Hunting for Blue Compact Dwarfs in WISE

Dominic Ludovici & James Toomey

Reference:

WISE discovery of low-metallicity blue compact dwarf galaxies

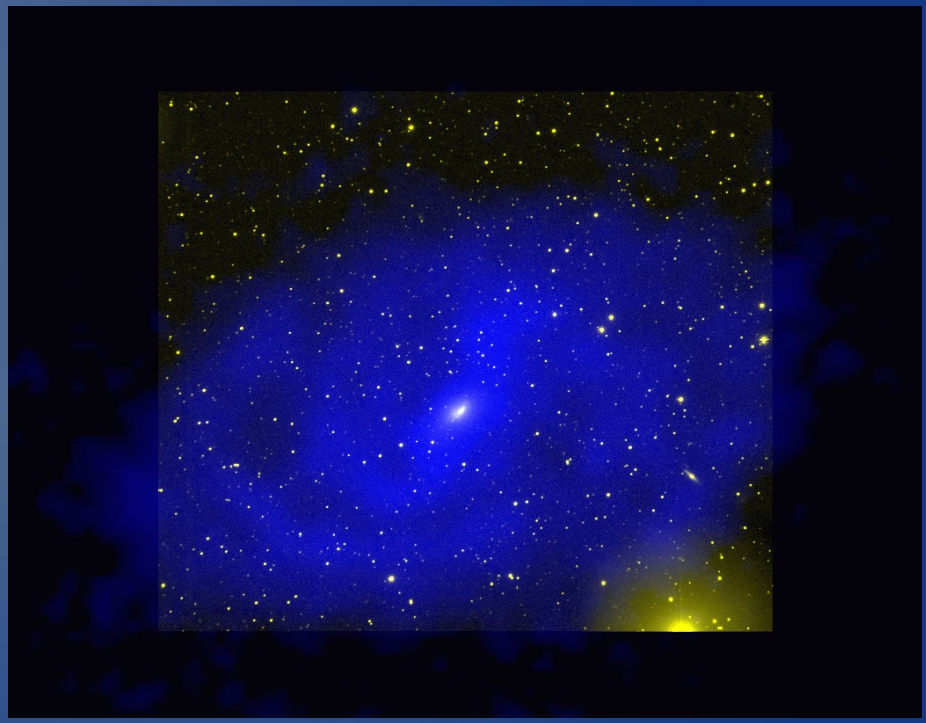
Griffith, Roger L., et al. Astrophysical Journal Letters, 736:L22 (5pp), 2011 July 20

Background

What is a Blue Compact Dwarf (BCD)?

General Characteristics?

- Dwarfs with $M_B \geq -18$ mag
- Optical size (starburst) < 1kpc
- Metallicity: 1/50 $Z_\odot$ to 1/2 $Z_\odot$
- SFR: 10^{-3} - 1 $M_\odot$ yr^{-1}
- Gas rich: H1 typically more than 30 percent by mass
- Faint blue optical continuum with strong narrow emission lines (due to intense star formation)
- <B-V>: 0.0-0.3



NGC 2915 Yellow: optical Blue: HI (21 cm)

Credit: G. R. Meurer (Johns Hopkins U.), C. Carignan (U. Montreal), S. Beaulieu and K. Freeman (MSSSO), Radio Image: ATCA, Optical Image: AAT

What is a Blue compact Dwarf?

Hubble Image

http://hera.ph1.uni-koeln.de/~heintzma/U1/I_Zwicky18.htm

I Zw 18

Stellar Characteristics

- Light dominated by young, hot stars
- Star Formation History
  - Blue main-sequence (MS) stars (age < 30 Myr)
  - Blue/red supergiants (10-100 Myr)
  - Asymptotic giant branch (AGB) stars (100-500 Myr)

Why do we want to find them?

Purpose Statement

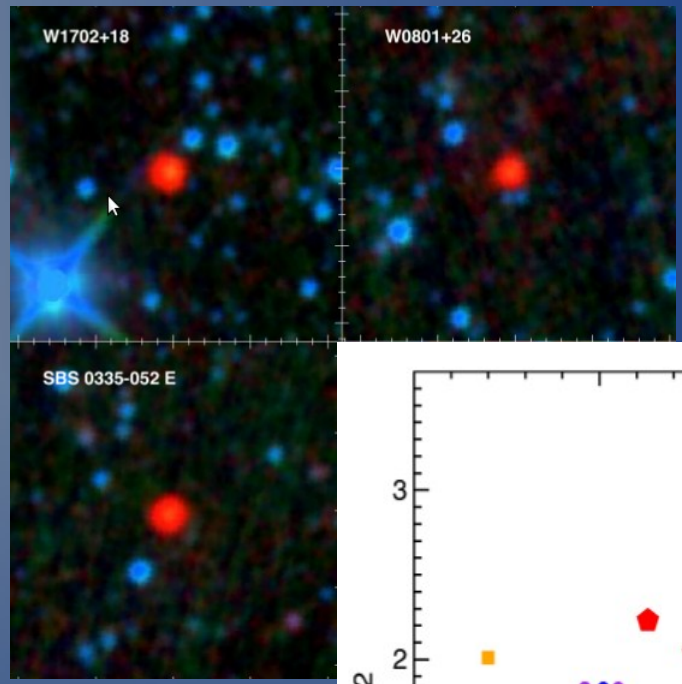
- BCDs are likely common at moderate redshifts
- BCDs represent the local analogs to the building blocks of modern galaxies at high redshift
- Observations of local BCDs provide insight into the conditions of the early universe

Credit: NASA, ESA, J. English (U. Manitoba), and the Hubble Heritage Team (STScI/AURA);

