The AGN activity in a sample of IR Luminous Major Mergers

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Are AGN triggered as a consequence of a merging process? or by secular evolution?. Studying "twin" (similar size and mass) galaxies interacting with each other could provide useful insights.

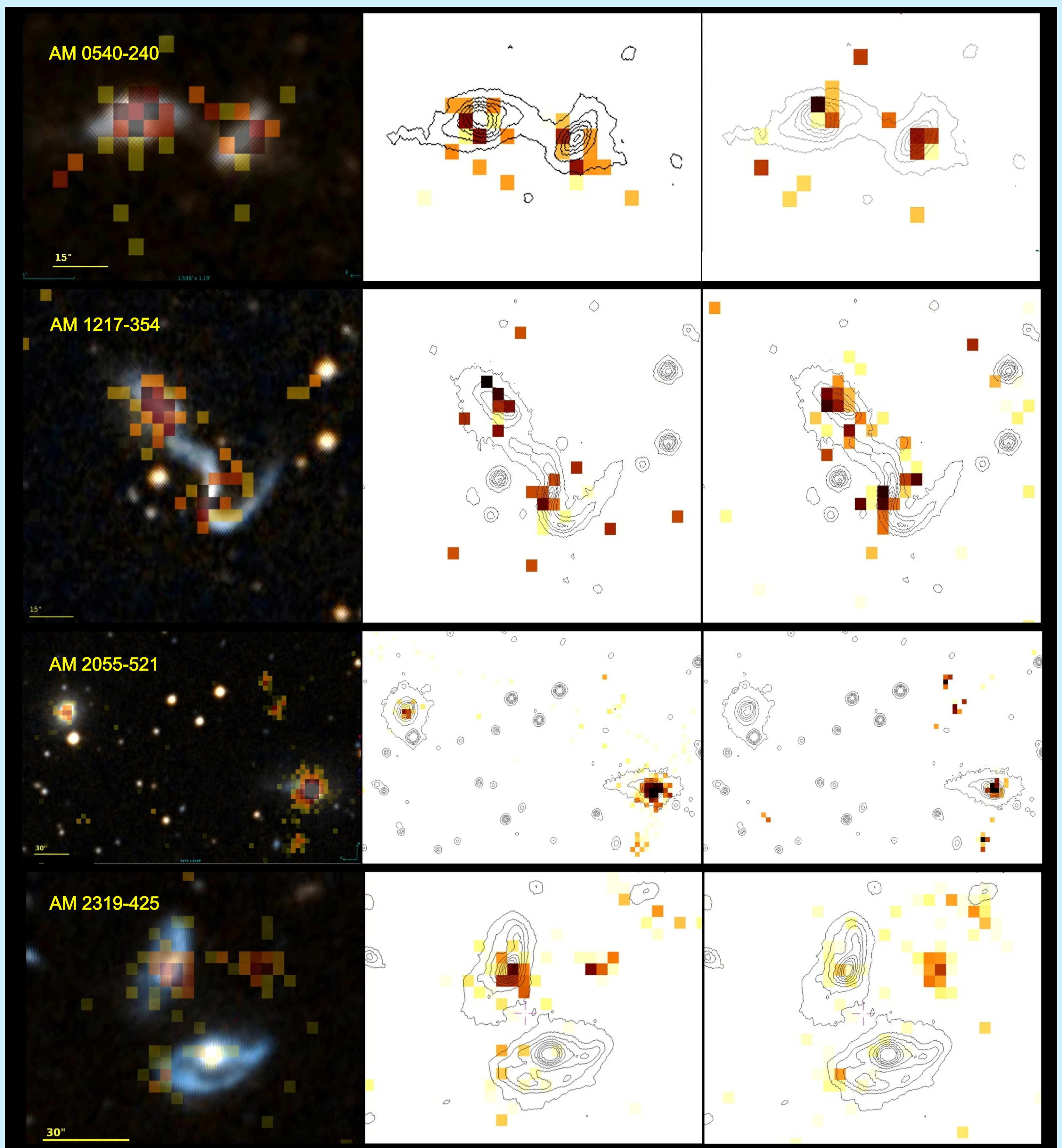
- GW by SMBH-SMBH coalescense - *e.g. Mortlock + 99.*
- ULIRGs are mergers - *known since IRAS Catalogue of BG in 1985.*
- Most low–z Radio Galaxies are mergers - *Heckman 86, Colina & de Juan 95, Ramos Almeida +12, Tadhunter +16.*
- Fraction of AGNs in mergers increases with smaller separations – *Silverman +11, Satyapal +14, Ellison +15 .*
- Radio-loud AGN are mergers -*Chiaberge +15.*
- AGNs are 5 times more likely to be obscured if hosted by mergers *WISE IR colours - Weston +16.*
- Obscuring material covers ~95% of the X-ray sources in later merger stages – *Ricci +17.*

