AGN results - timing analysis (lag-frequency)

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Table 1: AGN selected for this study listing the redshift, Eddington luminosity $L_{\rm Edd}$, the bolometric luminosity $L_{\rm bol}$, Eddington ratio $\lambda_{\rm Edd}$, the black hole mass and the Luminosity distance D_L. The numbers in brackets indicate the references for each item where: (1) Zoghbi et al. (2010); (2) Kara et al. (2016); (3) Bian & Zhao (2003); (4) Brandt et al. (1994); (5) Ponti et al. (2012); (6) Fabian et al. (2013); (7) González-Martín & Vaughan (2012); (8) Vaughan & Fabian (2004); (9) NED (2019); (10) Chainakun & Young (2015); (11) Bentz & Katz (2015); (12) Bentz et al. (2009); (13) Cerruti et al. (2011); (14) Woo & Urry (2002); (15) Keel (1996); (16) Mizumoto & Ebisawa (2017); (17) Zoghbi et al. (2012); (18) Baumgartner et al. (2013); (19) Vaughan et al. (2005); (20) Zoghbi et al. (2013); (21) Schulz et al. (1994); (22) Blustin et al. (2003); (23) Pounds & Page (2006); (24) Marconi et al. (2008); (25) Chainakun & Young (2017); (26) Lanzuisi et al. (2016); (27) Done et al. (2012); (28) Giacchè et al. (2014); (29) Alston et al. (2020); (30) Vestergaard (2002).

Source	Redshift (z)	$L_{\rm Edd}$ (erg s^{-1})	$L_{\rm bol}$ (erg s^{-1})	$\lambda_{\rm Edd}$	$\log M$ ($M_\odot$)	D_L (9) pc
1H 0707-495	0.0411(1)	2.57×10^{44}	2.69×10^{44}(2)	1.05	6.31 ± 0.50(3)	1.74×10^{8}
Ark 564	0.024(4)	2.35×10^{44}	2.29×10^{44}(2)	0.976	6.27 ± 0.50(5)	9.85×10^{7}
IRAS 13224-3809	0.0406(6)	7.95×10^{44}	5.50×10^{45}(2)	6.91	6.28 ± 0.20(29)	2.88×10^{8}
MCG-6-30-15	0.007749(8)	2.51×10^{44}	1.20×10^{44}(9)	0.478	$6.30^{+0.16}_{-0.24}$(11)	3.58×10^{7}
Mrk 335	0.0285(10)	2.14×10^{45}	1.26×10^{45}(2)	0.588	7.23 ± 0.04(11)	1.03×10^{8}
Mrk 766	0.01293(12)	8.32×10^{44}	1.95×10^{44}(28)	0.233	$6.822^{+0.05}_{-0.06}$(11)	5.76×10^{4}
Mrk 841	0.0365(13)	4.17×10^{46}	6.92×10^{45}(14)	0.166	7.88 ± 0.10(30)	1.57×10^{8}
NGC 1365	0.0045(7)	5.01×10^{45}	9.77×10^{43}(2)	0.0195	7.6 ± 0.50(7)	2.12×10^{7}
NGC 3516	0.00886(15)	3.13×10^{45}	1.95×10^{44}(14)	0.0623	$7.40^{+0.04}_{-0.06}$(11)	3.57×10^{7}
NGC 4051	0.0023(16)	1.70×10^{44}	1.82×10^{43}(2)	0.0107	$5.89^{+0.08}_{-0.15}$(11)	1.27×10^{7}
NGC 4151	0.0033(17)	5.63×10^{45}	1.02×10^{44}(2)	0.0182	7.56 ± 0.05(11)	1.71×10^{7}
NGC 4395	0.0011(18)	3.54×10^{43}	1.51×10^{41}(19)	0.00423	$5.45^{+0.13}_{-0.15}$(11)	8.03×10^{6}
NGC 5548	0.01718(12	6.58×10^{45}	6.17×10^{44}(2)	0.0937	7.72 ± 0.02(11)	7.45×10^{7}
NGC 6860	0.0149(20)	5.02×10^{45}	5.13×10^{43}(2)	0.0102	7.6 ± 0.50(11)	6.07×10^{7}
NGC 7314	0.0048(21)	6.31×10^{44}	9.55×10^{42}(2)	0.0151	6.7 ± 0.50(21)	1.54×10^{7}
NGC 7469	0.0164(22)	1.14×10^{45}	1.26×10^{45}(9)	1.11	6.96 ± 0.05(11)	6.27×10^{7}
PG 1211+143	0.0809(23)	5.13×10^{45}	1.48×10^{46}(9)	2.88	7.61 ± 0.50(5)	3.58×10^{8}
PG 1244+026	0.0482(25)	2.29×10^{45}	4.17×10^{44}(2)	0.182	7.26 ± 0.50(24)	2.10×10^{8}
PG 1247+267	2 ± 0.2(26)	1.05×10^{47}	2.19×10^{47}(9)	2.09	8.919 ± 0.50(26)	1.57×10^{10}
REJ 1034+396	0.04(27)	5.02×10^{44}	3.31×10^{44}(2)	0.660	6.18 ± 0.50(27)	1.84×10^{8}