The Plan

- To develop criteria, if possible, to search WISE catalog for BCD candidates

- Compare BCD WISE Colors to other galaxy types



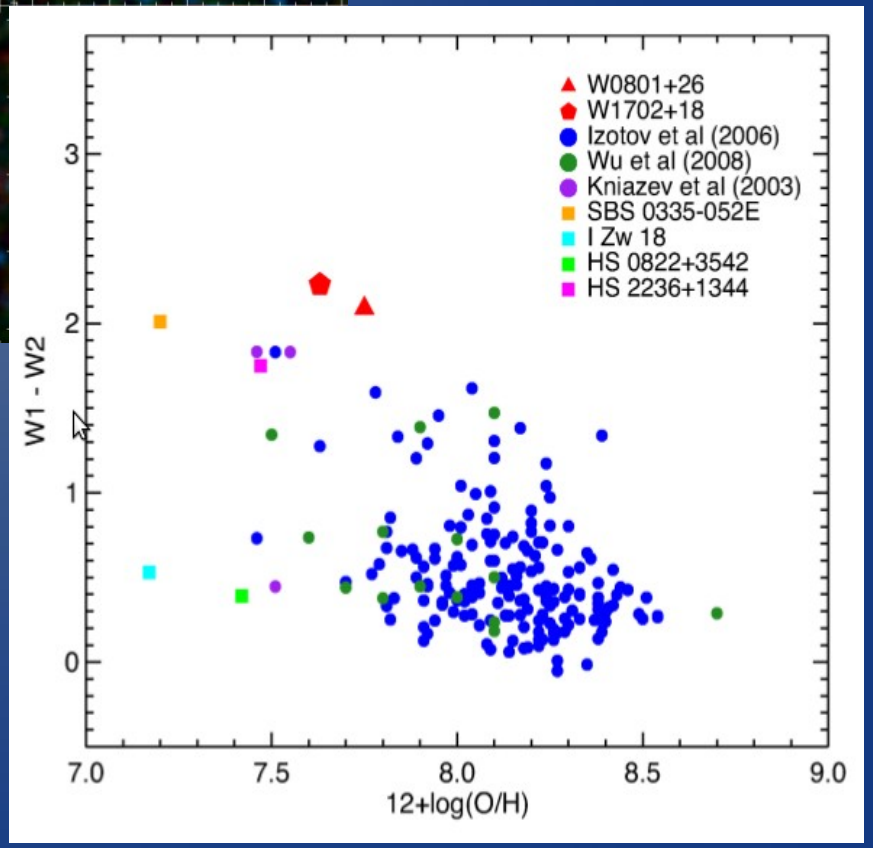


Image Credit: Griffith, R. L., Tsai, C.-W., Stern, D., et al. 2011, ApJ, 736, L22

Analysis and Data Collection:

- Compile sample of BCDs from references and online sources (NED)
- Search for sources in WISE catalog
- Compare BCDs with other galaxy types using WISE colors and fluxes in order to develop search criteria for large-scale use in the WISE catalog

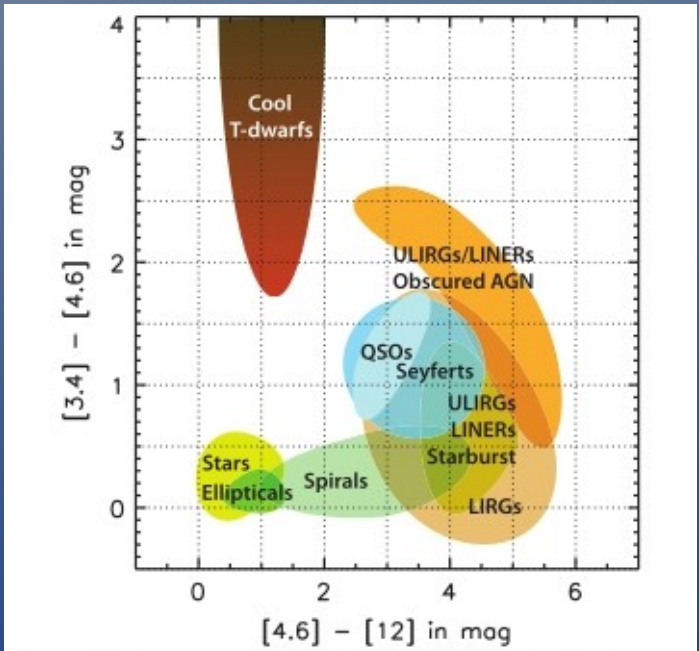


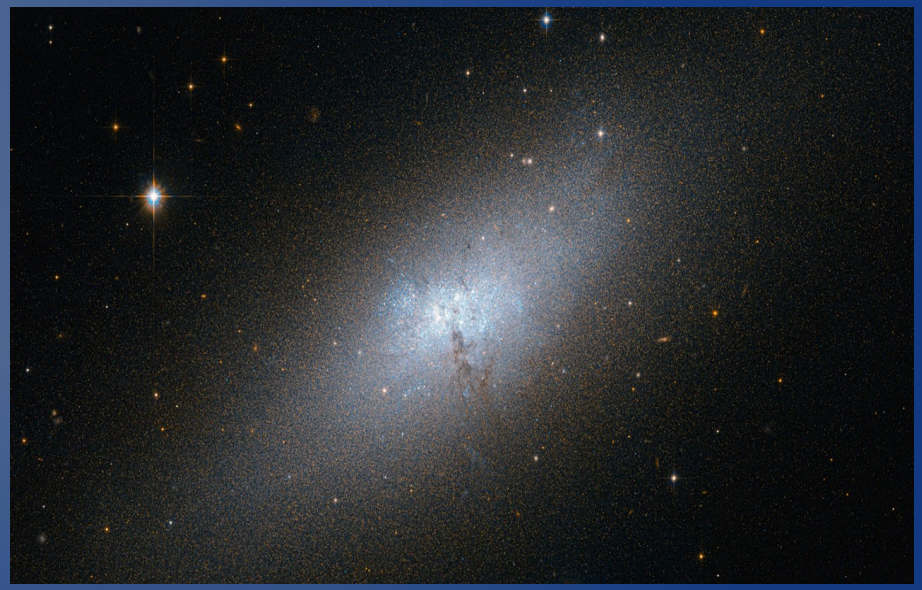
Figure 12. Color–color diagram showing the locations of interesting classes of objects. Stars and early-type galaxies have colors near zero, while brown dwarfs are very red in *W1*–*W2*, spiral galaxies are red in *W2*–*W3*, and ULIRGS tend to be red in both colors.

