SPECTRAL ENERGY DISTRIBUTIONS OF H_2O MEGAMASER DISKS

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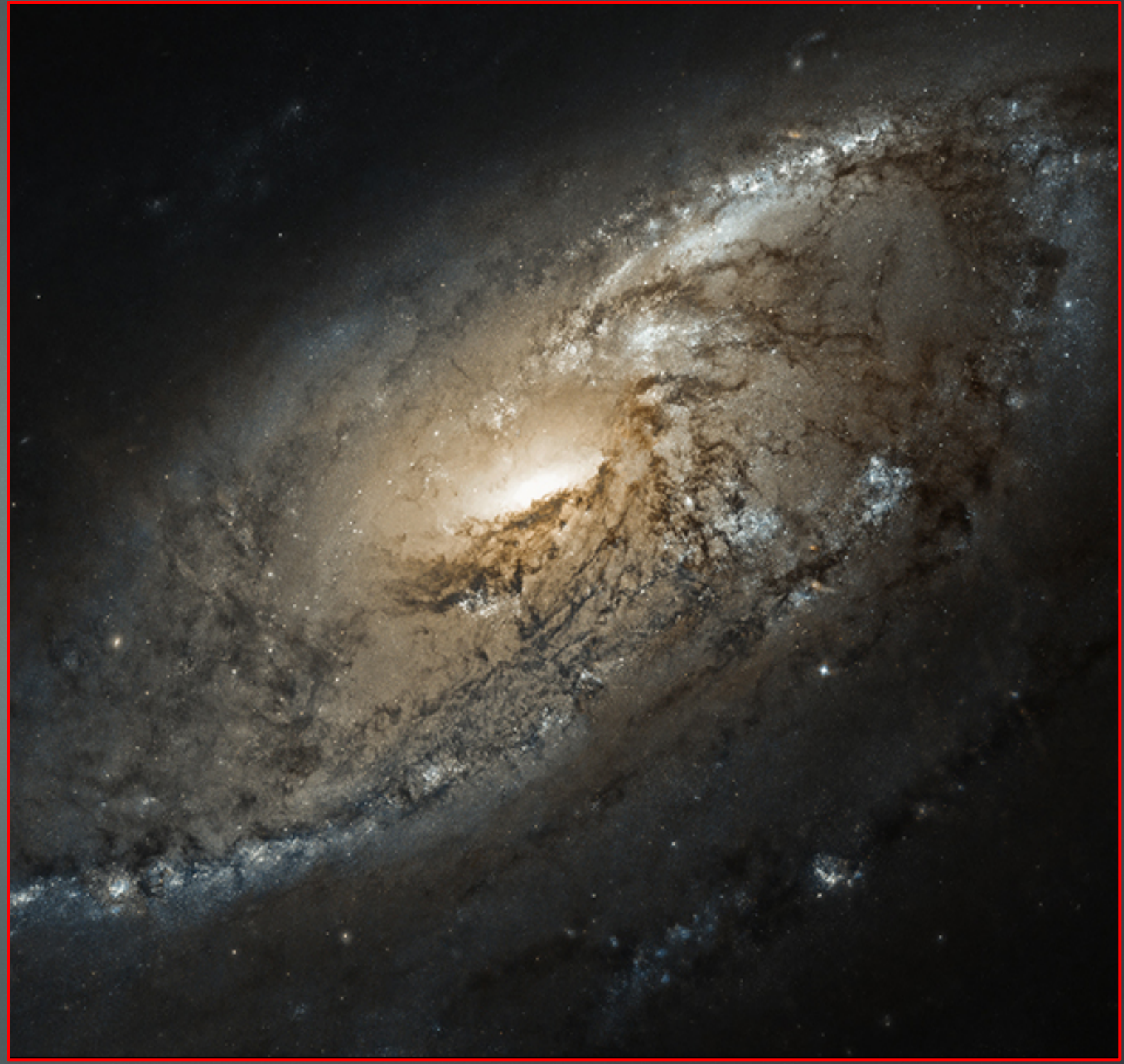
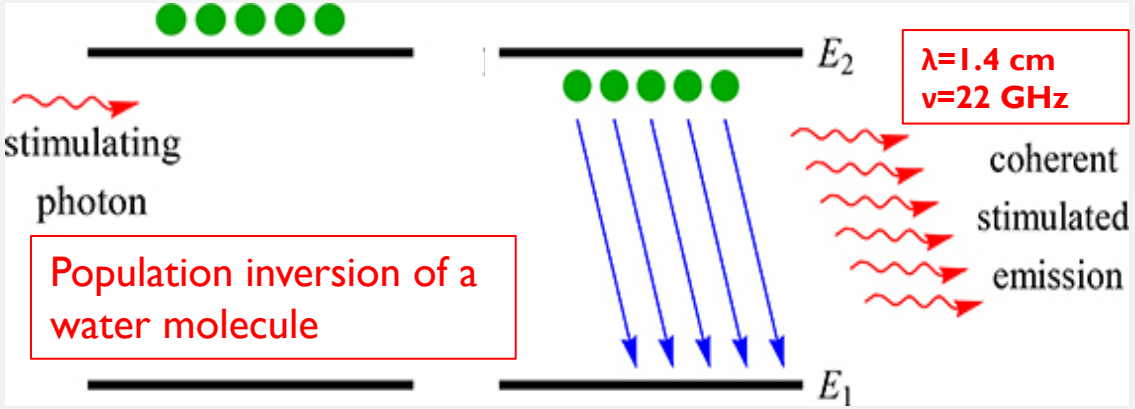


