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Comparing the hot and cold skies: INTEGRAL/BAT versus Planck

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A master catalogue of hard X-ray sources has been compiled from the various surveys performed with the INTEGRAL/IBIS and SWIFT/BAT telescopes. This represents the 'hot' view of the universe. A 'cold' view of the universe has recently been given in the form of the Planck Early Release Compact Source catalogue. We compare the two skies and find that only very few sources are common to both catalogues. These are generally active galaxies, mainly Blazars and Seyfert 2's. The latter are probably detected due to a mixture of the AGN and ongoing starburst activity.

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1. Introduction

We have used the published hard X-ray catalogues from INTEGRAL/IBIS and SWIFT/BAT, symbolising the hot sky and the Planck Early release point source catalogue, representing the cold sky and searched for sources common to both. Clearly one would expect to find very little in common between to such extreme examples of celestial emission. Nevertheless, should there be a certain commonality found, this could provide important information about the nature of these objects.

2.The Catalogues

The 'Master' Hard X-ray catalogue was compiled from 4 catalogues: two from the SWIFT/BAT telescope - the second Palermo 54 month [1]; and the 58 month survey [2] and two from the INTEGRAL/IBIS instrument - the 4th Catalogue [3] and the 7-year all sky hard X-ray survey [4]. Merging these four catalogues and removing obvious double entries leads to a list containing 1574 individual sources. The Planck data used was the 350µm (857 GHz) list from the Early Release Compact Source catalogue (ERCSC, [5]) containing 8988 entries. From a simple spatial correlation analysis we find that there are a total of 54 sources detected in both the hard-X and GHz frequencies. Of these there are 5 galactic objects (e.g. The Crab) and one cluster of galaxies. Table 1 lists the remaining 48 sources from which it is apparent that they are dominated by active galaxies, in particular Seyfert 2s.

3.Source Classification

The source type in table 1 has been obtained in general from NED/Veron-Veron 13th edition [6], however this was not possible for all objects as either the information was not available (rows in italics) or ambiguous/partial (rows in bold font). For example, Gonçalves et al. [7] classified the optical spectrum of NGC 4102 as composite, concluding that the nucleus is dominated by starburst emission, although a weak Type 2 Seyfert component is also present; the AGN component has recently been confirmed by a Suzaku observation of the source [8]. Further, IC 2461 has recently been observed within our optical follow-up program of high energy sources and classified as a Seyfert 2 galaxy (see fig 1. and [9]) .

Hard X Name	Planck Name	GHz Flux	X-ray Flux	Z	Type
3C454.3	G086.11-3	18340.7	131.8	0.8590	Blazar
3C273	G289.96+6	4065.28	430.84	0.1583	Blazar
3C 279	G305.11+5	3333.66	34.82	0.5362	Blazar
PKS 0537-441	G250.08-3	3057.01	14.16	0.8940	Blazar
NGC 4102	**G138.07+6**	**9084.47**	**28.55**	**0.0028**	**Liner**
NGC 4593	G297.47+5	3244.15	88.68	0.0090	S1
NGC 235A	G093.84-8	3025.72	47.8	0.0222	S1
NGC 7469	G083.09-4	5438.24	68.69	0.0163	S1.2
NGC 7214	G022.23-5	2428.57	64.97	0.0231	S1.2
NGC 4151	G155.06+7	2625.54	533.09	0.0033	S1.5
NGC6814	G029.34-1	7747.16	75.29	0.0052	S1.5
NGC 1566	G264.30-4	16870.6	20.08	0.0050	S1.5
NGC 3227	G216.98+5	5879.35	112.78	0.0039	S1.5
NGC 7213	G349.58-5	3879.45	44.3	0.0058	S1.5
NGC 4051	G148.87+7	10500.1	37.62	0.0023	S1.5
IGRJ12131+0700	G276.81+6	1839.95	14.44	0.2095	S1.5-1.8
NGC 1365	G237.95-5	43160	64.47	0.0055	S1.8
NGC 3786	G191.54+7	3018.31	20.49	0.0089	S1.8
NGC 4395	G162.11+8	6199.53	26.08	0.0011	S1.8
NGC 2992	G249.71+2	3597.66	30.13	0.0077	S1.9
NGC 5674	G355.89+5	1357.17	13.61	0.0249	S1.9
NGC 5290	G089.27+7	2500.52	19.14	0.0086	S1.9
NGC 5728	G337.32+3	4939.8	90.9	0.0094	S1.9
NGC 4138	G147.30+7	2717.09	30.67	0.0030	S1.9
M58	G290.41+7	8989.44	10.41	0.0051	S1.9
UGC 07064	G188.54+7	1071.49	13.64	0.0250	S1.9
IC 2461	*G186.28+4*	*1146.39*	*20.73*	*0.0075*	*S2*
CEN A	G309.51+1	115319	1379.67	0.0018	S2
NGC 4388	G279.12+7	4857.95	275.78	0.0084	S2
NGC 4945	G305.27+1	297415	300.97	0.0019	S2
NGC 6300	G328.49-1	13484.2	96.99	0.0037	S2
NGC 5643	G321.44+1	13688	18.33	0.0040	S2
NGC 4258	G138.33+6	25691	23.92	0.0015	S2
NGC 4939	G308.09+5	4561.28	25.43	0.0104	S2
NGC 6240	G020.72+2	3469.74	66.96	0.0245	S2
4C55.19	G157.80+4	21735.7	31.1	0.0037	S2
MCG-01-05-047	G157.36-6	2504.66	22.33	0.0172	S2
NGC 5899	G069.38+5	4585.51	20.95	0.0085	S2
NGC 612	G261.65-7	1354.66	57.11	0.0298	S2
NGC 4941	G308.79+5	2922.98	19.41	0.0037	S2
NGC 2655	G134.91+3	2969	14.05	0.0047	S2
NGC 1068	G172.09-5	48923.7	33.75	0.0038	S2
NGC 7582	G348.07-6	14057.4	80.95	0.0053	S2
NGC 835	G173.96-6	5351	17.72	0.0136	S2
IC1663	G262.57-8	1847.79	15.32	0.0361	S2
NGC 2712	*G175.64+41*	*2257.52*	*10*	*0.0061*	*S2?*
NGC4500	**G128.08+58**	**966.87**	**8.69**	**0.0104**	**SB(S2)**
M82	G141.40+4	156993	5.96	0.0007	SB