Locations of other WISE objects on a color-color diagram. Wright, E.~L. Eisenhardt, P.R.M., Mainzer, A.K., et al. 2010, aj, 140, 1868

Data Processing

- Developed a python script to plot WISE colors
- Analyzed all 20 possible 3-D WISE Color Combinations
- Directly compare sample spiral galaxies to known BCDs

NGC 5253



Credit: Hubble/ NASA

Selection Criteria for WISE Data Table

BCDs:

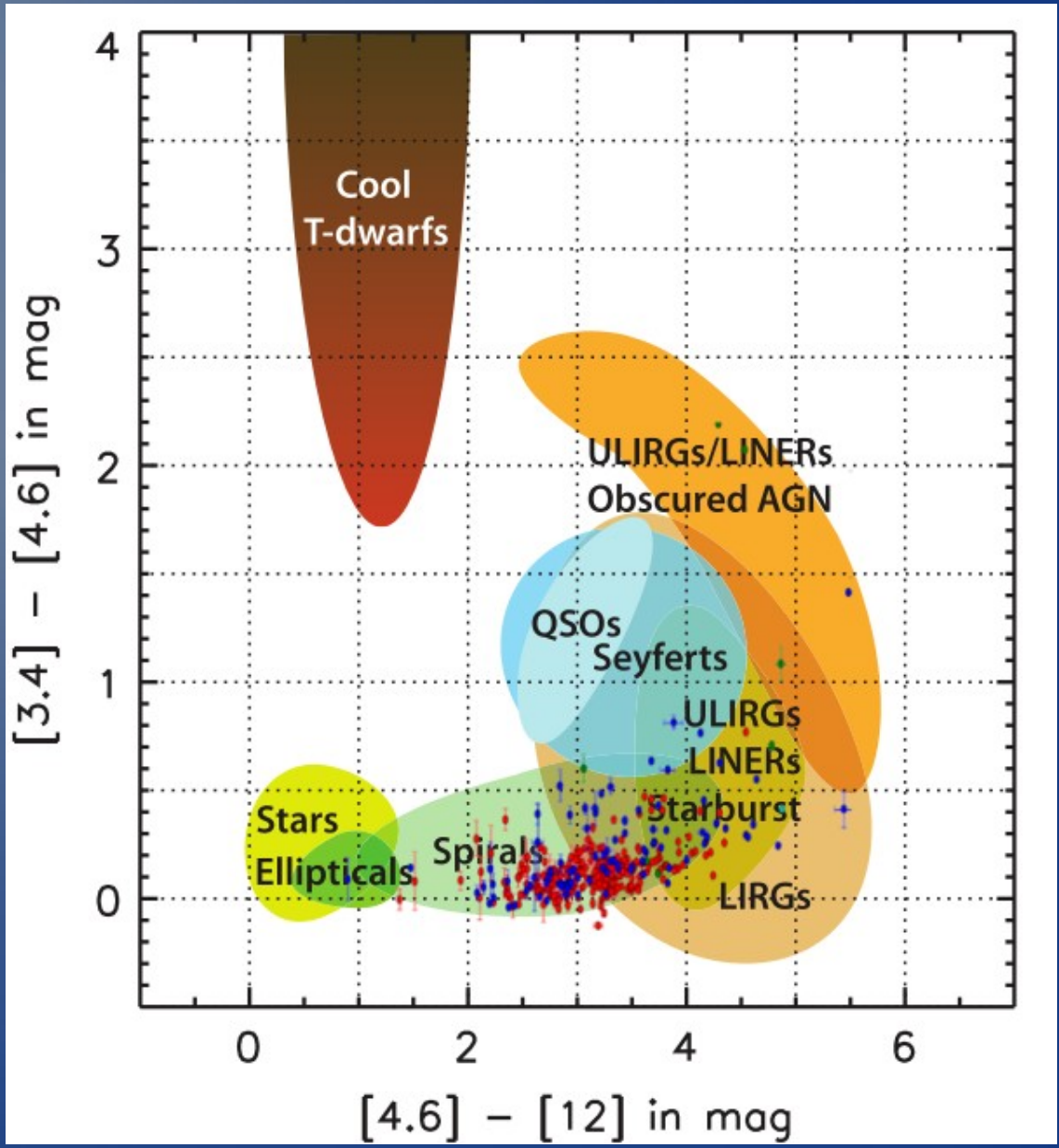
- NASA/IPAC Extragalactic Database – NED (nedwww.ipac.caltech.edu)
- A few additional BCDs pulled from the literature
- 213 “BCDs” listed in NED, however, some are antiquated designations
- Each source had to be independently verified for its current classification – reduced sample size to 143
- Sources loaded into WISE All-Sky Catalog

Spirals:

