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The WISE $W4$ Compendium

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ABSTRACT
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Key words: Astronomical data bases: surveys – Quasars: general – galaxies: evolution – galaxies: infrared.

1 INTRODUCTION

Along with nuclear fusion, gravitational accretion onto a black hole is one of the two major energy sources available to a galaxy. After dark matter, dust in galaxies is the most poorly understood constituent of galaxies. Sky surveys, in new electromagnetic wavebands, have long provided key datasets and led to new insights into out Universe. In this paper, we present the "WISE W4 Compendium" (WW4C); a detailed study into the objects that were detected in the longest waveband, 20-28μm observed, on the Wide-Field Infrared Survey Explorer (WISE; Wright et al. 2010; Cutri 2013) mission. This study will describe all 40 million objects that are detected in the WISE W4-band, but will concentrate on those objects most affected by radiating dust emission and well described by extragalactic, and AGN, spectral energy distributions (SEDs). The motivations of the WW4C are numerous, but the primary science we will pursue is the identification of bolometric luminous AGN, especially those that might not be observered in X-ray/UV/optical surveys. However, we will aim to remain as agnostic as possible to the origin of the objects that are emit in the mid-infrared.

WISE mapped the sky in 4 passbands, in bands centered at wavelengths of 3.4, 4.6, 12, and 23μm. In total the release all sky "ALLWISE" catalog, contains nearly 750 million detections at high-significance[1]. This dataset is a significant advance in quality and depth than prior missions, and will remain the all-sky state-of-the-art for the foreseeable future.

Numerous studies have investigated the WISE MIR AllWISE data release for various scientific reasons. Indeed there are too many studies to mention here and do all justice to their findings. As such, we concentrate with those with a AGN flavour.

Assef et al. (2013), Stern et al. (2012)

Description	# objects	% of Total
AllWISE Source Catalog	747,634,026	100.0000
All W4 detections	40,939,966	5.4759
W4 Only	35,818	0.0048

Table 1.

1.1 A Few Preparatory Notes

Brown et al. (2014), in PASA, is the paper about Recalibrating the Wide-field Infrared Survey Explorer (WISE) W4 Filter,

Brown et al. (2014), in ApJS, is the paper about An Atlas of Galaxy Spectral Energy Distributions from the Ultraviolet to the Mid-infrared.

2 DATA

There are 747,634,026 total entries in the AllWISE Source Catalog. Of these, 40,939,966 (5.476%) are W4-detected.

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[1] http://wise2.ipac.caltech.edu/docs/release/allwise/expsup/sec2_1.html

3 THE WW4C

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3.1 Dust Overview

http://arxiv.org/pdf/1605.06671.pdf

4 GALACTIC OBJECTS IN THE WW4C

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4.1 Stars

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4.2 Brown Dwarfs

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4.3 PNe

http://www.astroscu.unam.mx/apn6/PROCEEDINGS/Kronberger.pdf

Kronberger et al. 2014

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5 LOCAL EXTRAGALACTIC OBJECTS

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5.1 Spirals in the Beam

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5.2 Mergering Systems

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6 DISTANT EXTRAGALACTIC OBJECTS

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6.1 The so-called "DOGs"

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7 AGN

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7.1 Mullaney SEDs

7.2 Number Density of High-z Sources

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8 CONCLUSIONS

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- This sample spans a redshift range of $0.28 < z < 4.36$ and has a bimodal distribution, with peaks at $z \sim 0.8$ and $z \sim 2.5$.
- We recover a wide range of quasar spectra in this selection. The majority of the objects have spectra of reddened Type 1 quasars, Type 2 quasars (both at low and high redshift) and objects with strong absorption features.
- There is a relatively high fraction of Type 2 objects at low redshift, suggesting that a high optical-to-infrared colour can be an efficient selection of narrow-line quasars.
- There are three objects that are detected in the $W4$-band but not $W1$ or $W2$ (i.e., "W1W2-dropouts"), all of which are at $z > 2.6$.
- We identify an intriguing class of objects at $z \simeq 2-3$ which are characterized by equivalent widths of REW(C IV) $\gtrsim$ 150Å. These objects often also have unusual line properties. We speculate that the large REWs may be caused by suppressed continuum emission analogous to Type 2 quasars in the Unified Model. However, there is no obvious mechanism in the Unified Model to suppress the continuum without also suppressing the broad emission lines, thus potentially providing an interesting challenge to quasar models.

