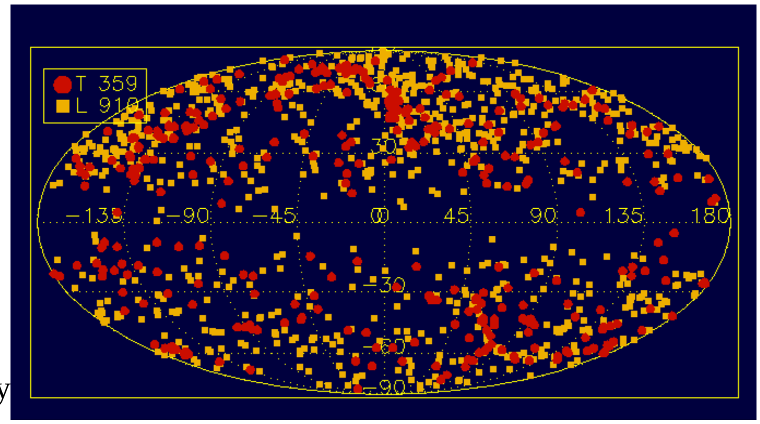
The Gaia Brown Dwarf Content Smart-Jones

Abstract

The ESA Gaia mission will revolutionize Astronomy observing objects as diverse as minor planets, stars throughout the galaxy to distant QSOs and addressing areas from extrasolar planets to relativity. Most brown dwarfs will be too faint for Gaia but some of the younger or older more massive ones will be detected. Here we attempt using the current compilation of known brown dwarfs to find which ones will be observed directly. This is part of a larger project to evaluate the impact of Gaia on brown dwarf research funded by the ESF GREAT program.

The starting list

From the compendium of L/T dwarfs at dwarfarchive.org list on 14/8/2013 there were 1281 L/T dwarfs. Any brown dwarf visible to Gaia would have been within the limits of the 2MASS surveys so objects without J magnitudes in this archive were removed. The selection criteria used for the discovery of these objects was mainly photometric and in the galactic plane the photometric errors were high the completeness is reduced. This is seen clearly in the distribution in galactic coordinates of the 1281 objects shown here.

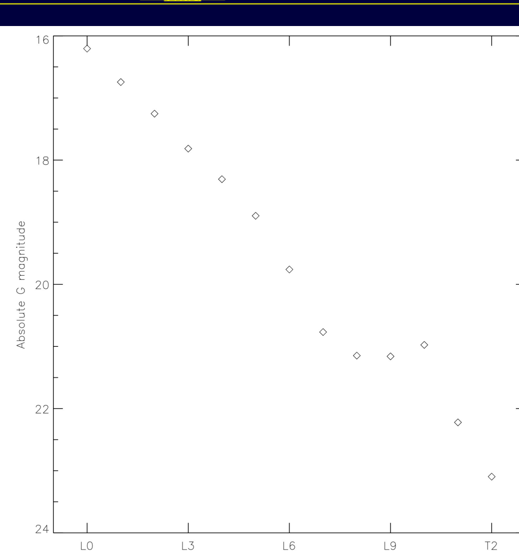


Determining Gaia magnitudes

We used the average SDSS and 2MASS color by spectral type from table 3 Hawley et al (2002) and the color transformations between Gaia and SDSS systems from Carme Jordi (Gaia internal document)

$$G - r = -0.05 + 0.1598 (r - i) - 0.5613*(r - i)^2 + 0.0628 * (r - i)^3$$

to find G-J:2MASS vs spectral type calibration listed and plotted here. The Jordi transformations are for main sequence stars but the difference going from the blue to red stars is less than a 0.1 magnitudes.



SpT	r-i	i-J	G-r	G-J	M_J	M_G
L0	2.64	4.23	-2.38	4.49	11.72	16.21
L1	2.56	4.45	-2.27	4.74	12	16.74
L2	2.5	4.64	-2.18	4.96	12.29	17.25
L3	2.34	4.84	-1.94	5.24	12.58	17.82
L4	2.38	5.06	-2	5.44	12.87	18.31
L5	2	5.21	-1.47	5.74	13.16	18.9
L6	2.79	5.27	-2.61	5.45	14.31	19.76
L7	2.31	5.91	-1.9	6.32	14.45	20.77
L8	2.19	6.11	-1.73	6.57	14.58	21.15
L9	2.33	6.04	-1.93	6.44	14.72	21.16
T0	2.43	5.76	-2.07	6.12	14.86	20.98
T1	1.47	6.59	-0.83	7.23	14.99	22.22
T2	1.8	7.38	-1.21	7.97	15.13	23.1
T3	1.16	6.75	-0.52	7.39	15.27	22.66
T4	1.04	7.35	-0.42	7.97	15.4	23.37