- Extracted over 30,000 Spiral Galaxies from NED
- Removed all Galaxy pairs, $Z > 0.025$, $\theta > 18.9$”
  - (θ determined by 20 Kmag Isophotal Diameter)
  - (WISE resolution in W1 θ=6.3”)
- Imported this list into WISE Point Source Catalog
- Found 481 Spirals that fit our criteria
- Used these as comparisons to detected BCDs

Analysis

Blue: BCDs (NED)
Cyan: He 2-10
Green: BCDs (additional refs)
Red: Spirals



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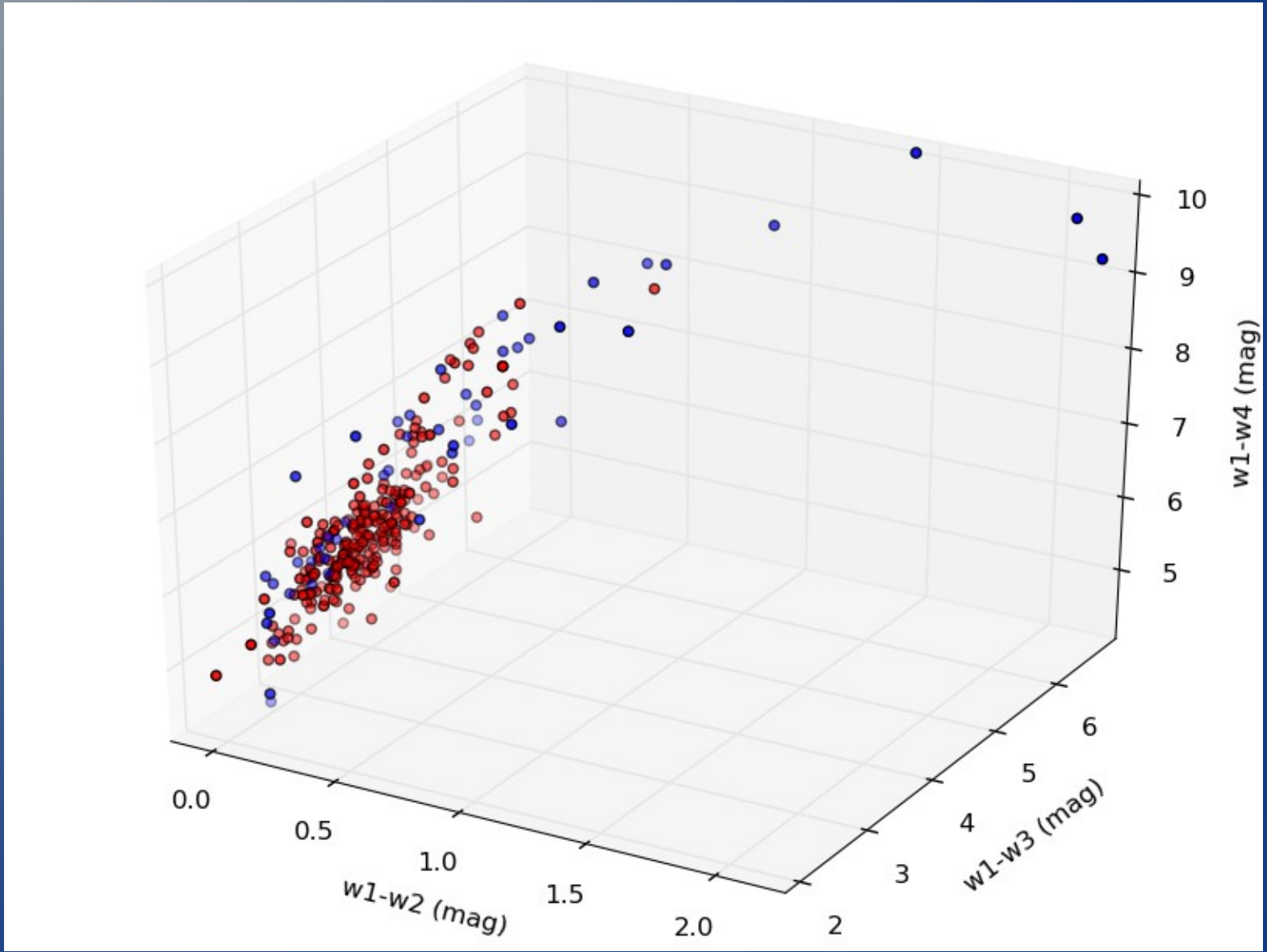
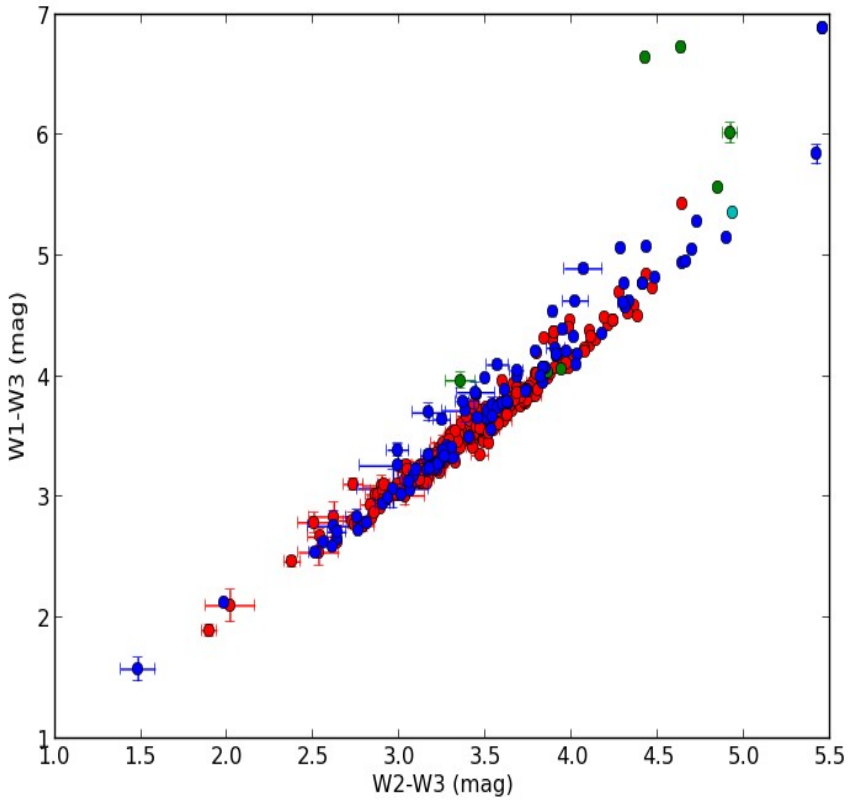
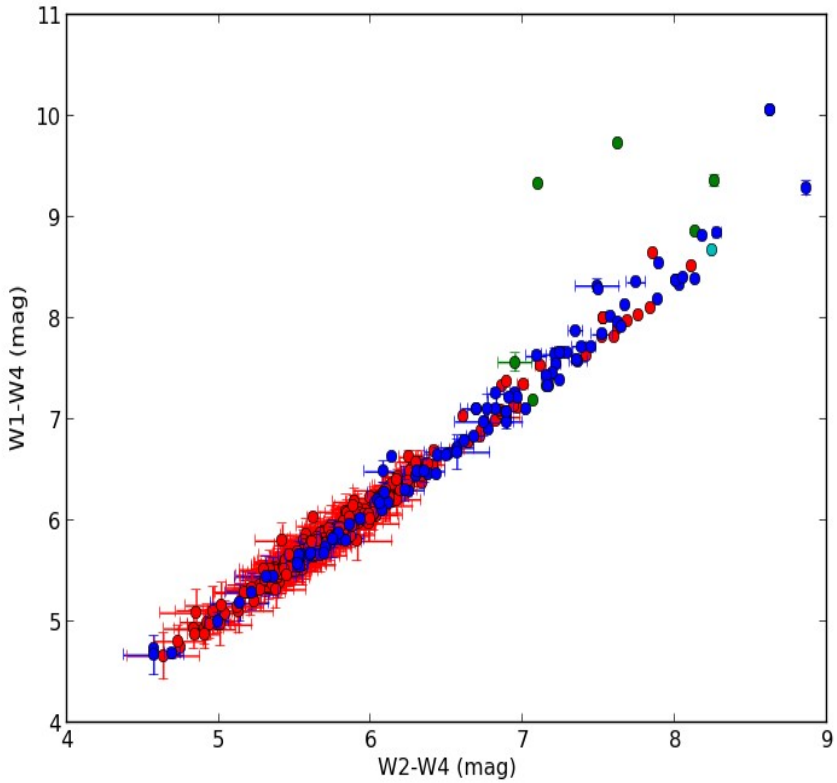
Three Dimensional Plots?



