The power of MULTI-wavelength astrophysics: using optical-to-radio data to uncover properties of star-forming galaxies in the Universe

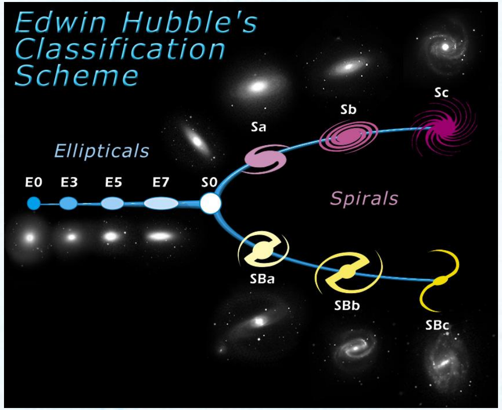
Katarzyna Małek
BP4 (astrophysics department)

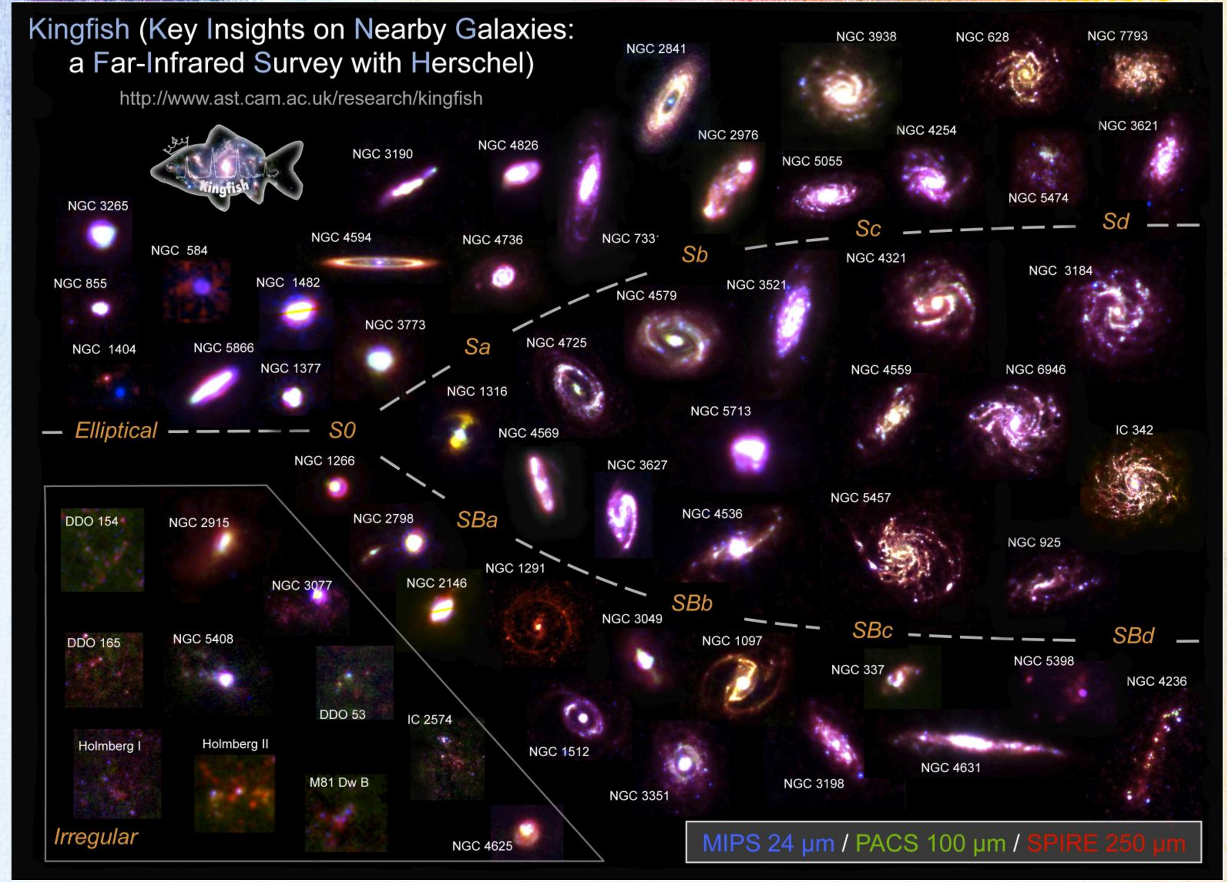
OUTLINE

- a quick introduction to the complex world of galaxies,
