Combing the WISE W4 catalogue and the Gaia Data Release 1: Searching for Infrared bright, optically faint objects across the full sky.

May 30, 2017

Preamble

All the code and plotting packages, and smaller catalogues are available at `https://github.com/d80b2t/WW4C`. The .tex and PDF file can be found `here`.
The four 'obvious' files that aren't on the GitHub are::
GaiaDR1xWISEw4_10as_noDupes_sorted.csv (1.1G);
WISE_W4_DecOrdered.dat (1.4GB);
WISE_W4_cat_with_GaiaNull.csv (2.6GB);
WISE_W4_cat_with_Gaia.csv (3.2GB).

1 Motivation

The WISE W4 23μm band is shallow. Therefore, anything that is detected in W4, and is *not* a Milky Way star, or nearby e.g. dusty spiral galaxy, is going to be intrinsically very luminous. Furthermore, objects that are also detected in W4, but are faint/non-detected in the optical, or in the shorter WISE W1/W2 bands also have very interesting properties, (e.g., Assef et al., 2015; Tsai et al., 2015; Lonsdale et al., 2015; Assef et al., 2016; Díaz-Santos et al., 2016; Ricci et al., 2017; Wu et al., 2017; Jones et al., 2017; Farrah et al., 2017). The WISE W4 band is also crucial in the discovery and characterization of the "Extremely Red Quasar" population, using a colour selection of $r_{\rm AB}W4_{\rm Vega} > 14.0$ (Ross et al., 2015; Zakamska et al., 2016; Hamann et al., 2017).

Note, the W4 channel effective wavelength was recalibrated from the original 22μm by Brown et al. (2014).

2 Matching the Gaia DR1 and WISE W4 catalogs

2.1 WISE

The Wide-field Infrared Survey Explorer (WISE) mission description and initial on-orbit performance is described in Wright et al. (2010). We use the `AllWISE Data Release`.

There are 40,939,966 objects, with $> 2\sigma$ detections at WISE W4 in the AllWISE Catalog. The W4 PSF is 12", but the centroid positions should be good to $\lesssim 2''$ (WISE HelpDesk, priv. comm.). Figure 1 shows the sky distribution of these 40.9M objects. The WISE scanning pattern can clearly be `seen`.

2.2 Gaia DR1

We use the `Gaia Data Release 1`. (Gaia Collaboration et al., 2016,?)[1]

The Gaia DR1 magnitude histogram peaks around 20th magnitude in G-band. The G-band is a very wide filter, that covers the wavelength range frthat covers the wavelength range from about 350 to 1000nm, with the maximum energy transmission at ∼715 nm and the full width at half maximum of 408 nm. (Jordi &. Carrasco, 2007, ASPC, 364, 215).

There are 1,142,679,769 sources in total in the Gaia DR1.

2.3 Matching

We match the two catalogues with a matching radius of 2" and 10". This is done using some v. nice and quick code from R. Collins [More details required here]. The results are given in Figure 2 and Figure 4. Figure 3 shows the WISE W4 Unique ID (UID; which isa a proxy for object declination) versus the Gaia DR1 Source ID.

3 Results of matching

The matched 10" GaiaDR1xWISEW4 catalogue returns 71,593,922 objects since one-to-many (WISE-to-Gaia) matches are allowed. The Python `numpy unique` command is used to return the sorted unique elements of this catalogue. 24,671,865 WISE W4 objects have a unique match with a Gaia source within 10".

Thus, 16,268,101 objects in the WISE W4 catalogue do not have a

Figure 4 shows the matching radius separation histograms for objects, with and without duplicates.

[1] I don't know how to fix this citation.