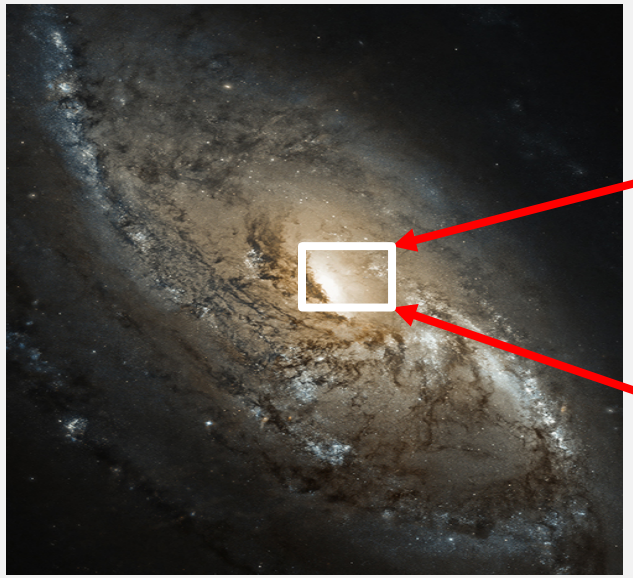
THE PHYSICS OF MEGAMASERS

MASER – **M**icrowaves **A**mplified

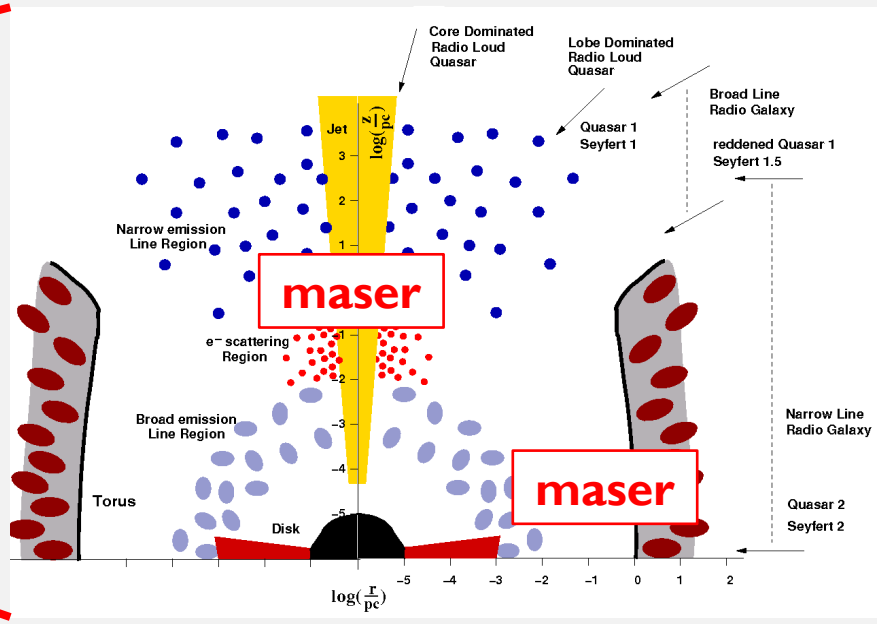
by **S**timulated **E**mission of **R**adiation



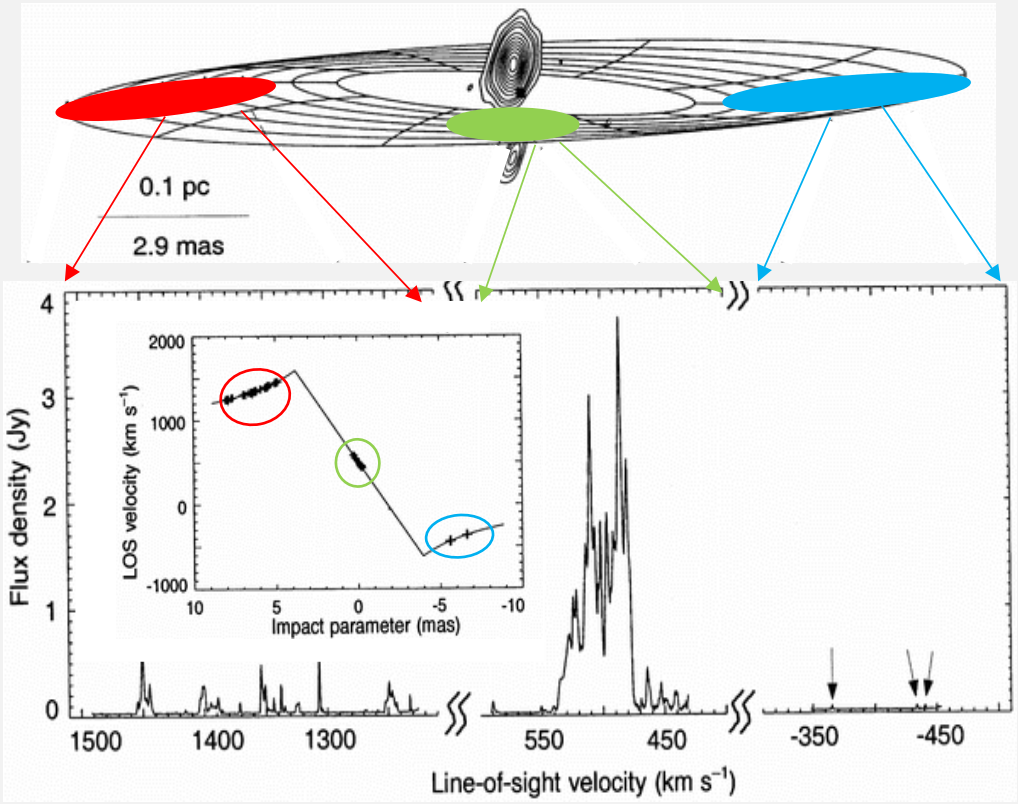
Megamasers – 10^6 times more luminous than typical galactic masers



Optical image of NGC4258



THE HOLY GRAILS OF ASTRONOMY



Megamasers in a disk-like configuration:

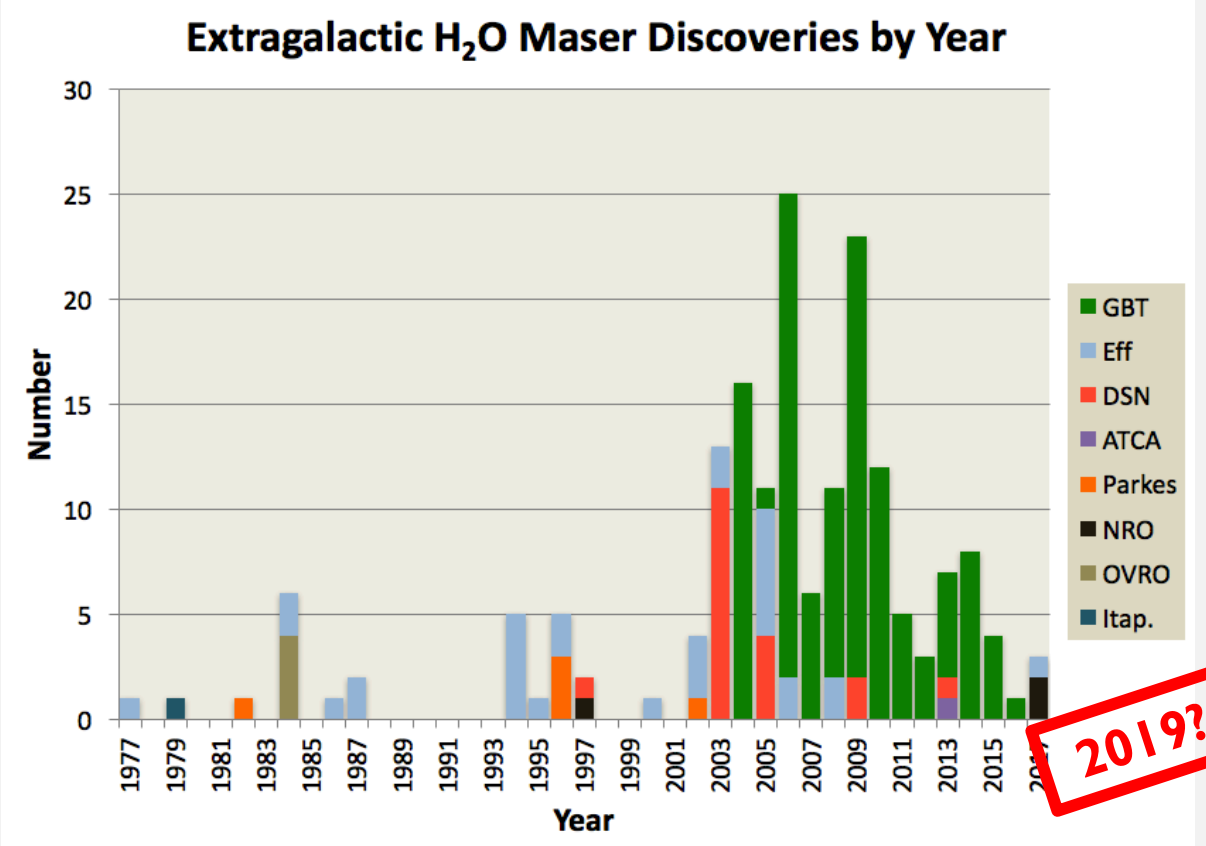
1. Measure **direct distances** to their host galaxies
   - Constrain geometry of the universe
   - Independent constraint to the age of the universe
   - Better understand nature of dark energy
2. Measure the **masses of the central supermassive black hole**

GBT spectrum at 22 GHz (Hernstein et al. 1999).

THE NEED FOR MORE

- ~3% of all galaxies host maser emission
- ~20% of galaxies that host megamaser emission in a disk-like configuration
- Previous searches: no systematic analysis of properties of galaxies with maser emission and those without

To **find** more water megamaser disks, we must **know how to search** for them!