Candidate Selection

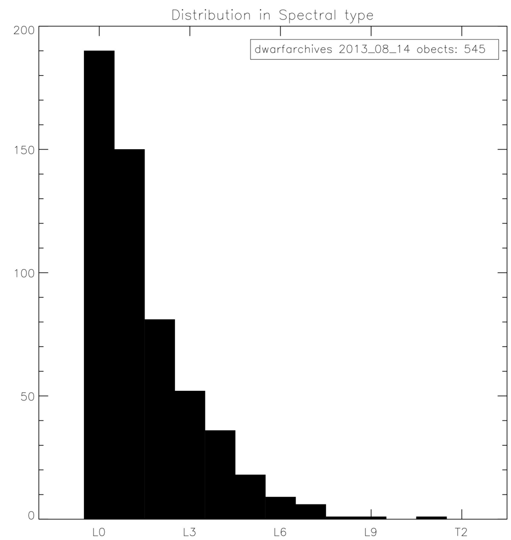
The nominal magnitude limit for detection in Gaia is G=20 at 10 sigma, however as the actual limit will be spectral type dependent and not precisely known until Gaia actually flies we adopt a limit of G=21. This also allows for G to J transformation and J magnitude errors. Adopting the optical spectral types and J magnitudes in dwarfarchive we estimate a G magnitude for each object and find 554 objects that maybe detected by Gaia. Here we plot the distribution in G, spectral type and distance as well as listing the brightest 30 and those later than L5.