1 AGN basic data

2 AGN sample selection

Table 2: The full sample, listing the source, observation ID, year, exposure time, photon counts and grouping where lc and hc refer to observations containing $20 <$ cts $s^{-1} > 20$ respectively.

Source	Obs ID	Year	Exposure [eff] (ks)	Total counts	Group
1H0707-495	0110890201	2000	46[41]	4.2198×10^4	med(lc)
	0148010301	2002	80[76]	2.6646×10^5	hi(lc)
	0506200201	2007	41[38]	2.4509×10^4	lo(hc)
	0506200301		41[39]	7.1211×10^4	med(lc)
	0506200401		43[41]	1.6336×10^5	hi(hc)
	0506200501		47[41]	2.0238×10^5	hi(lc)
	0511580101	2008	124[111]	4.1346×10^5	hi(lc)
	0511580201		124[93]	4.5403×10^5	hi(hc)
	0511580301		123[84]	4.1172×10^5	hi(hc)
	0511580401		122[81]	2.7764×10^5	hi(hc)
	0653510301	2010	117[112]	4.0564×10^5	hi(lc)
	0653510401		128[118]	6.5802×10^5	hi(hc)
	0653510501		128[93]	4.1624×10^5	hi(lc)
	0653510601		129[105]	5.5009×10^5	hi(lc)
	0554710801	2011	98[86]	2.6845×10^4	lo(hc)
Ark 564	0006810101	2000	35[10]	3.8959×10^5	hi
	0206400101	2005	102[96]	2.6760×10^6	hi
	0670130201	2011	60[59]	2.6475×10^6	hi
	0670130301		56[55]	1.3931×10^6	hi
	0670130401		64[55]	1.3980×10^6	hi
	0670130501		67[67]	2.4174×10^6	hi
	0670130601		61[53]	1.4116×10^6	hi
	0670130701		64[41]	6.4190×10^5	lo
	0670130801		58[57]	1.8283×10^6	hi
	0670130901		56[56]	2.3028×10^6	hi
IRAS13224-3809	0110890101	2002	64[61]	1.0113×10^5	med(hc)
	0673580101	2011	133[49]	1.0897×10^5	med(lc)
	0673580201		132[99]	1.7448×10^5	med(hc)
	0673580301		129[82]	8.8891×10^4	lo(hc)
	0673580401		135[113]	8.8891×10^4	med(lc)
	0780560101	2016	141[141]	6.8267×10^4	med(hc)
	0780561301		141[127]	2.8064×10^5	med(lc)
	0780561401		141[126]	2.1072×10^5	med(lc)
	0780561501		141[126]	1.7607×10^5	med(lc)
	0780561601		141[137]	4.0806×10^5	med(lc)
	0780561701		141[123]	2.2300×10^5	med(hc)
	0792180101		141[123]	1.8324×10^5	med(lc)
	0792180201		141[129]	2.5110×10^5	med(lc)