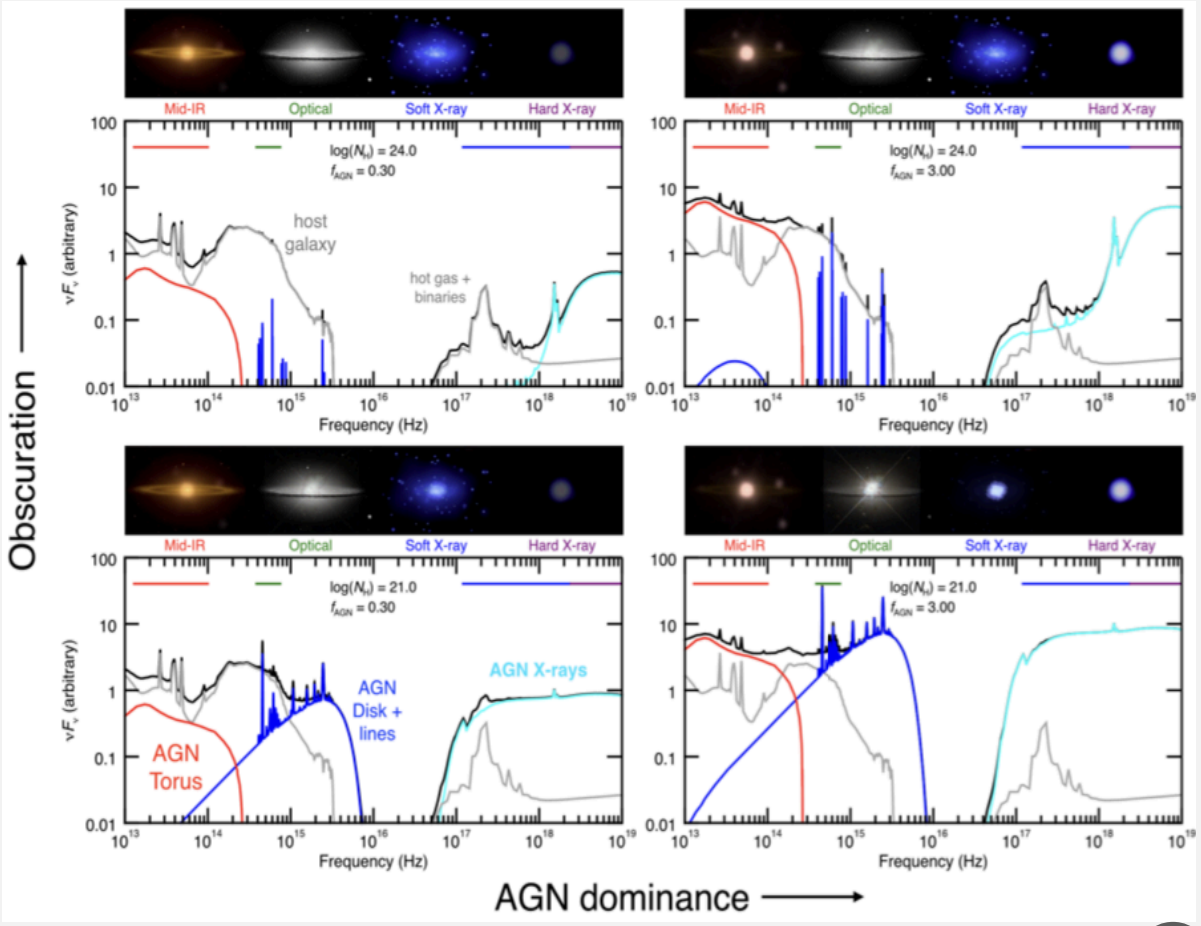


OUR STUDY

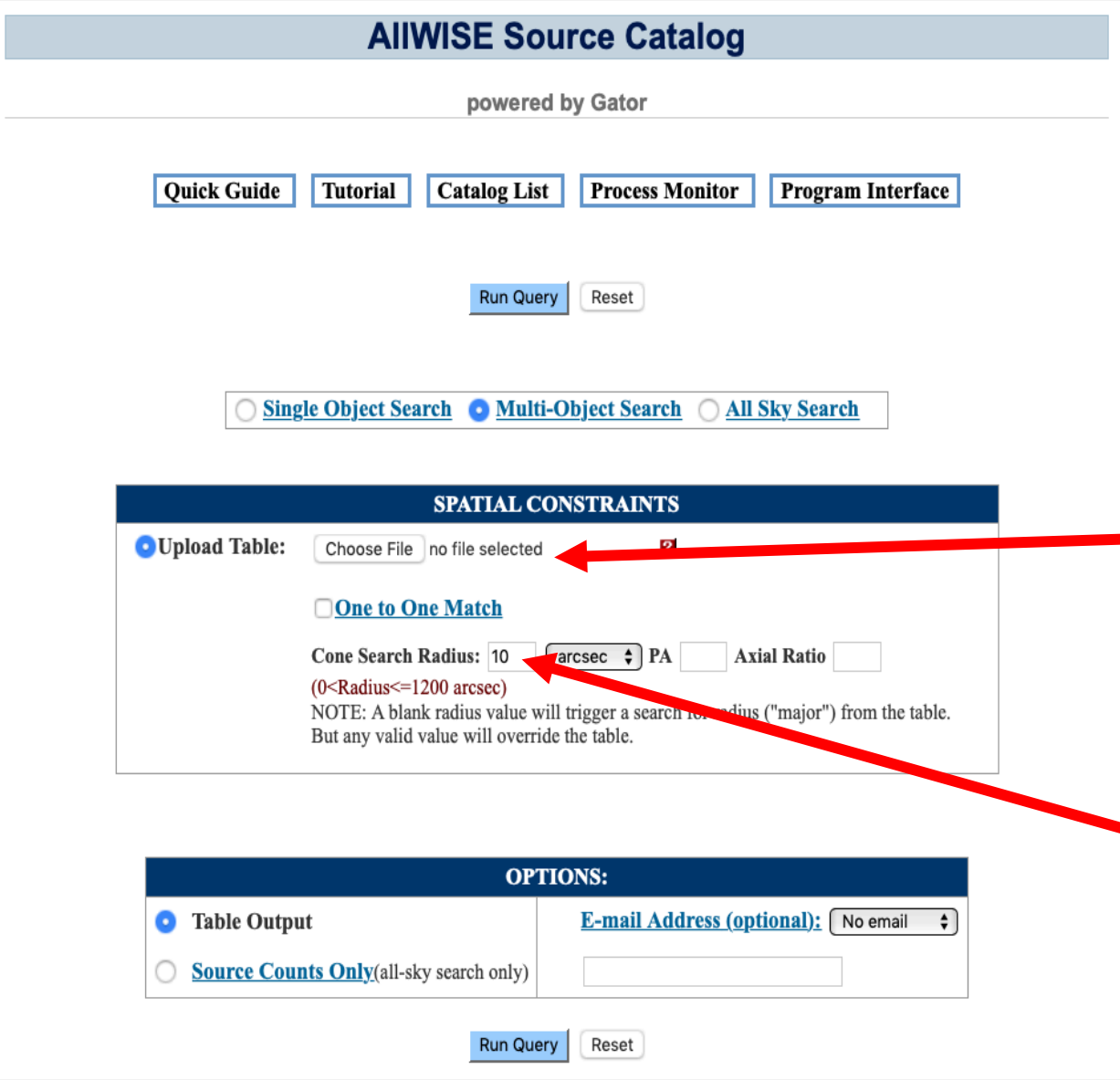
Systematic search to identify galaxy traits connected to the megamaser disk phenomenon

(Hickox & Alexander 2018)

- How?
  - Collect fluxes from public databases
  - Build **S**pectral **E**nergy **D**istributions (SEDs)= total flux emitted across the electromagnetic spectrum
  - Quantify the degree to which various energetic components contribute to the total galaxy light
  - Find links to megamaser emission to design more efficient maser survey selection methods