Pairs of galaxies with two AGNs have mainly been discovered serendipitously in X-rays (Komossa +03, Ballo+04, Guainazzi+05, etc), in radio (Green+10) or, few of them, in large X-ray samples (Teng+12, Comerford+15) and in other wavelengths (i.e. Mueller-Sanchez+15).

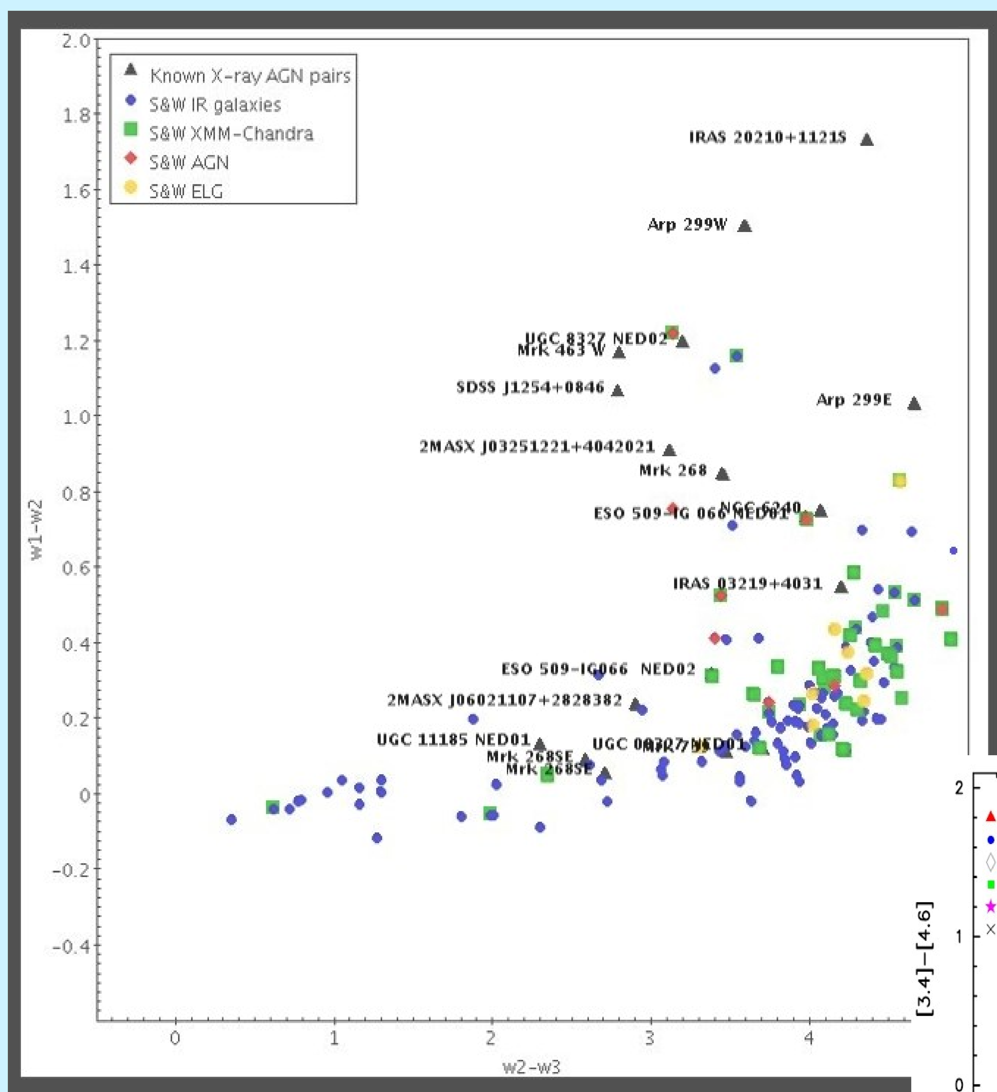
X-rays are probably the best tool to detect hidden AGN (i.e. Koss +12).