Analysis

W1 = 3.4 microns
W2 = 4.6 microns
W3 = 12 microns
W4 = 22 microns





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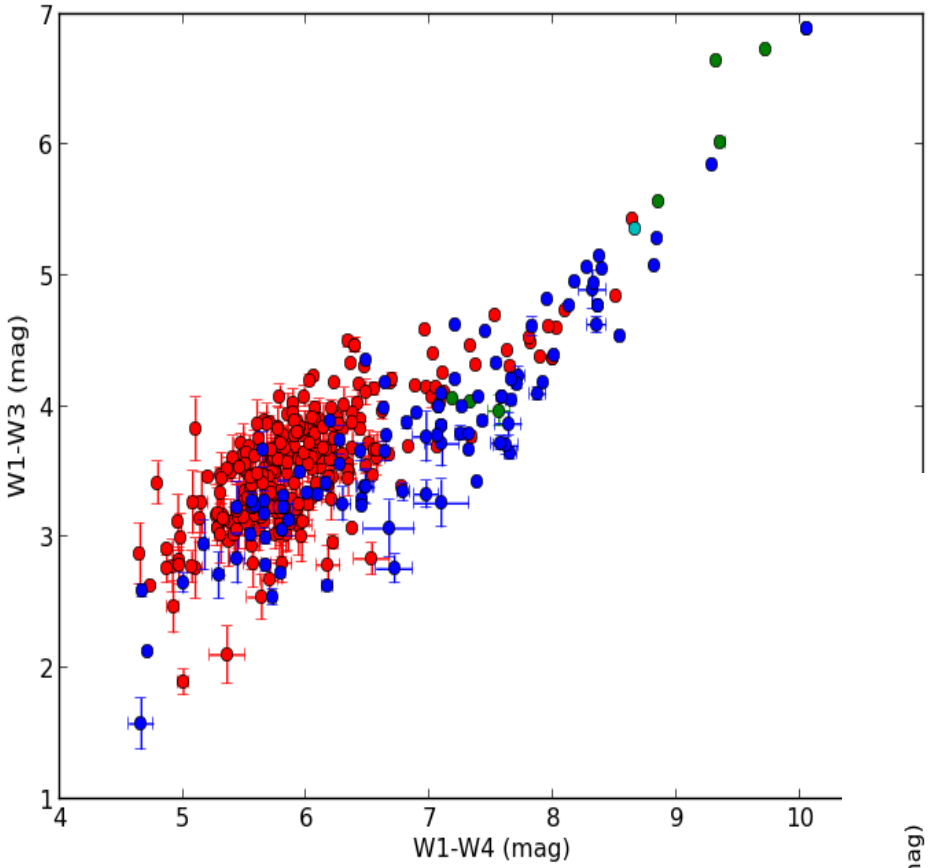