	0792180301		141[129]	1.0760×10^5	lo(hc)
	0792180401		141[120]	5.2155×10^5	hi(hc)
	0792180501		138[122]	2.1865×10^5	med(lc)
	0792180601		136[122]	5.3759×10^5	hi(hc)
MCG-6-30-15	0029740101	2001	89[80]	1.3655×10^6	hi
	0029740701		129[122]	2.2598×10^6	hi
	0029740801		130[124]	2.1023×10^6	hi
	0111570101	2000	46[43]	3.9648×10^5	lo
	0111570201		66[41]	5.0582×10^5	lo
	0693781201	2013	134[121]	2.6950×10^6	hi
	0693781301		134[130]	1.7075×10^6	lo
	0693781401		49[49]	4.7201×10^5	lo
Mrk 335	0306870101	2006	133[120]	1.7998×10^6	hi
	0600540501	2009	83[80]	2.7347×10^5	lo
	0600540601		132[107]	2.4358×10^5	lo
Mrk 766	0096020101	2000	59[27]	2.4525×10^5	med
	0109141301	2001	130[104]	1.7852×10^6	hi
	0304030101	2005	96[78]	2.2150×10^5	lo
	0304030301		99[98]	5.9688×10^5	med
	0304030401		99[92]	7.3631×10^5	med
	0304030501		96[73]	7.3079×10^5	med
	0304030601		98[85]	7.0732×10^5	med
	0304030701		34[29]	2.0834×10^5	med
Mrk 841	0070740101	2001	123[108]	1.2577×10^5	hi
	0070740301		148[122]	1.4110×10^5	hi
	0205340201	2005	73[43]	1.6170×10^5	lo
	0205340401		30[18]	8.9102×10^4	lo
NGC 1365	0151370101	2003	19[13]	8.6760×10^3	lo
	0151370201		11[2]	1.0760×10^3	lo
	0151370701		11[8]	7.6110×10^3	lo
	0205590301	2004	60[48]	7.6334×10^4	lo
	0205590401		69[33]	3.1702×10^4	lo
	0505140201	2007	129[38]	2.0808×10^4	lo
	0505140401	2007	131[107]	6.2724×10^4	lo
	0505140501(1)	2007	131[88]	5.4515×10^4	lo
	0505140501(2)	2007	131[53]	3.1217×10^4	lo
	0692840201	2012	139[101]	1.0164×10^5	lo
	0692840301		126[44]	1.2009×10^4	hi
	0692840401	2013	134[87]	3.4571×10^5	hi
	0692840501(1)		135[64]	1.0998×10^5	lo
	0692840501(2)		135[34]	4.3562×10^4	lo
NGC 3516	0107460601	2001	128[114]	4.3384×10^5	lo
	0107460701		130[121]	2.8333×10^5	lo
	0401210401	2006	52[51]	8.9508×10^5	hi
	0401210501		69[61]	9.8191×10^5	hi
	0401210601		68[62]	5.3934×10^5	med

	0401211001		68[58]	9.0659×10^5	hi
NGC 4051	0109141401	2001	122[106]	1.8972×10^6	hi
	0157560101	2002	52[42]	1.7100×10^5	lo
	0606320101	2009	46[45]	3.2081×10^5	lo
	0606320201		46[42]	4.8114×10^5	hi
	0606320301		46[21]	2.9192×10^5	hi
	0606320401		45[18]	6.2512×10^4	hi
	0606321301		33[30]	4.8625×10^5	hi
	0606321401		42[35]	3.6173×10^5	lo
	0606321501		42[36]	3.7188×10^5	hi
	0606321601		42[39]	7.7558×10^5	hi
	0606321701		45[28]	1.4327×10^5	lo
	0606321801		44[40]	2.9873×10^5	lo
	0606321901		45[36]	1.3425×10^5	lo
	0606322001		40[37]	2.5787×10^5	lo
	0606322101		44[24]	4.8918×10^4	lo
	0606322201		44[36]	1.3448×10^5	lo
	0606322301		43[35]	2.6474×10^5	lo
NGC 4151	0112310101	2000	33[30]	1.3054×10^5	lo
	0112830201		62[57]	3.0694×10^5	lo
	0112830501		23[20]	1.0612×10^5	lo
	0143500101	2003	19[19]	2.9040×10^5	hi
	0143500201		19[18]	2.9434×10^5	hi
	0143500301		19[19]	3.7503×10^5	hi
	0402660101	2006	40[40]	1.5613×10^5	lo
	0402660201		53[34]	2.0554×10^5	lo
NGC 4395	0142830101	2003	113[90]	9.2203×10^4	hi
	0744010101	2014	54[52]	1.5747×10^4	lo
	0744010201		53[48]	3.0323×10^4	lo
NGC 5548	0089960301	2001	96[84]	1.2394×10^6	hi
	0720110801	2013	58[52]	1.5582×10^5	lo
	0720110901		57[55]	1.5063×10^5	lo
	0720111001		57[53]	1.4671×10^5	lo
	0720111101		57[35]	1.2577×10^5	lo
	0720111201		57[56]	1.8784×10^5	lo
	0720111301		57[50]	1.5891×10^5	lo
	0720111401		57[52]	1.3915×10^5	lo
	0720111501		57[53]	1.3530×10^5	lo
	0720111601	2014	57[56]	2.0296×10^5	lo
NGC 6860	0552170301	2009	123[117]	8.3564×10^5	–
NGC 7314	0111790101	2001	45[43]	2.7240×10^5	hi
	0311190101	2006	84[74]	3.4552×10^5	lo
	0725200101	2013	140[122]	1.3001×10^6	lo
	0725200301		132[128]	1.0903×10^6	lo
NGC 7469	0112170101	2000	19[18]	2.1839×10^5	lo
	0112170301		25[23]	3.4552×10^5	hi