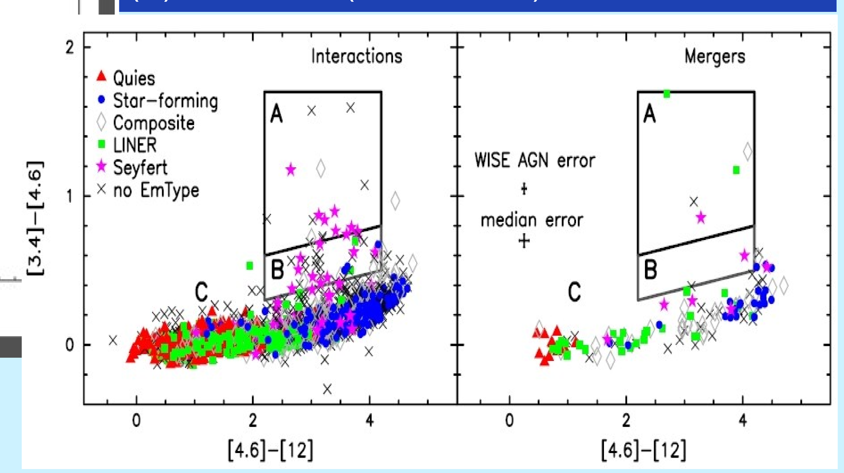
We are studying a sample of 70 nearby (z<0.05) IR bright Arp-Madore major mergers (Cat-2), for which Sekiguchi+92 (S&W) obtained optical/IR spectra. From these we have previously observed 3 pairs with projected separations 10<r_p<100 kpc with XMM-Newton (Jiménez-Bailón+07), and 8 pairs with r_p~10 kpc with Chandra (in prep.). Archival search for XMM-Newton and Chandra observations provided data of other 14 galaxies of the sample (see table below).

We present here new XMM-Newton observations of 4 more pairs of this sample, which have been selected using their WISE IR colours as a diagnostic tool. We compare the results for these 8 galaxies with the data of the 35 merging galaxies of this sample previously detected with XMM-Newton and/or Chandra.