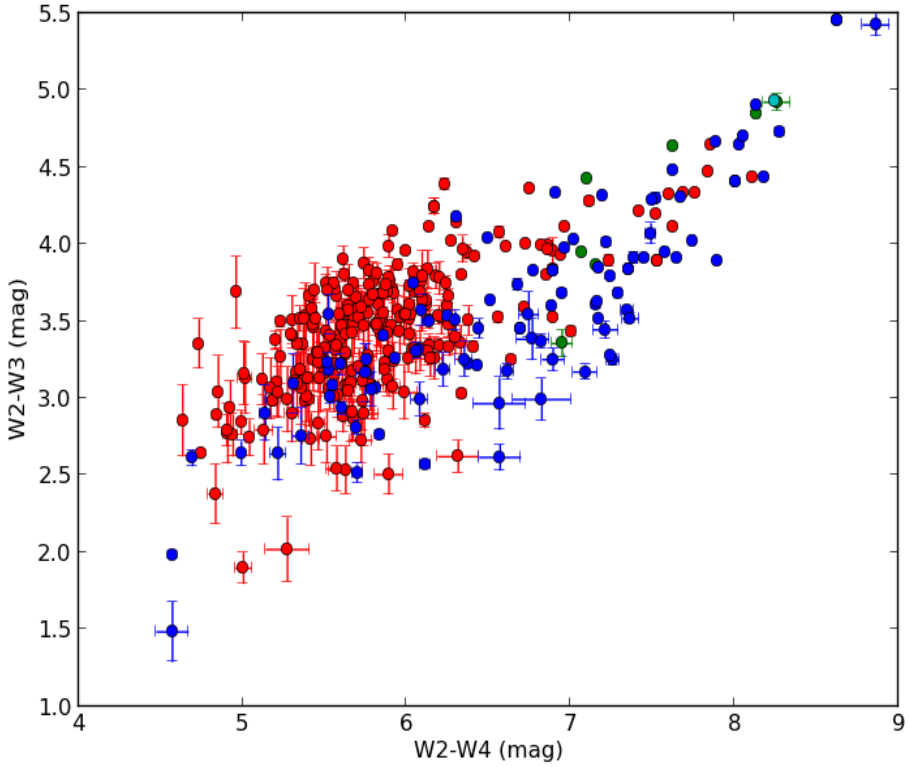

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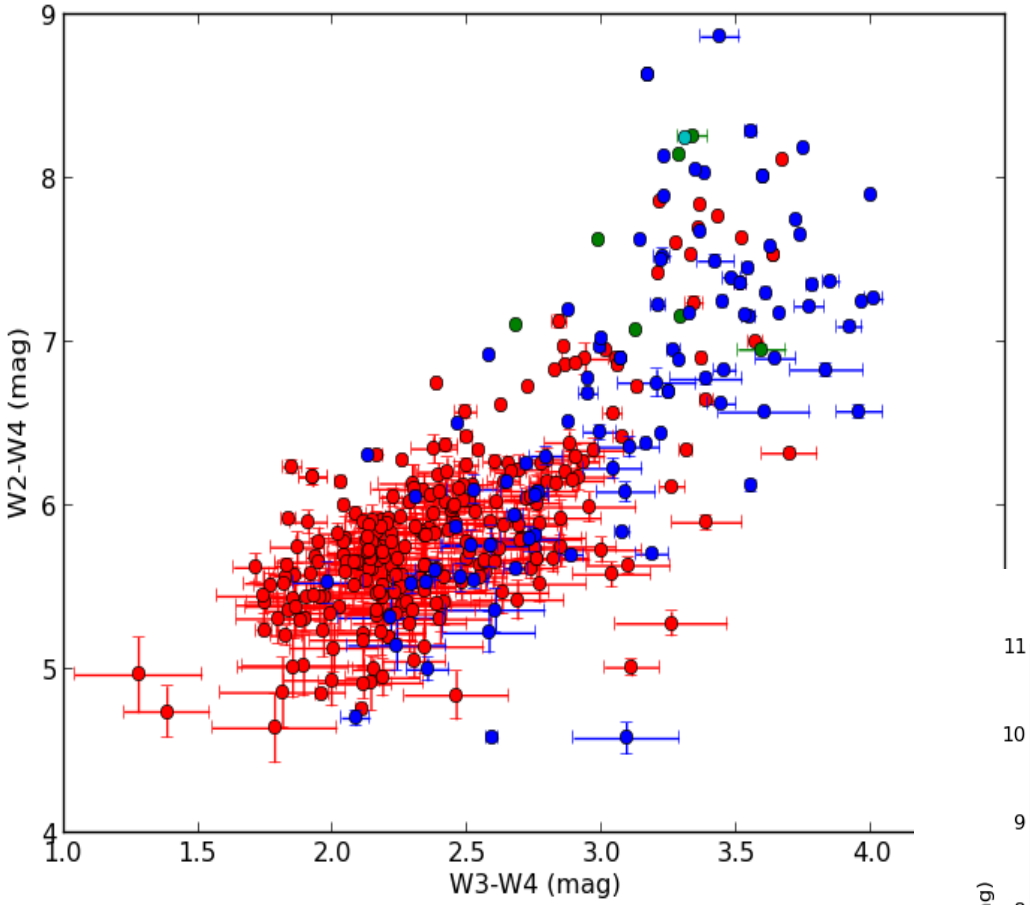