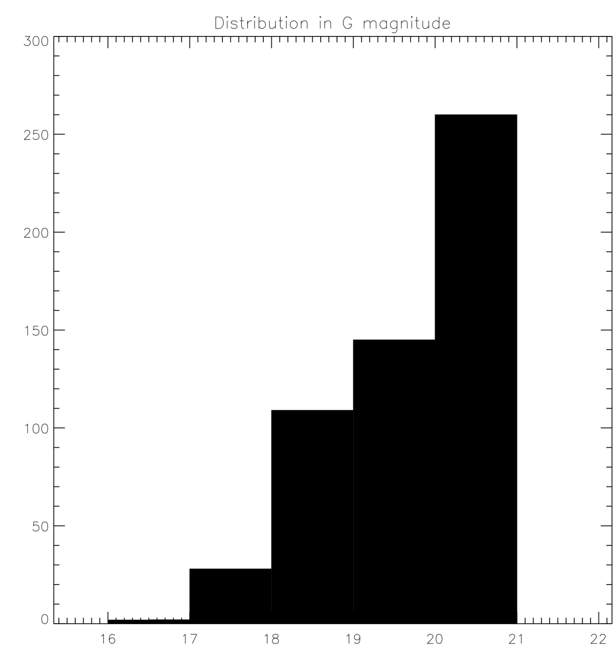
Candidates later than L5

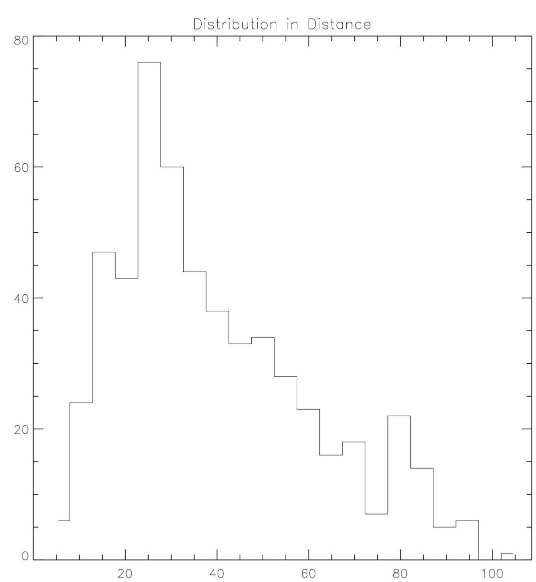
RA	Dec	J	G	Dist	SpT	Name
0.0763444	-40.7349434	13.11	18.85	9.67	L5.0	GJ 1001B
1.7431556	-7.27061081	14.19	19.93	15.12	L5.0	2MASS J01443536-0716142
3.92315841	11.56213856	14.05	19.79	12.42	L5.0	2MASS J03552337+1133437
5.66444445	-0.98386103	14.03	19.77	15.57	L5.0	SDSSp J053951.99-005902.0
6.41276407	-45.3652229	14.48	20.22	17.47	L5.0	2MASS J06244595-4521548
8.59515572	-8.32324982	13.17	18.91	9.23	L5.0	2MASSI J0835425-081923
9.14389706	50.53577805	14.55	20.29	19.03	L5.0	2MASSI J0908380+503208
12.21759987	-4.54547215	14.68	20.42	20.15	L5.0	2MASSI J1213033-043243
12.47089767	-15.7928333	14.38	20.11	17.68	L5.0	DENIS-P J1228.2-1547
12.65757465	55.26030731	14.71	20.45	19.34	L5.0	2MASSW J1239272+551537
15.12991428	-16.460722	12.83	18.57	8.92	L5.0	2MASSW J1507476-162738
17.19599724	40.48272324	15	20.74	26.51	L5.0	2MASS J17114559+4028578
17.76999855	50.56767273	15.1	20.83	24.7	L5.0	2MASS J17461199+5034036
19.60051918	-55.0422783	14.49	20.22	19.6	L5.0	2MASS J19360187-5502322
21.62706184	8.14619446	14.77	20.51	20.32	L5.0	2MASS J21373742+0808463
13.25859451	-26.8309174	15.19	20.79	24.87	L5.5	2MASSI J1315309-264951
17.84023476	-0.27086499	13.29	18.89	11.27	L5.5	2MASS J17502484-0016151
22.92183876	-57.2182388	14.08	19.68	16.03	L5.5	2MASS J22551861-5713056
10.17077827	-4.11386108	15.51	20.96	16.37	L6.0	2MASSI J1010148-040649
13.53026104	-1.28055596	15.46	20.91	17.69	L6.0	SDSS J133148.92-011651.4
14.27335739	13.80731773	13.15	18.6	6.77	L6.0	ULAS J141623.94+134836.3
15.25023079	48.79488754	14.11	19.56	9.13	L6.0	2MASSW J1515008+484742
20.04742432	-5.36455584	15.32	20.77	15.16	L6.0	2MASS J20025073-0521524
21.80453682	40.06650162	14.15	19.6	7.88	L6.0	2MASS J21481633+4003594
21.80453682	40.06650162	14.15	19.6	7.88	L6.0	2MASS J21481633+4003594
21.87391472	9.63263893	15.19	20.64	14.26	L6.0	2MASS J21522609+0937575
4.65028048	-23.8856392	14.41	20.29	10.52	L6.5	2MASSI J0439010-235308
2.09150004	-11.9915562	14.59	20.91	11.03	L7.0	DENIS-P J0205.4-1159
9.25948048	4.36791706	14.55	20.87	10.93	L7.0	2MASS J09153413+0422045
21.44976616	76.29555511	14.34	20.65	10.97	L7.0	2MASS J21265916+7617440
4.3968277	-4.23430586	14.47	20.91	10.55	L7.5	SDSSp J042348.57-041403.5
18.00738907	1.58141696	14.3	20.74	9.01	L7.5	WISEP J180026.60+013453.1
22.86964798	-17.5037212	14.31	20.76	10.11	L7.5	DENIS-P J225210.73-173013.4
2.91765833	-47.0141373	13.25	19.81	5.29	L8.0	DENIS-P J0255-4700
16.17472267	-0.68138897	12.91	19.35	5.05	L9.0	LSR 1610-0040
22.06958961	-56.7826958	12.29	19.52	2.96	T1.0	eps Indi