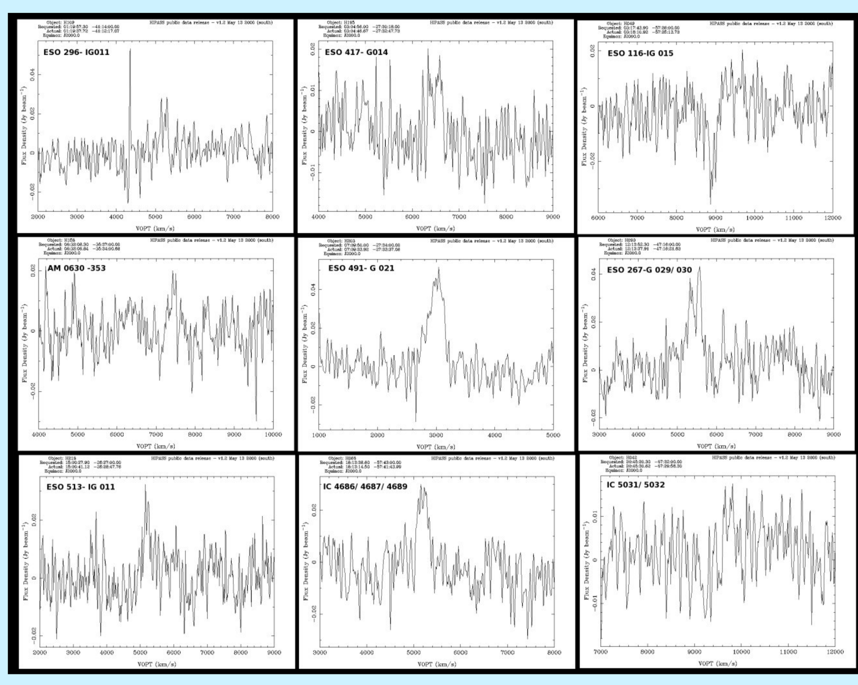


Images of the new 4 pairs of galaxies observed with XMM-Newton: *left*: X-ray emission in the 0.3 – 8.0 keV band, overlaid on DSS colour images, *centre:* X-ray emission in the 0.3 – 1.2 keV band overlaid on optical DSS contours, *right:* X-ray emission in the 1.2 – 8.0 keV band overlaid on optical DSS contours (*"Aladin Sky Atlas", CDS, France, was used to produce these images).*





Left: WISE color-color plot for the galaxies of the S&W sample, classified by their activity type, and for the known pairs of AGNs detected in X-rays (black triangles). *Bottom: WISE* color-color plot for a sample of Interacting and Merging galaxies with the AGN region (A) and extended AGN region (B) indicated (Weston+17)



HI profiles of some of the HI brightest pairs, from the HI Parkes All Sky Survey (HIPASS). We are analysing possible correlations of the gas content and kinematics of these interacting galaxies in relation to their SF or AGN activities (see i.e. Gereb +15).