- panchromatic view on the galaxy and the importance of the dust (and the dust attenuation),
- new data - new results.

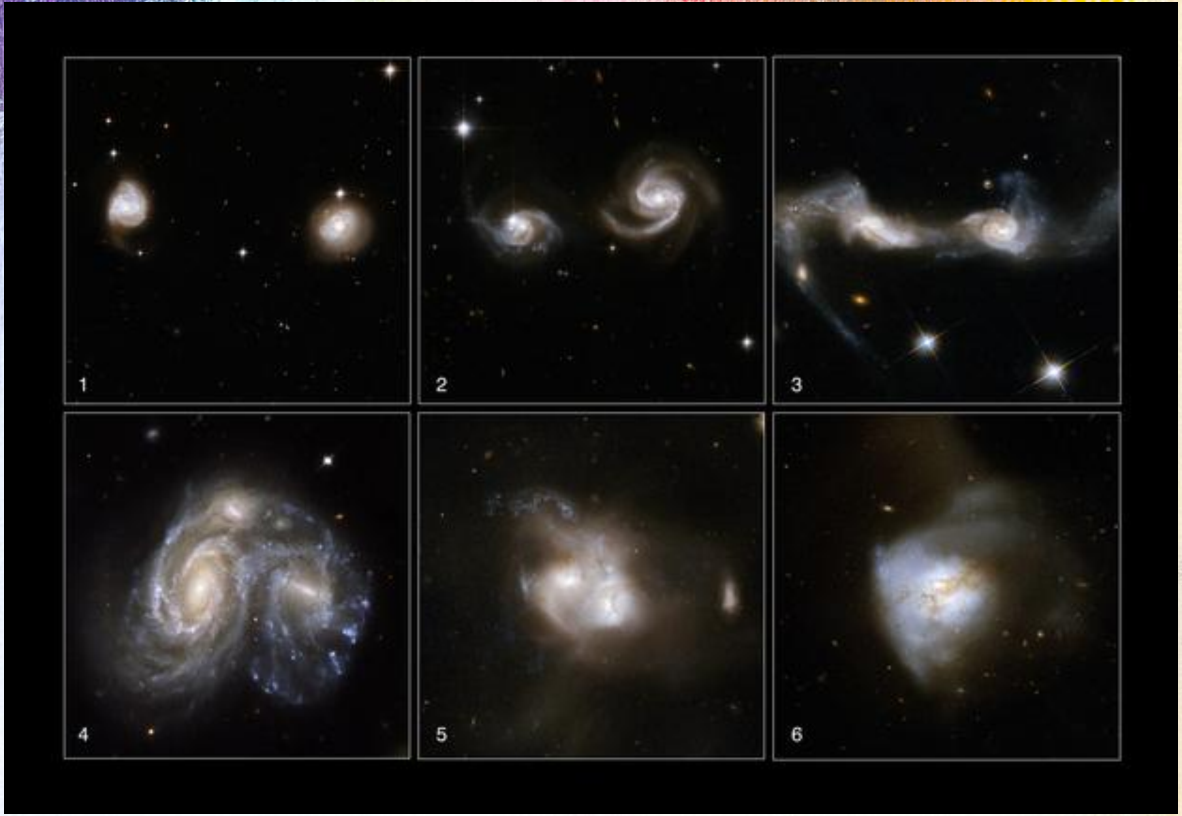
a quick introduction to the complex world of galaxies

What do we know about galaxies?





What do we know about galaxies?



What do we know about galaxies?