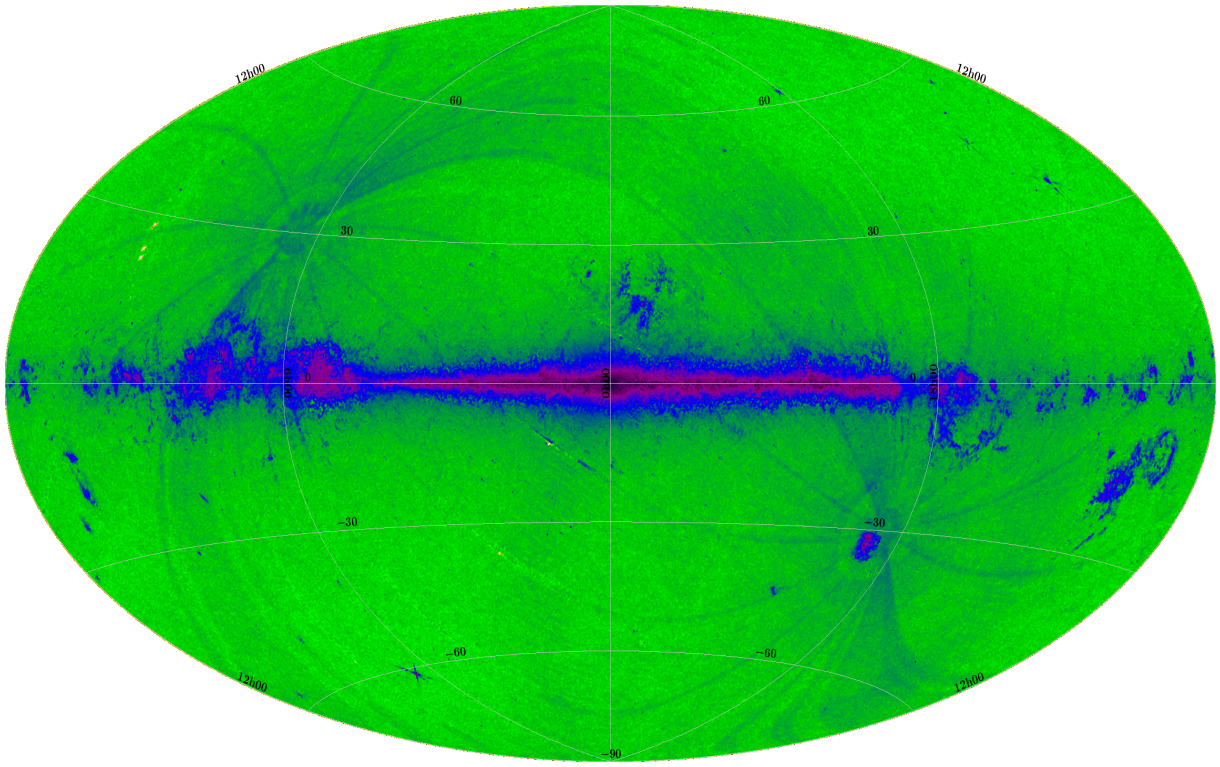

Figure 1: The all-sky distribution of the 40.9M objects in the AllWISE W4 catalog. The WISE scanning pattern can clearly be seen.

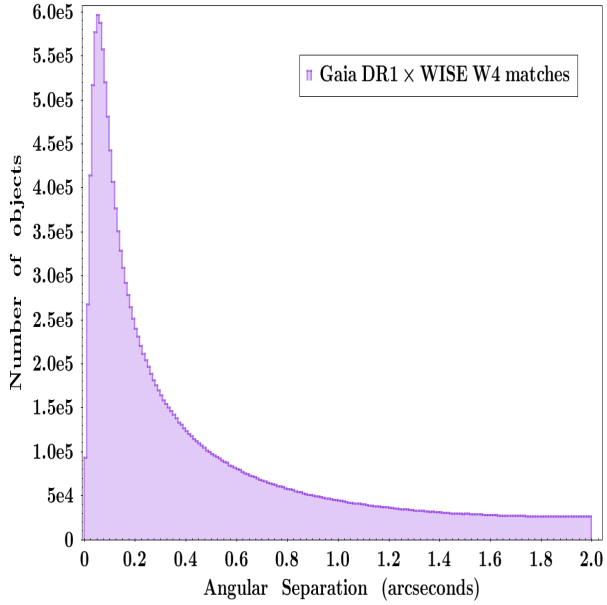

Figure 2: The matching radius separation histograms for objects, when a 2" matching radius is applied.