The brightest 30 candidates

RA	Dec	J	G	Dist	SpT	Name
14.70604134	66.05549622	11.51	16	9.42	L0.0	G 239-25
7.77848911	20.00891685	11.76	16.37	10.27	L0.5	2MASSI J0746425+200032
17.52492714	27.35647202	12.09	16.58	12.28	L0.0	2MASS J17312974+2721233
3.23428893	16.05155563	12.53	17.01	14.74	L0.0	2MASS J03140344+1603056
6.04179192	39.18310928	12.3	17.04	11.08	L1.0	LSR 0602+3910
23.86401176	-25.6268616	12.47	17.09	14.46	L0.5	2MASS J23515044-2537367
6.872159	-25.580719	12.76	17.24	16.43	L0.0	DENIS-P J0652197-253450
15.92103577	-9.93486118	12.56	17.3	13.67	L1.0	2MASSW J1555157-095605
16.75614166	-13.3310003	12.45	17.3	12.26	L1.5	2MASSW J1645221-131951
9.18693638	74.01891327	12.92	17.41	17.96	L0.0	2MASS J09111297+7401081
2.59998059	-23.5223618	12.69	17.43	17.75	L1.0	GJ 1048B
13.01181984	19.20983315	12.72	17.46	14.61	L1.0	2MASSW J1300425+191235
14.65787792	19.48747253	12.76	17.5	14.44	L1.0	2MASSW J1439284+192915
8.47616386	-13.1555176	12.8	17.55	13.6	L1.0	SSSPM J0829-1309
9.35391712	-21.0790558	12.78	17.63	15.07	L1.5	2MASS J09211410-2104446
2.47845459	16.65916634	13.17	17.65	19.19	L0.0	2MASS J02284243+1639329
12.35769463	2.95549989	13.17	17.65	19.86	L0.0	2MASS J12212770+0257198
10.81189156	1.19944406	12.92	17.67	15.21	L1.0	SDSS J104842.84+011158.5
14.35873604	18.4613266	13.23	17.72	20.08	L0.0	2MASSW 1421314+182740
8.47616386	-13.1555004	12.8	17.77	12.92	L2.0	SSSPM J0829-1309
11.92764473	-37.4597206	12.81	17.77	13.68	L2.0	2MASSW J1155395-372735
18.12109184	50.25877762	12.93	17.79	15.16	L1.5	2MASSI J1807159+501531
0.60449171	18.35288811	12.47	17.8	9.74	L3.5	2MASSW J0036159+182110
19.11346436	40.18522263	13.08	17.82	16.23	L1.0	WISEP J190648.47+401106.8
11.14189148	68.50469208	13.12	17.87	15.84	L1.0	2MASSW J1108307+683017
0.1160833	-64.6149979	13.39	17.87	22.07	L0.0	DENIS J0006579-643654
17.94894409	-48.0860176	13.41	17.89	22.38	L0.0	DENIS-P J1756561-480509
10.75666714	-1.83266699	13.16	17.9	16.7	L1.0	2MASSI J1045240-014957
9.88924122	-10.2390461	13.47	17.95	22.19	L0.0	2MASS J09532126-1014205
15.8830719	29.81347275	13.48	17.96	21.7	L0.0	2MASSW J1552591+294849

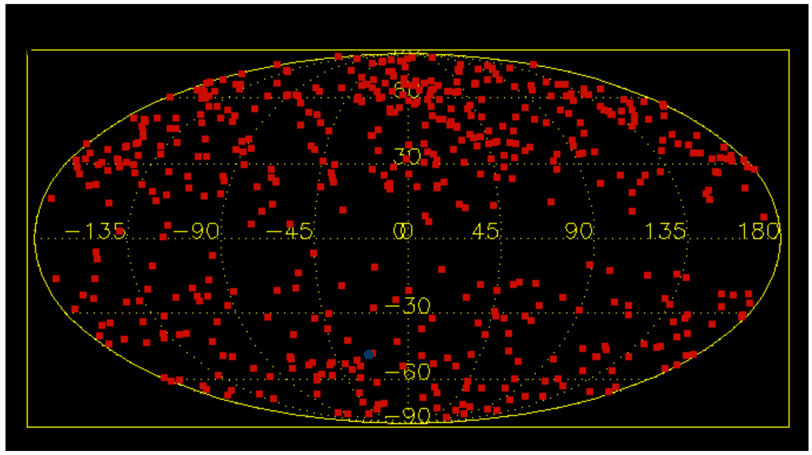






Expected Final Candidate List

Looking at the distribution in galactic coordinates we note that we are still missing many objects in the plane. Comparing the density of objects in the SDSS footprint where the search for L dwarfs is mostly complete we estimate the actual number of candidates all sky should be around 1000 of which around 500 would be brighter than G=20.



Candidate Gaia brown dwarfs in galactic coordinates. The blue point is the only T dwarf visible to Gaia, Epi Ind Aa.

Future Work

Future work for the detected Gaia BDs. To fully exploit the Gaia observations for these objects spectroscopic observations will be required to find radial velocities, chemical composition and age indicators. In particular due to their small distances the perspective acceleration effect will be high so radial velocities are required to improve the determination of their astrometric parameters.
Outside the direct detections BD research will be directly impacted by the Gaia mission, in particular Gaia will:
1. Find many BDs indirectly that are unresolved companions of brighter stars due to detection of orbital motions.
2. Find many new common proper motion systems that will become useful benchmark systems. These could either be bonafide binary systems gravitationally bound or members of recognised moving groups.
3. Characterize the primary stars in benchmark binary systems directly finding astrometric/photometric and sometimes spectroscopic details of the primaries, and indirectly by improving stellar models.
4. Measure direct masses of a couple of isolated BDs via their astrometric micro-lensing effect.
5. Provide the kinematical frame work for age determination of many BDs via their motions
6. Increase the value of BDs as galactic evolution indicators following a better understanding of our galaxy
7. Increase the robustness of many statistical properties currently being used, e.g. the BD desert, the wide binary limit.
Some of these areas are being investigated by the OATo/UH groups as part of the ESF GREAT program.