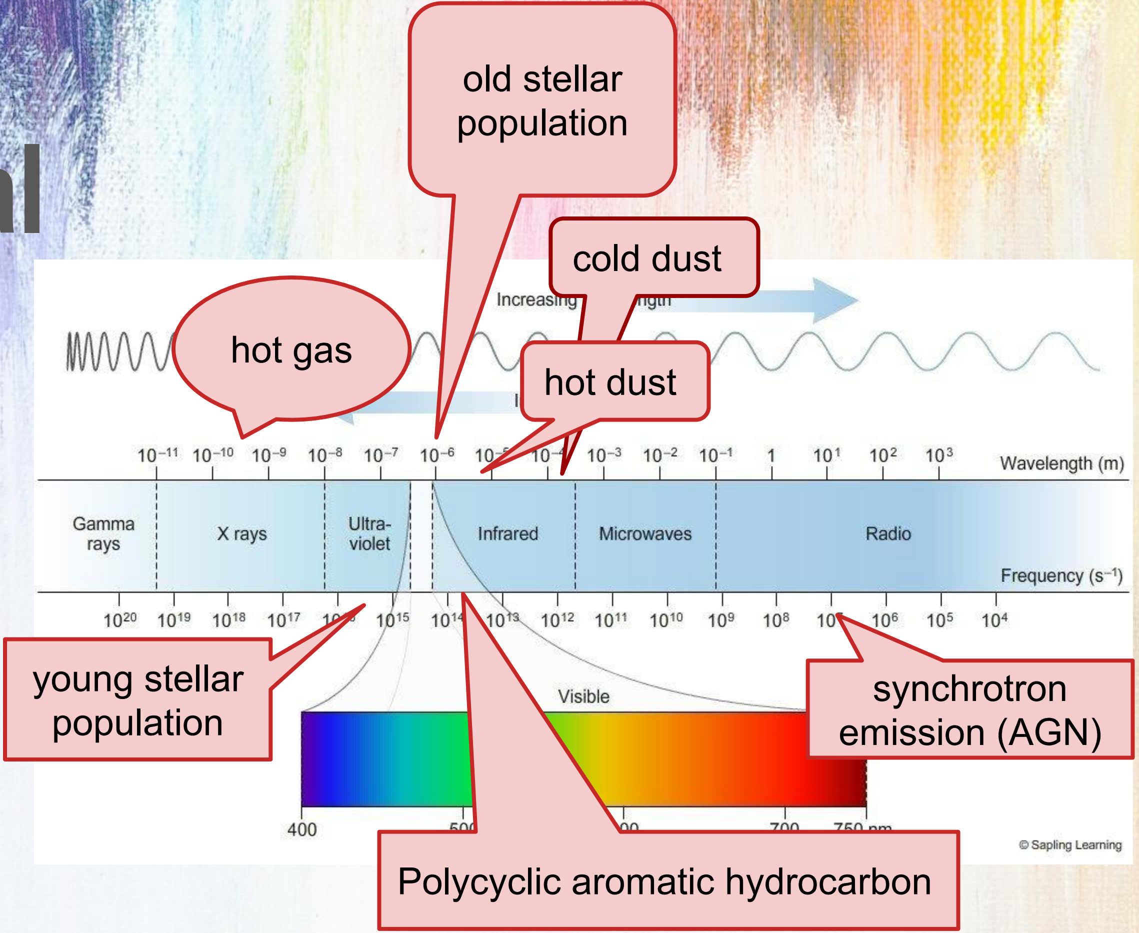
Credit: NASA, ESA, R. Ellis (Caltech), and the HUDF 2012 The Hubble Ultra Deep Field 2012