	0207090101	2004	85[85]	1.3001×10^6	hi
	0207090201		79[78]	1.0903×10^6	lo
PG1211+143	0112610101	2001	56[53]	1.9601×10^5	lo
	0208020101	2004	60[46]	1.9078×10^5	lo
	0502050101	2007	65[45]	3.6026×10^5	hi
	0502050201		51[35]	2.2251×10^5	hi
	0745110101	2014	87[78]	3.0162×10^5	hi
	0745110201		104[98]	2.6068×10^5	lo
	0745110301		102[54]	2.1892×10^5	lo
	0745110401		100[91]	4.3563×10^5	hi
	0745110501		58[55]	3.3463×10^5	hi
	0745110601		95[92]	5.4077×10^5	hi
	0745110701		99[96]	4.3535×10^5	hi
PG1244+026	0675320101	2011	124[123]	7.3977×10^5	hi
	0744440101	2014	119[108]	4.0065×10^5	lo
	0744440201		120[92]	4.2261×10^5	lo
	0744440301		122[121]	5.8676×10^5	lo
	0744440401		129[127]	5.3442×10^5	lo
	0744440501	2015	120[118]	4.5444×10^5	lo
PG1247+267	0143150201	2003	34[32]	8.1630×10^3	–
REJ1034+396	0506440101	2007	93[84]	5.7557×10^5	lo
	0561580201	2009	70[54]	2.4146×10^5	hi
	0655310101	2010	52[45]	1.5036×10^5	lo
	0655310201		54[50]	1.6376×10^5	lo

3 The lag-frequency results

Table 3: The lag-frequency results for all AGN groups detailing the spectral flux, soft reverberation lag and the lag frequency.

Source	**Group**	**Flux**$(0.3-10$ **keV)**	**Lag (s)**	**Lag-frequency (Hz)**
1H0707-495	Combined	2.92×10^{-12}	29.1 ± 3.6	1.55×10^{-3}
	hi	3.45×10^{-14}	29.0 ± 3.8	1.55×10^{-3}
	hi-cts>20	2.80×10^{-12}	24.5 ± 7.8	9.66×10^{-4}
	Med	3.28×10^{-14}	34.0 ± 11.8	1.93×10^{-3}
	lo	4.07×10^{-13}	74.6 ± 36.8	1.55×10^{-3}
	lo-cts<20	2.84×10^{-12}	26.0 ± 4.9	1.84×10^{-3}
Ark 564	Combined	4.23×10^{-11}	36.2 ± 10.5	6.07×10^{-4}
	hi	1.47×10^{-10}	61.1 ± 19.3	6.07×10^{-4}
	lo	2.53×10^{-11}	15.6 ± 5.6	2.21×10^{-3}
IRAS 13224-3809	Combined	1.81×10^{-12}	39.3 ± 9.6	5.06×10^{-4}
	hi	3.46×10^{-12}	43.7 ± 24.0	5.06×10^{-4}
	hi-cts>20	1.81×10^{-12}	40.6 ± 6.28	9.66×10^{-4}
	med	1.41×10^{-12}	37.7 ± 11.5	5.06×10^{-4}
	lo	5.18×10^{-13}	67.1 ± 11.2	9.66×10^{-4}
	lo-cts<20	1.44×10^{-12}	38.4 ± 13.3	5.06×10^{-4}
MCG-6-30-15	Combined	5.67×10^{-11}	15.9 ± 5.9	9.66×10^{-4}
	hi	6.44×10^{-11}	15.2 ± 16.1	9.66×10^{-4}
	lo	4.36×10^{-11}	16.1 ± 7.1	9.66×10^{-4}
Mrk 335	Combined	1.61×10^{-11}	132.7 ± 36.4	2.65×10^{-4}
	hi	3.03×10^{-11}	141.4 ± 56.3	2.65×10^{-4}
	lo	6.50×10^{-12}	24.0 ± 47.2	5.06×10^{-4}
Mrk 766	Combined	2.33×10^{-11}	23.9 ± 6.7	9.66×10^{-4}
	hi	4.03×10^{-11}	35.2 ± 13.8	9.66×10^{-4}
	med	2.16×10^{-11}	10.2 ± 8.4	9.66×10^{-4}
	lo	9.32×10^{-12}	157.6 ± 98.2	2.65×10^{-4}
Mrk 841	Combined	1.72×10^{-11}	265.85 ± 217.5	1.02×10^{-4}
	hi	2.53×10^{-11}	212.0 ± 122.4	4.77×10^{-4}
	lo	1.41×10^{-11}	562.8 ± 121.0	1.02×10^{-4}
NGC 1365	Combined	9.57×10^{-12}	144.2 ± 113.4	7.27×10^{-5}
	hi	2.48×10^{-11}	108.9 ± 104.3	7.27×10^{-5}
	lo	6.54×10^{-12}	156.7 ± 95.1	2.65×10^{-4}
NGC 3516	Combined	4.20×10^{-10}	256.6 ± 144.4	7.27×10^{-5}
	hi	5.60×10^{-11}	296.3 ± 229.6	7.27×10^{-5}
	med	4.32×10^{-11}	131.5 ± 213.2	7.27×10^{-5}
	lo	2.25×10^{-11}	143.7 ± 79.6	2.65×10^{-4}
NGC 4051	Combined	2.30×10^{-11}	17.2 ± 7.1	9.66×10^{-4}
	hi	3.19×10^{-11}	17.2 ± 10.0	5.06×10^{-4}