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APPENDIX A: DIFFERENCES AND USAGE OF VARIOUS WISE CATALOGS

The WISE Mission consisted of different stages and subsequently different catalog releases.

A1 Parts of the WISE mission

As noted at http://irsa.ipac.caltech.edu/Missions/wise.html and in Meisner et al. (2016), there are several surveys that were carried out as first part of the WISE, and then part of the NEOWISE mission. Table A1 summarises the salient details.

APPENDIX B: II. ALLWISE SOURCE CATALOG AND REJECT TABLE

B1 II.1.a. Format and Column Descriptions

http://wise2.ipac.caltech.edu/docs/release/allwise/expsup/sec2_1a.html#det_bit
Bit-encoded integer indicating bands in which a source has a $w?snr > 2$ detection. For example, a source detected in W1 only has `det_bit`=1 (binary 0001). A source detected in W4 only has `det_bit`=8 (binary 1000). A source detected in all four bands has `det_bit`=15 (binary 1111).
http://wise2.ipac.caltech.edu/docs/release/allwise/expsup/sec2_1.html

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Mainzer A., et al., 2014, ApJ, 792, 30
Meisner A. M., Lang D., Schlegel D. J., 2016, ArXiv e-prints
Stern D., et al., 2012, ApJ, 753, 30
Wright E. L., et al., 2010, AJ, 140, 1868

Mission Part	Duration	Cryogenic?	Connected Data Release	Sky Coverage	No. of deteced objects	Key Reference(s)
First 105 days	14 January 2010 - 29 April 2010	Yes	`Preliminary`	57%	[a]257,310,278	Wright et al. (2010)
Full Cryogenic	07 January 2010 - 06 August 2010	Yes	`All-Sky`	120%	[a]563,921,584	Wright et al. (2010)
3-band Cryo	06 August 2010 - 29 September 2010	Yes[a]	`3-Band Cryo`	30%	[a]261,418,479	Wright et al. (2010)
NEOWISE	29 September 2010 - 01 February 2011	No	`NEOWISE`	70%	[c]7,337,642,955[c]	Mainzer et al. (2011)
AllWISE	14 January 2010 to 29 April 2010	Yes and no	`AllWISE`	>100%	[a]747,634,026	Wright et al. (2010) Mainzer et al. (2011)
NEOWISE-Reactivation 2015	13 December 2013 to 13 December 2014	No	`NEOWISE 2015`	>100%	[c]18,468,575,596	Mainzer et al. (2014)
NEOWISE-Reactivation 2016	13 December 2014 to 13 December 2015	Yes	`NEOWISE 2016`	>100%	[c,d]38,159,806,157	Mainzer et al. (2014)

Table A1. [a]Objects detected on the Atlas Intensity images. [b]The detectors continued to be cooled by the hydrogen ice in the inner cryogen tank. The telescope warmed from the 12K maintained during the main mission to 45K. This reduced the sensitivity of the W3 12μm measurements and fully saturated the W4 23μm detector [c]Source detections extracted from the Single-exposure images. [d]The second year NEOWISE-Reactivation data products are concatenated with those from the first year (originally released on March 26, 2015).

WISE band combination	`det_bit`	Number of objects	Percentage of AllWISE
W1-W2-W3-W4	15	25 882 083	3.5
W1-W2-W4	11	11 309 923	1.5
W1-W4	9	2 347 472	0.3
W1-W3-W4	13	859 426	0.1
W3-W4	12	454 160	0.1
W4	8	35 818	<0.1
W2-W3-W4	14	35 528	<0.1
W2-W4	10	15 556	<0.1
W4-any		40 939 966	5.5

Table B1. Band-Detection Combinations ($> 2\sigma$ per Band) in the AllWISE Catalog. See `http://wise2.ipac.caltech.edu/docs/release/allwise/expsup/sec2_1.html`.