WIDE-FIELD INFRARED SURVEY EXPLORER



- **WISE**: all-sky survey with the best sensitivities in mid-IR wavelengths (W1=3.4μm, W2=4.6μm, W3=12μm, W4= 22μm)
- Cross-match positions of 46 H_2O megamaser disks
  - Infrared Processing and Analysis Center (IPAC) table
  - Input: count, galaxy name, right ascension, declination
- Search parameters
  - Test a range of cone search radii to match the angular resolution of WISE filters

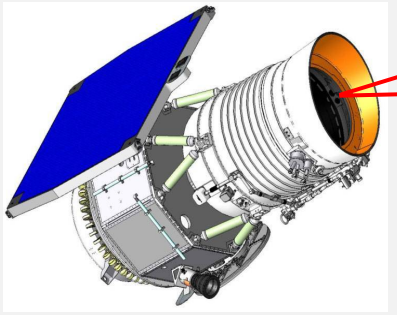
RESULTS OF CROSS-MATCHING

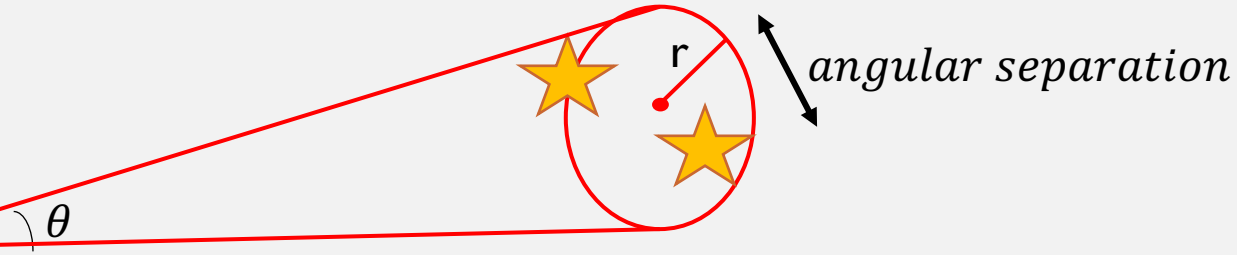
cntr_01	dist_x	pang_x	mcpnum_01	name_01	ra_01	dec_01	ra	dec	w1mpro	w1sigmpro	w1snr	w2mpro	w2sigmpro	w2snr	w3mpro	w3sigmpro	w3snr	w4mpro	w4sigmpro	w4snr
1	0.33662	-53.28569	13	2MASXJ01094510-0332329	17.43792	-3.542444	17.43784	-3.542388	11.805	0.023	47.1	10.105	0.020	55.3	5.966	0.014	75.7	3.007	0.019	58.4
2	0.139592	-99.95006	16	2MASXJ01260163-0417564	21.50692	-4.298944	21.50688	-4.298951	11.999	0.023	46.9	11.527	0.021	50.8	8.562	0.027	39.9	6.026	0.049	2.1
3	0.57568	127.4333	18	NGC591	23.38	35.66833	23.38016	35.66824	10.685	0.023	46.6	10.198	0.020	54.9	6.327	0.014	76	3.413	0.020	54.7
4	0.227935	-178.7384	22	MRK1029	34.26487	5.292056	34.26487	5.291992	11.553	0.022	48.7	11.176	0.021	51.5	6.723	0.016	69.7	3.704	0.018	59
5	14.91948	-148.8252	24	NGC1068	40.66958	0.01333333	40.66744	0.0097875	14.349	0.028	39	14.015	0.041	26.6	9.169	0.030	35.9	5.743	0.043	25.2
6	0.23165	-152.3523	27	Mrk1066	44.99417	36.82056	44.99413	36.8205	9.617	0.023	47.1	8.81	0.019	56.1	4.764	0.016	65.8	1.656	0.016	68.7
7	4.012343	-89.72757	28	NGC1194	45.95462	-3.042222	45.95351	-3.042217	17.807	0.187	5.8	17.466	null	-0.6	12.327	null	1.2	9.219	null	-0.2
8	0.21581	-122.3759	29	NGC1320	51.20292	-3.042222	51.20287	-3.042254	9.505	0.021	50.6	8.587	0.020	54.5	5.037	0.013	82.1	2.399	0.018	61.1
9	5.506144	-27.72408	31	NGC1386	54.19333	-36.00056	54.19246	-35.9992	8.934	0.022	49.9	8.088	0.020	54.1	4.642	0.014	74.9	2.046	0.017	64.6
10	0.455871	-57.14451	32	IRAS03355+0104	54.54333	1.238333	54.54323	1.238402	12.229	0.035	31.1	10.808	0.023	47.1	6.674	0.016	66	3.476	0.025	43.8
10	10.36919	58.12288	32	IRAS03355+0104	54.54333	1.238333	54.54578	1.239854	10.461	0.023	47	10.456	0.020	54.4	8.687	0.026	42.2	4.354	0.028	39.5
11	0.371773	38.69578	38	WISEPJ043703.69+245606.9	69.26529	24.93522	69.26537	24.9353	11.507	0.023	47.1	11.439	0.022	48.3	8.668	0.027	40.2	6.2	0.059	18.3
12	0.19887	117.6078	39	2MASXJ04370825+6637424	69.28442	66.62842	69.28454	66.62839	10.751	0.023	46.8	10.541	0.020	53.3	7.487	0.017	64.7	5.066	0.026	41.4
13	2.737799	-49.77733	42	UGC3193	73.21958	3.056667	73.219	3.057158	10.352	0.023	48.1	10.118	0.020	53.7	6.317	0.015	70.1	4.017	0.027	40.3
13	14.67092	68.22593	42	UGC3193	73.21958	3.056667	73.22337	3.058178	14.07	0.455	2.4	12.651	0.455	2.4	9.77	null	0.7	6.893	0.121	9
14	0.384878	-108.4303	51	NGC2273	102.5362	60.84583	102.536	60.8458	9.234	0.022	48.9	8.545	0.019	56.4	4.855	0.015	71.9	2.148	0.015	70.3
15	0.327872	-23.84742	52	ESO558-G009	106.0876	-21.58867	106.0875	-21.58858	10.979	0.028	38.3	10.692	0.022	50.4	7.532	0.016	67.3	5.257	0.032	34
16	5.546611	-116.2926	53	UGC3789	109.8817	59.35583	109.879	59.35515	10.293	0.023	48.1	10.083	0.020	54.4	6.339	0.016	69.7	3.725	0.021	52.6
17	0.5507	1.761385	55	Mrk78	115.6738	65.17694	115.6738	65.17709	10.886	0.023	47.4	9.801	0.020	54.9	6.025	0.016	66.7	3.179	0.021	50.8
18	0.779442	99.6517	57	Mrk1210	121.0242	5.113889	121.0244	5.113853	10.006	0.022	50.2	8.614	0.020	53.7	4.634	0.015	74.9	1.697	0.019	57.2
19	0.46431	-140.2768	60	2MASXJ08362280+3327383	129.095	33.46083	129.0949	33.46074	12.632	0.026	42.1	12.342	0.026	41.6	9.167	0.035	30.9	6.511	0.121	9
19	5.381118	48.0711	60	2MASXJ08362280+3327383	129.095	33.46083	129.0963	33.46183	14.743	0.078	14	14.555	0.100	10.8	11.493	0.233	4.7	7.884	null	0.7