	lo	1.51×10^{-11}	19.8 ± 6.7	9.66×10^{-4}
NGC 4151	Combined	9.47×10^{-11}	488.0 ± 278.6	1.39×10^{-4}
	hi	2.38×10^{-10}	585.5 ± 380.8	1.39×10^{-4}
	lo	6.02×10^{-12}	41.9 ± 142.2	2.65×10^{-4}
NGC 4395	Combined	5.88×10^{-12}	23.9 ± 16.2	5.06×10^{-4}
	hi	6.16×10^{-12}	22.4 ± 17.4	5.06×10^{-4}
	lo	6.27×10^{-12}	59.2 ± 26.7	8.60×10^{-4}
NGC 5548	Combined	3.48×10^{-11}	156.7 ± 55.9	2.65×10^{-4}
	hi	5.44×10^{-11}	197.3 ± 98.7	2.65×10^{-4}
	lo	3.07×10^{-11}	300.4 ± 240.3	1.39×10^{-4}
NGC 6860	2009	2.90×10^{-11}	186.7 ± 192.5	1.94×10^{-4}
NGC 7314	Combined	2.74×10^{-11}	1.6 ± 5.8	1.84×10^{-3}
	hi	4.90×10^{-11}	104.2 ± 101.7	2.65×10^{-4}
	lo	4.90×10^{-11}	1.2 ± 2.9	2.95×10^{-3}
NGC 7469	Combined	4.42×10^{-11}	82.2 ± 51.1	3.71×10^{-4}
	hi	4.46×10^{-11}	292.3 ± 80.3	3.71×10^{-4}
	lo	4.37×10^{-11}	18.4 ± 12.1	1.35×10^{-3}
PG 1211+143	Combined	5.89×10^{-12}	215.6 ± 112.7	8.33×10^{-5}
	hi	6.37×10^{-12}	162.1 ± 140.4	8.33×10^{-5}
	lo	4.90×10^{-12}	313.8 ± 170.7	7.27×10^{-5}
PG 1244+026	Combined	6.02×10^{-12}	54.5 ± 20.3	5.06×10^{-4}
	hi	7.44×10^{-12}	72.8 ± 45.2	5.06×10^{-4}
	lo	5.71×10^{-12}	45.0 ± 23.0	5.06×10^{-4}
PG 1247+267	2003	7.55×10^{-13}	498.6 ± 513.2	1.16×10^{-4}
REJ 1034+396	Combined	2.53×10^{-12}	55.5 ± 68.5	2.65×10^{-4}
	hi	2.29×10^{-12}	3.0 ± 5.0	3.52×10^{-3}
	lo	2.57×10^{-12}	72.9 ± 72.0	2.65×10^{-4}

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