Name		z	rp (kpc)	Fx	AllWISE	w1-w2	w2-w3	L12μ	Lxcalc	Lxobs	
AM 0117-412 NW_E	HI	0.0176	8.50	7.19E-15	J011957.12-411405.7	0.152	4.073	1.35E+42	1.11E+42	4.71E+39	Chandra+
AM 0117-412 NW_W	HI	0.0176	8.50	2.75E-14						1.80E+40	Chandra+
AM 0117-412 SE		0.0169	8.15	2.70E-15						1.63E+39	Chandra+
AM 0127-524 S		0.0544	9.15	2.88E-13	J012925.10-523417.8	0.436	4.297	1.46E+44	7.53E+43	7.18E+42	Chan+,XMM
AM 0240-600 SE	HI	0.0394	8.78	4.01E-14	J024215.79-595353.6	0.112	4.230	3.11E+43	1.87E+43	1.32E+41	XMM
AM 0302-274 NE		0.0218	6.63	5.61E-15	J030456.19-273018.5	0.392	4.418	3.91E+42	2.90E+42	5.68E+39	Chandra+
AM 0302-274 SW		0.0213	6.48	3.47E-15	J030455.68-273027.9	0.156	4.126	1.56E+42	1.27E+42	3.29E+39	Chandra+
AM 0316-573 E	HI	0.0283	15.00	1.83E-14	J031743.77-572647.6	0.332	4.058	3.80E+43	2.25E+43	3.10E+40	Chandra+
AM 0316-573 W	HI	0.0283	15.00	5.97E-14						1.01E+41	Chandra+
AM 0337-711 N		0.0485	11.00	2.00E-14	J033755.00-710336.6	0.235	3.942	3.83E+43	2.26E+43	9.96E+40	Chandra+
AM 0337-711 S		0.0485	11.00	6.14E-15						3.06E+40	Chandra+
AM 0506-374 NE		0.0522	24.68	1.70E-14	J050828.14-373923.2	0.364	4.517	7.30E+43	4.04E+43	9.84E+40	XMM
AM 0540-240 NE		0.0285	17.30	1.65E-14	J054302.24-240350.7	0.827	4.574	2.76E+43	1.68E+43	2.98E+40	XMM+
AM 0540-240 SW		0.0283	17.20	1.20E-14	J054300.23-240356.0	0.388	4.553	1.49E+43	9.67E+42	2.14E+40	XMM+
AM 0545-453 N		0.0410	21.73	6.29E-15	J054714.12-452835.9	0.336	3.802	3.04E+43	1.84E+43	2.25E+40	Chandra+
AM 0545-453 S		0.0415	21.99	4.81E-14	J054714.50-452857.8	0.048	2.351	7.49E+42	5.20E+42	1.76E+41	Chandra+
AM 0630-353 SE	HI	0.0270	6.99	2.02E-15	J063206.93-353741.1	0.213	3.748	1.03E+43	6.93E+42	3.09E+39	Chandra+
AM 0707-273 E		0.0099	9.09	4.45E-14	J070949.93-273429.6	0.222	4.307	4.16E+42	3.06E+42	8.96E+39	XMM+
AM 0707-273 W		0.0099	9.09	7.38E-14	J070946.85-273408.0	0.511	4.661	2.19E+43	1.37E+43	1.48E+40	XMM+
AM 0905-274 W		0.0358	100.32	3.17E-12	J090719.72-280058.2	0.312	4.157	2.76E+43	1.68E+43	8.65E+42	XMM Slew
AM 1204-314 N		0.0234	5.98	1.43E-14						1.79E40	Chandra
AM 1204-314 S		0.0228	5.83	8.59E-15	J120651.92-315659.2	0.483	4.465	5.17E43	2.96E43	1.00E40	Chandra
AM 1211-465 NE	HI	0.0185	101.98	2.50E-12	J121412.83-471342.7	0.419	4.256	4.80E+43	2.77E+43	1.82E+42	XMM+
AM 1211-465 SW	HI	0.0182	100.15	7.49E-14	J121352.27-471625.5	0.323	4.555	2.67E+43	1.63E+43	5.18E+40	XMM+
AM 1217-354 NE		0.0577	43.35	3.94E-14	J121958.96-355735.1	1.159	3.546	9.68E+43	5.21E+43	3.06E+41	XMM+
AM 1217-354 SW	S2	0.0575	43.13	5.85E-14	J121957.43-355805.7	0.524	3.442	2.31E+43	1.43E+43	4.50E+41	XMM+
AM 1331-231 E	S2	0.0332	11.71	9.23E-12	J133440.73-232645.4	0.311	3.386	7.76E+42	5.36E+42	2.17E+43	XMM+,Chan
AM 1331-231 W	S2	0.0343	12.10	4.44E-12	J133439.62-232647.5	0.728	3.983	5.71E+43	3.24E+43	1.10E+43	XMM+,Chan
AM 1457-261 SE	HI	0.0168	12.69	2.02E-13	J150029.24-262657.9	0.583	4.280	1.29E+42	1.06E+42	1.19E+41	XMM
AM 1457-261 SW	HI	0.0171	12.89	4.82E-14	J150026.77-262710.8	0.262	3.649	8.95E+41	7.66E+41	2.99E+40	XMM
AM 1809-574 N		0.0165	9.31	6.42E-14	J181338.76-574356.8	0.408	4.894	1.86E+43	1.18E+43	3.66E+40	XMM
AM 1809-574 NE	HI, S2	0.0173	29.57	1.94E-13	J181339.70-574330.9	0.489	4.837	8.11E+43	4.44E+43	1.24E+41	XMM
AM 1809-574 S	HI	0.0165	19.72	5.24E-14	J181340.34-574453.8	0.369	4.500	2.31E+43	1.43E+43	2.98E+40	XMM
AM 2040-674 N	HI	0.0325	31.40	1.15E-14	J204520.26-673221.0	0.238	4.231	1.09E+43	7.31E+42	2.59E+40	XMM+
AM 2040-674 S	HI	0.0341	32.95	2.80E-14	J204522.10-673306.6	0.300	4.324	5.45E+43	3.11E+43	6.84E+40	XMM+
AM 2049-691 NE		0.0372	9.98	1.76E-14	J205411.10-690213.9	0.277	4.098	2.87E+43	1.74E+43	5.12E+40	Chan+.XMM
AM 2049-691 SW		0.0366	9.83	3.85E-15	J205410.04-690224.6	0.120	3.685	1.28E+43	8.40E+42	2.50E+40	Chan+
AM 2055-521 SW	S2	0.0510	239.58	1.49E-13	J205912.85-520021.0	1.219	3.138	9.45E+43	5.10E+43	8.94E+41	XMM
AM 2055-521 NE		0.0488	228.58	1.67E-14	J205935.87-515917.4	-0.039	0.621	1.73E+42	1.39E+42	9.12E+40	XMM
AM 2056-425 NW		0.0295	25.34	7.28E-15	J205928.63-424615.1	0.115	4.212	1.12E+43	7.48E+42	1.34E+40	XMM+
AM 2056-425 SE		0.0299	25.64	2.57E-14	J205931.51-424642.3	0.306	4.087	2.71E+43	1.65E+43	4.89E+40	XMM+
AM 2319-425 NE	S2	0.0348	24.01	6.37E-14	J232212.93-423515.0	0.532	4.540	2.07E+43	1.30E+43	1.57E+40	XMM+
AM 2319-425 SW	S2	0.0349	24.11	5.73E-15	J232211.61-423543.9	-0.057	1.985	1.36E+42	1.12E+42	1.73E+41	XMM+