20	3.454939	-49.74128	62	2MASXJ08474769-0022514	131.9487	0.3809444	131.948	0.3815646	16.45	0.075	14.5	16.137	0.184	5.9	12.192	null	1	9.036	null	-1.6
21	0.369464	-31.61244	72	Mrk1419	145.1517	3.576944	145.1516	3.577032	10.386	0.022	48.7	10.256	0.020	53.4	6.83	0.014	75.5	4.569	0.024	44.8
22	0.398536	-11.96328	77	NGC3079	150.4908	55.67972	150.4908	55.67983	8.391	0.023	47.9	7.929	0.020	55.6	4.092	0.016	68.3	1.987	0.017	62.5
23	0.302328	18.1532	80	IC2560	154.0779	-33.56389	154.0779	-33.56381	10.026	0.022	49.9	9.387	0.020	53.3	5.504	0.015	70.4	2.499	0.019	57.4
24	0.07907	61.14405	84	UGC5713	157.912	25.98397	157.912	25.98398	10.802	0.022	49.2	9.92	0.020	54.5	6.877	0.015	70.1	4.207	0.021	52.5
25	0.360763	-41.37414	85	MRK34	158.5358	60.03111	158.5357	60.03119	11.213	0.024	45.9	10.029	0.020	53.3	6.299	0.015	72.4	3.349	0.021	51.7
26	0.935891	112.2174	87	NGC3393	162.0975	-25.16195	162.0978	-25.16204	9.991	0.022	48.6	9.597	0.020	53.8	6.09	0.015	70.2	2.817	0.019	55.8
27	0.07768	16.3982	88	UGC6093	165.1998	10.72814	165.1998	10.72816	11.83	0.024	45.4	11.866	0.022	48.5	9.886	0.052	21	7.561	0.154	7.1
28	1.796923	174.2115	102	2MASXJ12020465+3519173	180.5193	35.32169	180.5193	35.3212	12.497	0.036	30.4	12.318	0.036	29.8	9.519	0.052	20.8	7.246	0.182	6
28	2.918933	-0.345937	102	2MASXJ12020465+3519173	180.5193	35.32169	180.5192	35.32251	13.186	0.055	19.7	13.028	0.058	18.6	10.46	0.111	9.8	7.624	0.261	4.2
29	0.446424	0.595303	109	NGC4258	184.7396	47.30389	184.7396	47.30401	8.53	0.023	47.4	8.19	0.020	53.9	5.482	0.015	70.8	3.328	0.020	53.2
30	1.187084	101.6524	112	NGC4388	186.4446	12.66222	186.4449	12.66216	9.044	0.022	49.3	8.031	0.019	56.9	4.61	0.015	74.3	1.516	0.016	68.8
31	7.445563	-83.81686	116	ESO269-G012	194.1687	-46.90722	194.1657	-46.907	17.785	0.176	6.2	17.101	null	0.7	13.046	null	-1	9.429	null	-2.2
32	1.213722	-30.33014	119	NGC4968	196.7749	-23.67703	196.7747	-23.67674	9.993	0.022	49.8	9.102	0.020	53.5	5.105	0.014	78	2.41	0.022	49.5
33	0.420056	174.7888	125	SBS1344+527	206.67	52.47694	206.67	52.47683	11.738	0.022	49.4	11.745	0.021	52.8	9.377	0.033	33.1	7.11	0.087	12.5
34	1.04537	138.0901	133	NGC5495	213.0971	-27.10806	213.0973	-27.10827	10.941	0.023	47.7	10.903	0.020	54.1	7.706	0.018	61.7	4.885	0.031	35.5
35	4.166419	86.31047	134	Circinus	213.2888	-65.33916	213.2915	-65.33909	4.237	0.102	10.6	3.444	0.127	8.5	-0.358	0.231	4.7	-2.293	0.003	424.2
36	0.405312	-69.1893	139	NGC5728	220.5996	-17.25306	220.5995	-17.25302	9.356	0.022	49	9.026	0.019	56	5.352	0.014	80	2.736	0.020	54
37	0.265289	33.00402	141	NGC5765b	222.7146	5.114444	222.7146	5.114506	10.616	0.022	50.3	9.785	0.020	54.6	5.645	0.015	72.6	2.802	0.018	62
38	0.729	-29.23868	142	UGC9618b	224.2529	24.6175	224.2528	24.61768	10.097	0.023	46.4	9.619	0.019	56.3	5.674	0.014	77.8	3.666	0.021	51
39	0.19929	117.6616	143	UGC9639	224.65	44.88361	224.6501	44.88359	10.539	0.022	49.5	10.045	0.020	55.4	5.798	0.013	81.3	3.447	0.020	54.5
40	1.006553	108.3234	144	NGC5793	224.8529	-16.69333	224.8532	-16.69342	9.598	0.022	49.8	9.352	0.020	55.3	5.83	0.015	73.4	3.242	0.021	52.2
41	0.625365	137.5126	157	NGC6264	254.3171	27.84972	254.3172	27.84959	12.156	0.023	48.2	12.048	0.022	48.8	8.575	0.024	45.7	5.438	0.032	33.8
42	0.312751	29.23424	158	2MFGC13581	254.5646	39.39139	254.5646	39.39146	11.756	0.022	49	11.488	0.021	52.5	8.034	0.019	57.5	5.295	0.028	38.3
43	1.091646	35.68442	160	NGC6323	258.325	43.78222	258.3253	43.78247	11.422	0.023	47.4	11.379	0.021	52.4	8.209	0.021	51.4	5.739	0.038	28.4
44	0.818215	-13.50229	168	NGC6926	308.2754	-2.0275	308.2754	-2.027279	10.932	0.024	45.2	10.524	0.021	52.3	6.541	0.015	70.4	4.09	0.023	46.6
45	0.279253	-124.1991	177	IC1481	349.8546	5.906111	349.8545	5.906067	11.07	0.021	50.6	10.569	0.019	56.1	6.639	0.016	66.9	3.588	0.022	50
46	0.668698	53.14919	180	CGCG498-038	35	Screenshot	1222	358.9343	30.21233	11.327	0.023	47.2	10.935	0.020	53.7	6.68	0.015	70.3	3.626	0.023	47.9