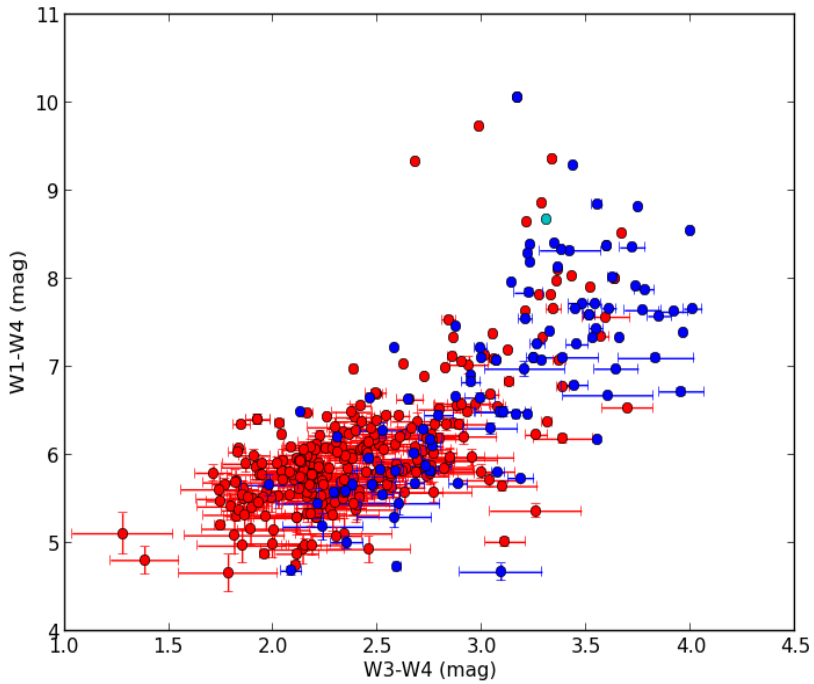

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WISE BCD Selection Criteria Based on CMDs

- $-0.1 < W1-W2 < 0.5$
- $1.9 < W2-W3 < 4.5$
- $2.2 < W3-W4 < 4.1$
- $4.0 < W2-W4 < 8.3$
- $2.1 < W1-W3 < 4.8$
- $4.6 < W1-W4 < 8.5$

- $W1-W3 < 1.04(W1-W4)-2.5$
- $W1-W3 < 1.23(W2-W4)-3.45$
- $W1-W4 > 1.10(W2-W3)+1.95$
- $W1-W4 > 1.91(W2-W3)-0.71$

WISE Catalog Search

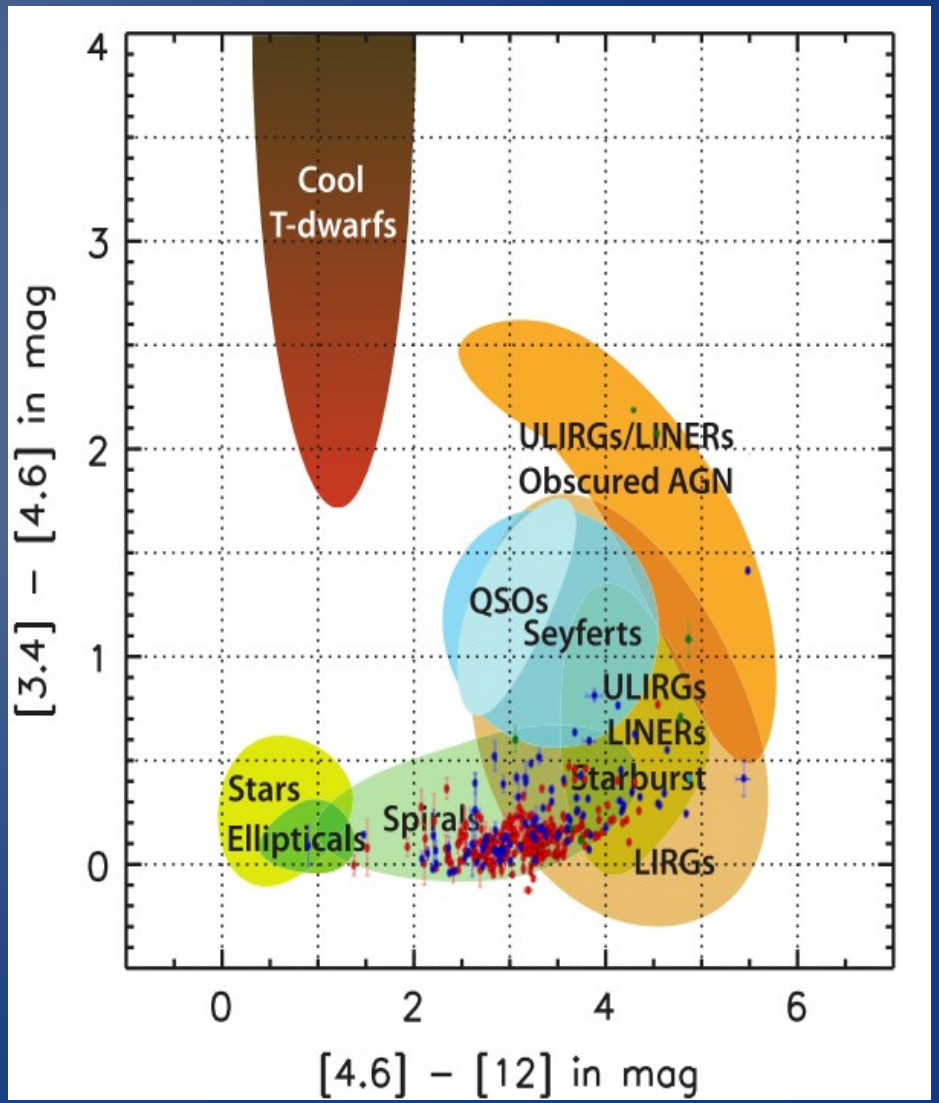
- Preliminary “random” sample: selected a 15 arcmin cone around BCD candidate CG 0563 (Wu et al 2008)
- 2290 objects located in WISE; 49 were detected in all four color bands and met color criteria (including CG 0563)
- Implies ~2% WISE sources fit criteria
- Larger search of entire WISE catalog (additional criteria of signal to noise ratio > 4, removed zone of avoidance region for galactic latitudes < |10deg|)
- 597756 sources met criteria
- This represents 0.1% of the total WISE point sources