Table 1. The 48 extragalactic sources in common between the Planck ERCSC and the Hard X-ray ‘Master’ catalogues. The Planck flux is in units of 10^{-26} ergs s^{-1} cm^{-2} Hz^{-1} while the X-ray flux is in units of 10^{-12} ergs s^{-1} cm^{-2}.

For two other sources (NGC 4500 and NGC 2712) SWIFT-XRT data can help in understanding the nature of the galaxy: both objects show absorption in excess of the galactic value (41 and $4x10^{22}$ cm^{-2} respectively) and an unabsorbed 2-10 keV flux of 4.6 and $3.5x10^{-12}$ erg/cm^2 sec respectively, which at the sources' redshifts indicate soft X-ray luminosities of $10.9x10^{41}$ erg/sec for NGC 4500 and $2.8x10^{41}$ erg/sec for NGC 2712. Combined with the hard (14-195 keV) X-ray luminosities of 20 and 8 10^{41} the observed values suggest an obscured AGN nature for both of these sources. Assuming that both these galaxies are type 2 objects from the detection of intrinsic absorption we conclude that the associations reported here consists of only 1 pure starburst galaxy and 47 AGN: 11 of type 1, 32 of type 2 and 4 blazars of the Low Synchrotron Peak type (i.e. with a first peak below 10^{14} Hz).

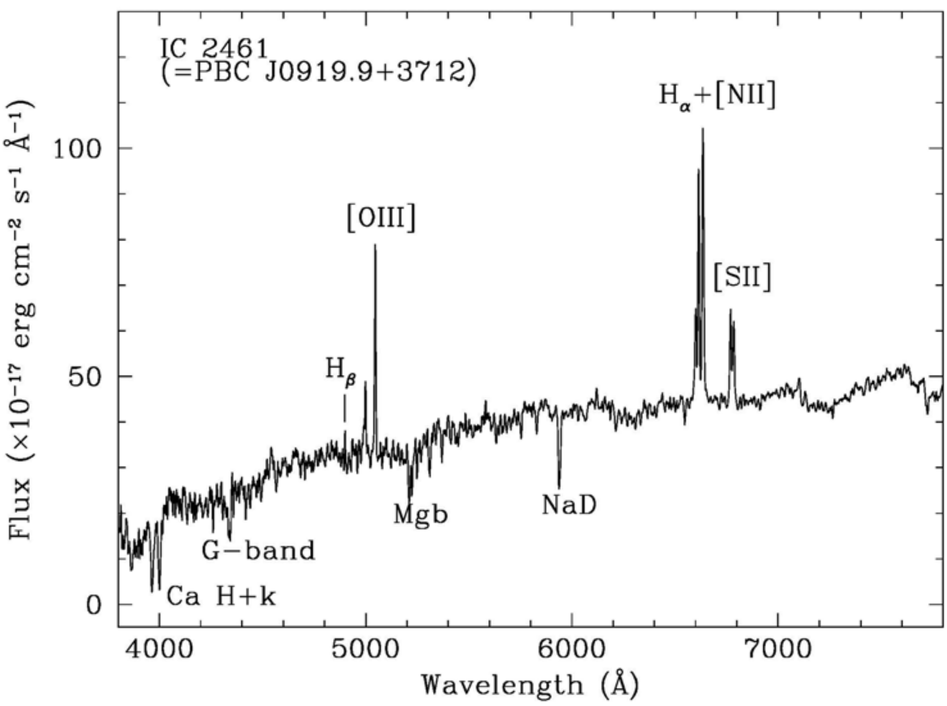

Fig 1. The optical spectrum of IC 2641 demonstrating the lack of broad line emission features leading to its classification as a type 2 Seyfert.

4.Discussion

It is interesting that, while there is a very small number of objects detected both by Planck and the Hard X-ray telescopes, the vast majority are extra-galactic in origin. For these sources the Hard X-ray observations probe the AGN phenomenon, while the GHz measurements track not only the nuclear component (radio loud in blazars and quiet in Seyferts), but also the presence of star formation. Therefore it is likely that the Seyfert sample will be dominated by composite starburst/AGN galaxies. Indeed, within table 1 we find many such objects e.g. NGC 6240 is one of the best examples of a galaxy hosting a luminous starburst simultaneously with AGN activity, while NGC 4102 is also a composite dominated by star formation. Other examples include NGC 1068, NGC 4388, NGC 4945 and NGC 7469. The fact that the vast majority of Seyfert galaxies in the sample are of type 2 suggests that star formation is more prevalent in this class, with it being suggested that up to 50% of all Seyfert 2s exhibit also circumnuclear starbursts, although this is still a matter of debate.

Composite starburst/AGN galaxies are of interest due to the still unclear relationship, if any, between the two phenomena, the distribution in fluxes between them (and so their relative contribution to the cosmic X-ray background) and the great difficulty in identifying composite galaxies. It would appear that Planck measurements over a wide operational range from 350 - 10000 µm will provide a new tool with which to study these objects in a relatively unexplored region of the spectrum. Combining these 'cold' and 'hot' observations will both increase the numbers of known composite galaxies and help untangle the two components.

References

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