_{-0.11}$	6	0.83±0.30	-2.37±0.45	1
PG 1116+215	QSO	45.40	$8.53^{+0.08}_{-0.10}$	6	0.57±0.12	-1.26±0.13	1
PG 2112+059	QSO	46.18	$9.00^{+0.09}_{-0.11}$	6	1.06±0.21	0.40±0.15	1
PG 2130+099	Sy1	44.46	$8.66^{+0.05}_{-0.06}$	7	0.62±0.15	-0.05±0.32	1
PG 2209+184	Sy1	44.47	$8.77^{+0.08}_{-0.10}$	6	0.83±0.29	-0.75±0.21	1
PG 2214+139	Sy1	44.66	$8.55^{+0.09}_{-0.12}$	6	1.58±0.18	-0.69±0.15	1
PG 2233+134	QSO	45.33	$8.04^{+0.08}_{-0.10}$	6	0.67±0.23	0.28±0.28	1
3C 390.3	Sy1	43.99	$8.85^{+0.09}_{-0.11}$	6	1.80±0.22	-0.61±0.15	1
I Zw 1	Sy1	44.80	$7.44^{+0.09}_{-0.12}$	6	0.85±0.13	-0.85±0.28	2
Mrk 509	Sy1	44.28	$8.16^{+0.04}_{-0.04}$	7	0.84±0.14	0.66±0.35	2
Mrk 573	Sy1	44.40	$7.28^{+0.08}_{-0.10}$	8	0.98±0.24	-2.35±0.14	3
Mrk 841	Sy1.5	44.29	$8.52^{+0.08}_{-0.10}$	6	1.07±0.25	0.05±0.35	2
NGC 3227	Sy1.5	42.38	$7.63^{+1.1}_{-1.9}$	7	0.98±0.24	-2.55±0.21	4,9
NGC 3783	Sy1	43.26	$7.47^{+0.07}_{-0.09}$	7	0.51±0.14	-0.34±0.35	2
NGC 4593	Sy1	43.09	$6.73^{+0.03}_{-0.09}$	7	0.34±0.13	-3.44±0.45	2,9
NGC 5548	Sy1	43.51	$7.83^{+0.02}_{-0.02}$	7	0.73±0.10	-0.81±0.26	5,9
NGC 7469	Sy1	43.72	$7.09^{+0.05}_{-0.05}$	7	0.26±0.06	-1.16±0.43	2

(1) This paper; (2) Smith et al. (2002); (3) Nagao et al. (2004); (4) Axon et al. (2008) (5) Goodrich and Miller (1994); (6) Vestergaard and Peterson (2006); (7) Peterson et al. (2004); (8) Satyapal et al. (2005); (9) Wu and Han (2001).

(**Afanasiev et al. arXiv:1104.3690v1, 2011**)



Linear polarization and power-law index n versus black hole masses from the data of Table 2

(**Afanasiev et al. arXiv:1104.3690v1, 2011**)

Object	p	s	$B(R_\lambda)$[G]
PG 0007+106	1/2	1	2.43
PG 0026+129	3/4	5/4	1
PG 0049+171	3/4	5/4	13
PG 0157+001	3/4	5/4	98
PG 0804+761	3/4	3/2	3.4
PG 0844+349	3/4	1	37
PG 0953+414	3/4	1	300
PG 1116+215	3/4	3/4	100
PG 2112+059	3/4	2	14.4
PG 2130+099	1/2	1	27
PG 2209+184	1/2	3/4	16
PG 2214+139	1/2	5/4	2.8
PG 2233+134	3/4	3/2	0.37
3C 390.3	3/4	1	6.4

Table 3: Physical parameters of the accretion disk obtained from our spectropolarimetric observations at the 6-m BTA telescope (SCORPIO) and published spectroscopic data.

(**Afanasiev et al. arXiv:1104.3690v1, 2011**)

THANKS FOR ATTENTION!