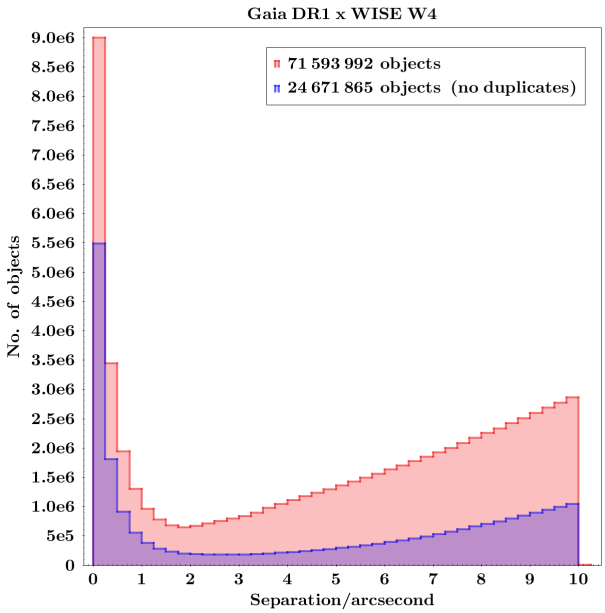

Figure 3: The matching radius separation histograms for objects, when a 10” matching radius is applied, with and without duplicates.

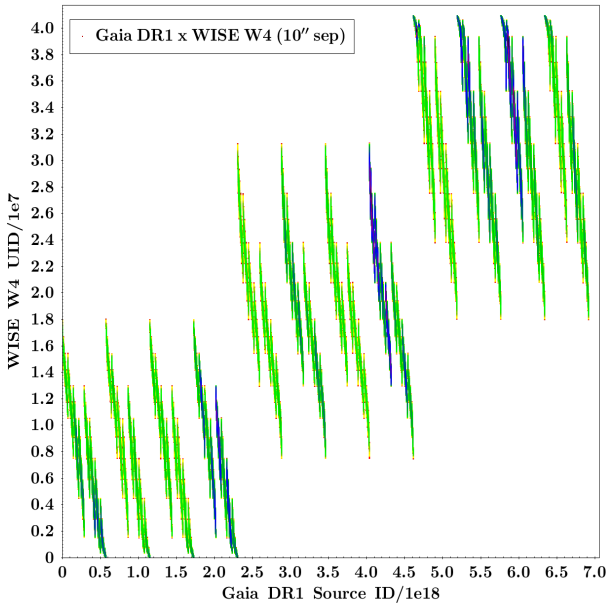

Figure 4: The WISE W4 Unique ID (UID; which isa a proxy for object declination) versus the Gaia DR1 Source ID.

Figure 5 (top) shows the all-sky distribution for the full 40.9M objects that are detected in WISE W4 (same as Figure 1 but with a different colour-scale). Figure 5 (middle) shows the all-sky distrubtion of objects that were matched to a Gaia DR1 source. The overdensity of the Milky Way is clearly seen. Figure 5 (bottom) shows the 16.3M objects that do *not* have a match in the Gaia DR1.

References

Assef R. J., et al., 2015, ApJ, 804, 27

Assef R. J., et al., 2016, ApJ, 819, 111

Brown M. J. I., Jarrett T. H., Cluver M. E., 2014, PASA, 31, 49

Díaz-Santos T., Assef R. J., Blain A. W., Tsai C.-W., Aravena M., Eisenhardt P., Wu J., Stern D., Bridge C., 2016, ApJ Lett., 816, L6

Farrah D., et al., 2017, ArXiv:1705.02649v1

Gaia Collaboration Brown A. G. A., Vallenari A., Prusti T., de Bruijne J. H. J., Mignard F., Drimmel R., Babusiaux C., Bailer-Jones C. A. L., Bastian U., et al. 2016, Astron. & Astrophys., 595, A2

Gaia Collaboration Prusti T., de Bruijne J. H. J., Brown A. G. A., Vallenari A., Babusiaux C., Bailer-Jones C. A. L., Bastian U., Biermann M., Evans D. W., et al. 2016, Astron. & Astrophys., 595, A1