Parameters of the S&W galaxies observed with XMM-Newton and Chandra

(**S2**: previously classified as Sy2; **HI**: has been detected in HI; "+" :X rays observations by our team; Fx: X-ray flux (0.3-8.0 keV) of the nuclear sources; Highlighted are the new pairs observed with XMM-Newton). Matched WISE sources are also listed together with their colors. The 12μ luminosity is used to estimate their possible AGN X-ray luminosity Lxcalc, using the relation determined by Gandhi +09 for AGN. For most of these pairs the observed X-ray luminosity is lower, indicating that part of the 12μ luminosity originates in a different region from the nuclear X-ray source, or that the nuclear X-ray emission is more absorbed than what we estimated.

- The X-ray spectra of some of the galaxies of this sample show strong evidences of AGN activity, like the pair AM 1211-465 NE / SW. This is the less perturbed and one of the most separated pairs of our sample, confirming the results by Ellison +11 that pairs of AGNs can be found at large separations even if they are more frequent at shorter separations.
- Individual AGN found: AM 0127-524 S, AM 0545-453 S and AM 0905-274 W.
- For AM 1217-354 SW, AM 2055-521 SW and AM 2319-425 NE their X-ray nuclear emission is compatible with their previous classification as Sy2. The nuclear emission in AM 2318-425, instead, was not detected.
- The spectra and luminosity of pairs like AM 0707-273 E / W or AM 0316-573 E / W, would be compatible with a very heavy absorption as observed in other binary AGNs serendipitously detected in X-rays (Bianchi +10, Piconcelli +10 and Koss +11).
- The X-ray luminosity of the nuclei of these galaxies is in most cases lower than the one expected if their WISE 12μ luminosity was coming from a nuclear AGN (as happens for very bright AGN). Note that most luminous SMBH at z<1reside in highly obscured nuclear environments, most of them so far undetected in X-rays at <10keV (Mateos +17).
- Besides the nuclear emission some of these pairs show some bright extranuclear sources, like AM 2319-425, and some extended emission is probably also enhanced by the interactions.
- The on-going analysis of the X-ray emission combined with data in other wavelengths is also being analysed in the context of interactions simulations (see Mihos +96, Lotz +08).

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(*) MAGNA (Multiple AGN Activity) is a collaboration lead by A. de Rosa, IAPS/INAF, Italy (http://www.issibern.ch/teams/agnactivity/Home.html)