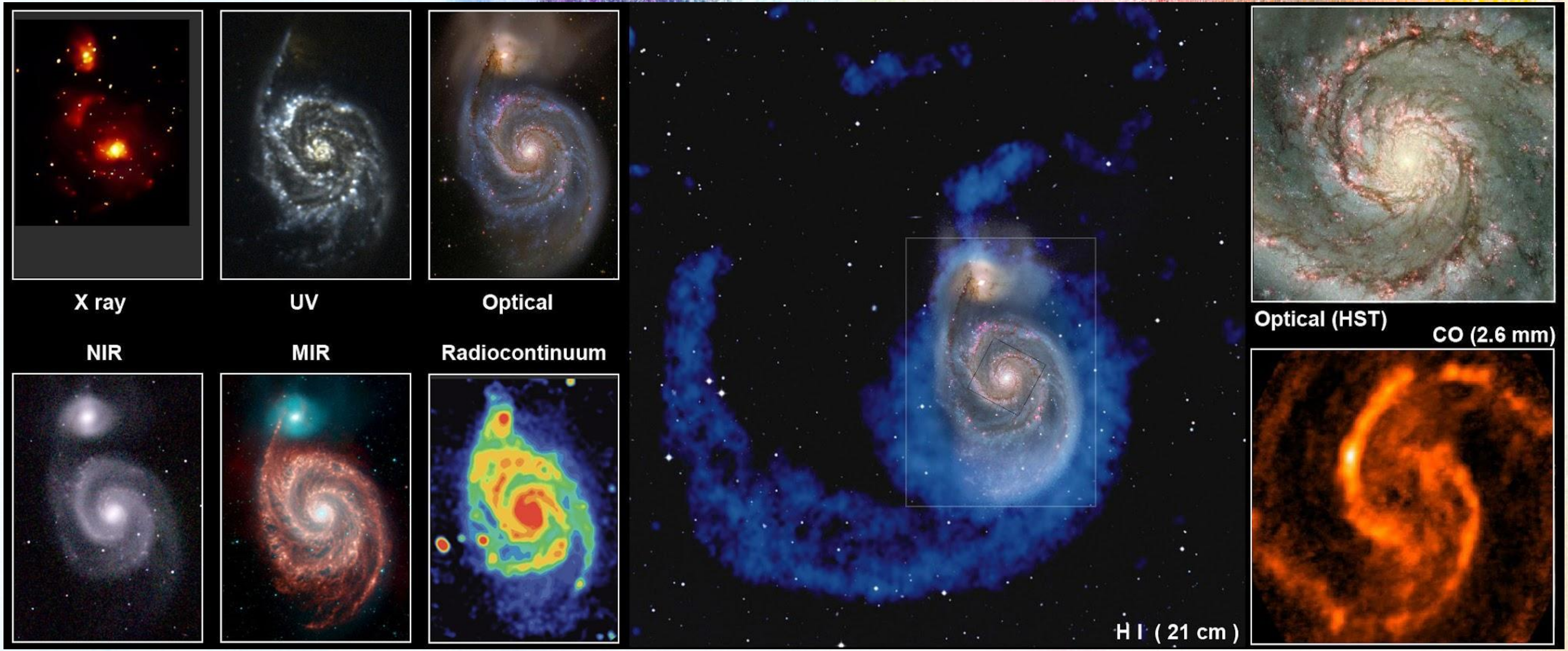
What do we know about galaxies?

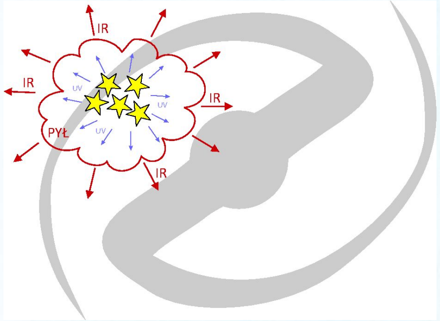
Credit: CANDELS collaboration

panchromatic view on the galaxy and the importance of the dust (and the dust attenuation)

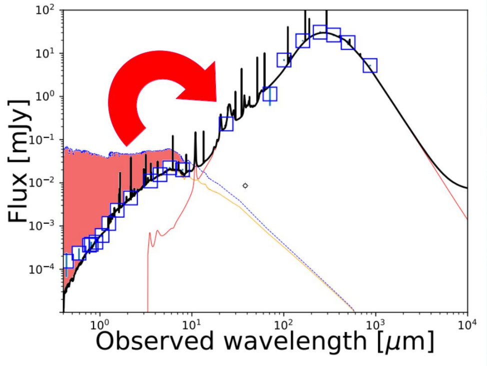
How do we estimate physical properties of galaxies?