Hamann F., et al., 2017, MNRAS, 464, 3431

Jones S. F., et al., 2017, ArXiv:1705.03680v1

Lonsdale C. J., et al., 2015, ApJ, 813, 45

Ricci C., et al., 2017, ApJ, 835, 105

Ross N. P., et al., 2015, MNRAS, 453, 3932

Tsai C.-W., et al., 2015, ApJ, 805, 90

Wright E. L., et al., 2010, AJ, 140, 1868

Wu J., et al., 2017, ArXiv:1703.06888v1

Zakamska N. L., et al., 2016, MNRAS, 459, 3144

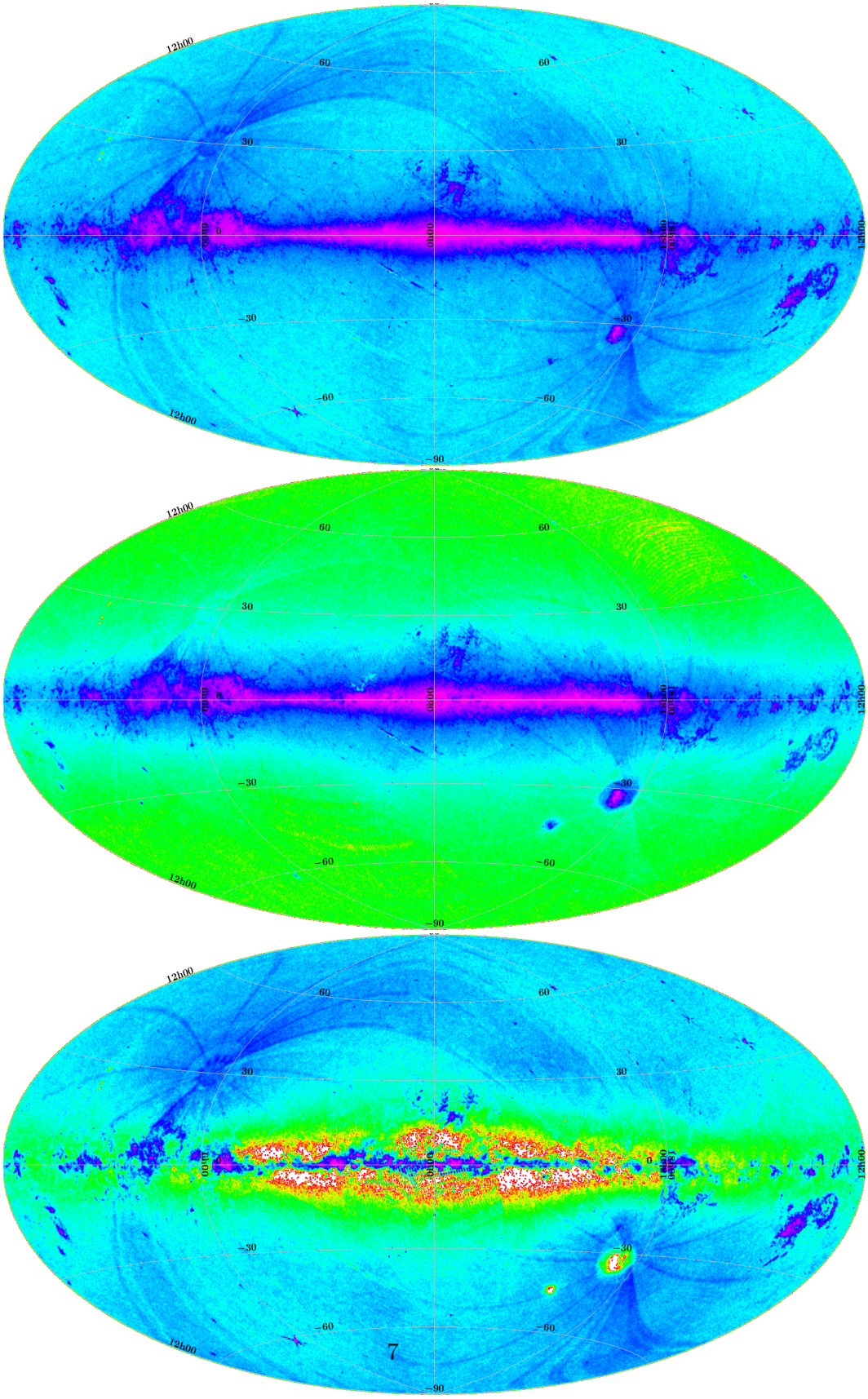

Figure 5: Three aitoff projects for the Gaia DR1×WISE W4 matched catalog. *Top:* The full 40.9M objects that are detected in WISE W4. *Middle:* The 24.7M WISE W4 objects that are matched to a Gaia DR1 source. *Bottom:* The 16.3M WISE W4 objects that are not matched to a Gaia DR1 source.