Results

- In some WISE colors, most BCDs follow a tight relation
- In others, a broad scatter is observed
- BCDs have significant overlap with spirals in WISE colors, however, they do form two obvious populations

Unexpected Results

- When comparing BCDs to other galaxies, most seem similar to quiescent late type galaxies
- However, significant number of BCDs follow the trends of active galaxies
- BCD WISE colors cover a large range of galaxy types



Locations of other WISE objects on a color-color diagram. Wright, E.~L. Eisenhardt, P.R.M., Mainzer, A.K., et al. 2010, aj, 140, 1868

BCD AGN Candidates	RA (J2000)	Dec (J2000)	Source
W0801+26	08:01:03.929	+26:40:53.91	Griffith 2011
W1702+18	17:02:33.534	+18:03:06.44	Griffith 2011
UGCA166 (I Zw 18)	09:34:02.088	+55:14:26.23	Griffith 2011/NED
SDSS J0825+3532	08:25:55.52	+35:32:32.0	NED
Holmberg II *(Im)	08:19:05.0	+70:43:12	NED
UGCA412	16:35:21.1	+52:12:53	NED
MRK0709	09:49:18.0	+16:52:44	NED
UGCA211 *(pec)	10:27:02.0	+56:16:14	NED
MRK1450	11:38:35.6	+57:52:27	NED
IC0691 *(Irr)	11:26:44.3	+59:09:20	NED
He 2-10 (I have an AGN!)	08:36:15.1	-26:24:34	Reines 2011/NED
VCC1313	12:30:48.5	+12:02:42	NED
UGC07354	12:19:09.9	+03:51:23	NED
UM455	11:50:23.9	-00:31:41	NED
UGCA296	12:45:36.4	+71:19:07	NED
UGCA272	12:07:47.6	+67:23:02	NED
TOLOLO0610-387	06:12:14.2	-38:46:23	NED
UGCA208	10:16:28.2	+45:19:18	NED
SBS1147+520	11:49:54.5	+51:44:11	NED
MRK1426	09:49:18.3	+48:33:50	NED

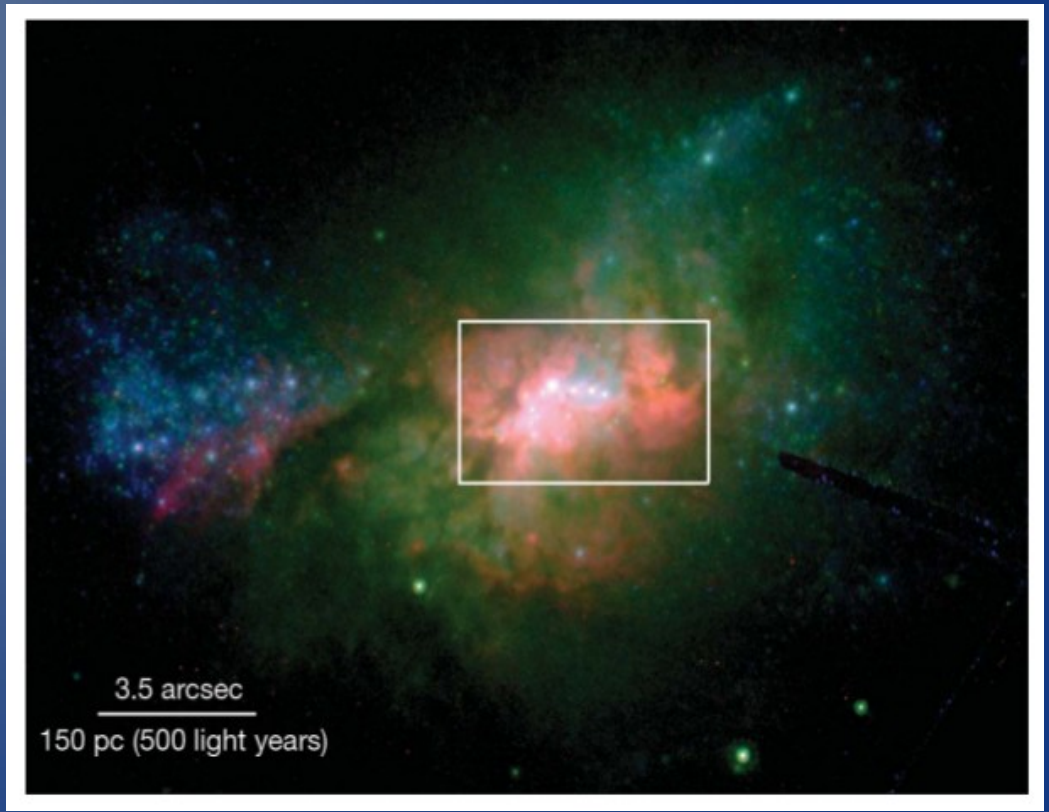
Conclusions

- BCDs can not be completely distinguished from other galaxy types using only WISE colors
- However, the list of possible BCDs can be limited using WISE colors
- Other properties, such as optical colors, may be used to further limit BCD candidates
- Do some BCDs need to be reclassified?

The next step

- Compare WISE colors with optical colors (such as B-V)
- Look for evidence of AGN within known BCDs with redder WISE colors using Chandra or VLA

Henize 2-10



Reines, Amy, et al. Nature. Vol 470. Feb 2011

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