THE NATURE OF DUPLICATES

- Cone–search radius (r) = 15 arcseconds

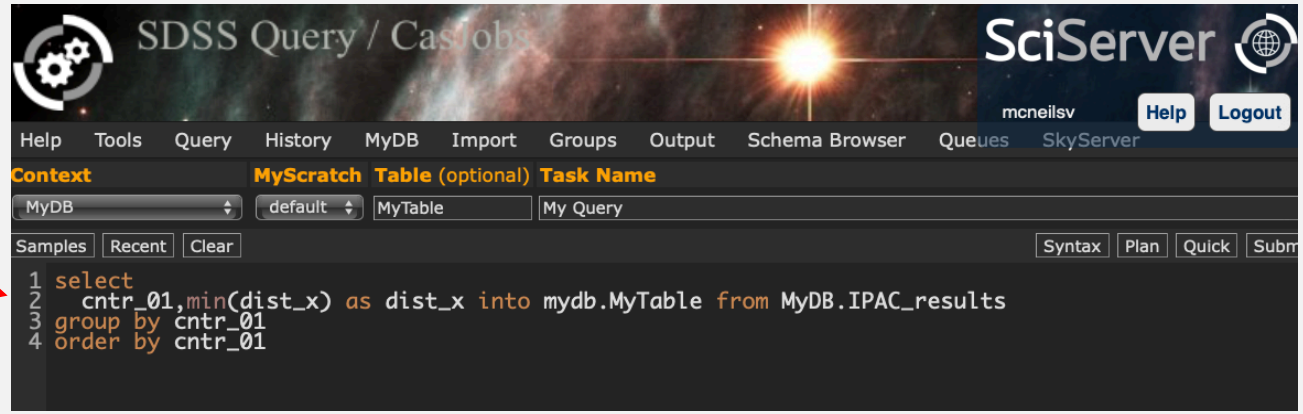
WISE telescope



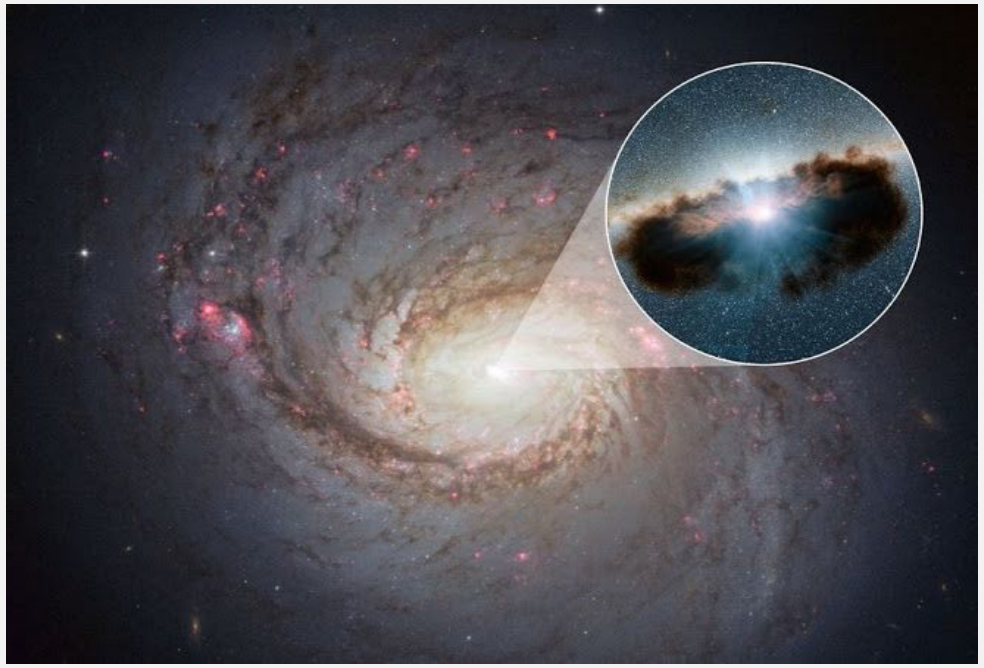


- Both WISE detections are included

- SQL query to select smallest separation to the input source

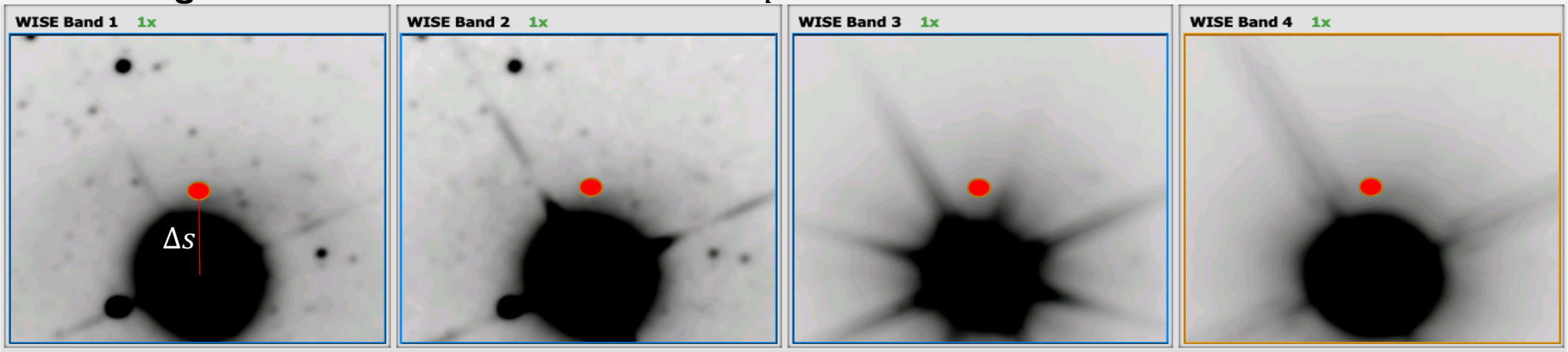


THE MYSTERY OF NGC1068

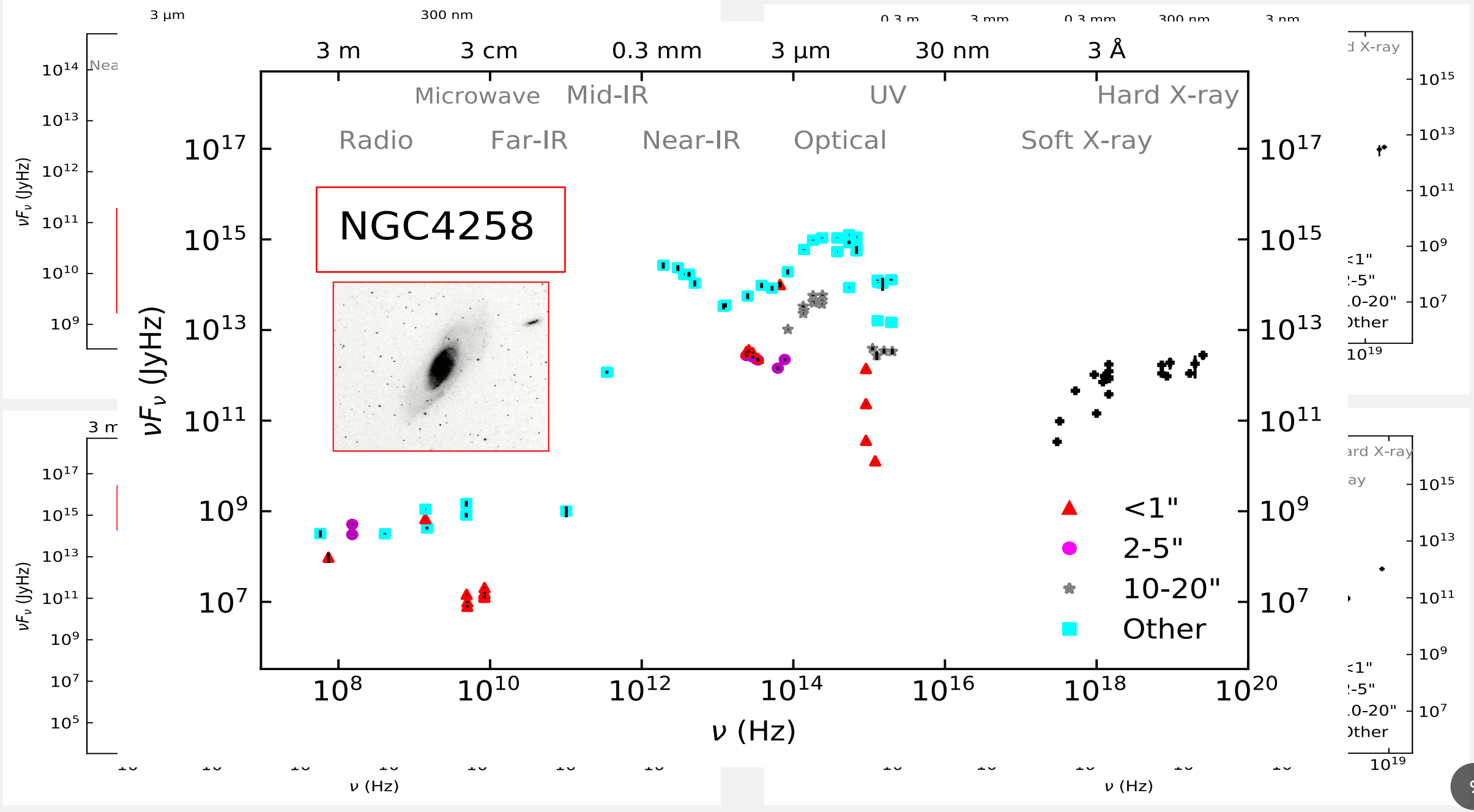


- $\Delta s = 14.92$ arcseconds
- Diameter= 170,000 light years

WISE Image Search: $mid - IR\ detection\ encompasses\ the\ \Delta s$



SPECTRAL ENERGY DISTRIBUTIONS



IN THE FUTURE…

- Compare the optical and mid-IR images for NGC1068
- We will be **adding the mid-IR data** to the SEDs
- Proceed with **SED fitting to quantify the contribution** of AGN compared to stellar light and other energetic phenomena in these galaxies

THANK YOU

Dr. Anca Constantin

4-VA Collaborative at James Madison University

National Science Foundation NSF:AST #1814594

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