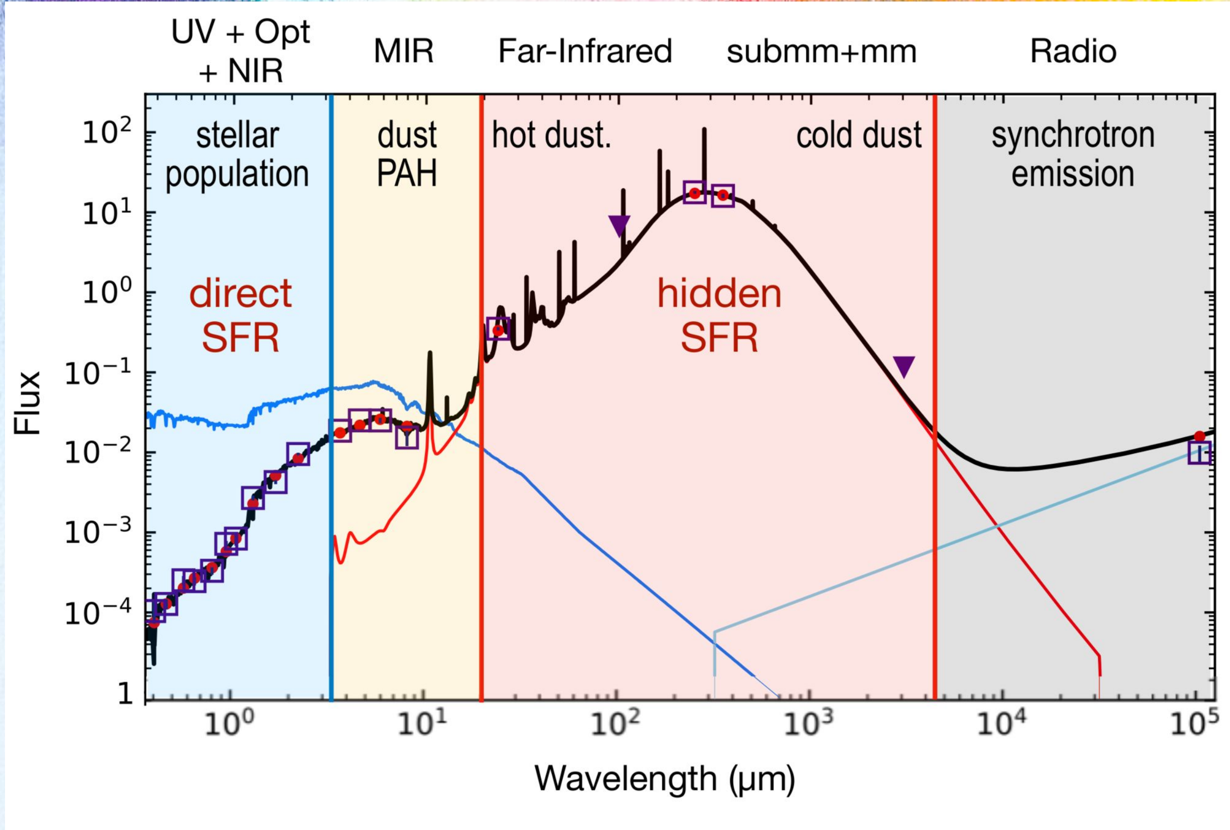



X ray
UV
Optical
NIR
MIR
Radiocontinuum
H I (21 cm)
Optical (HST)
CO (2.6 mm)



Dust absorbs part of the UV (0,1-0,4μm) radiation from young, massive stars and then **re-emits** the energy in the IR rage (IR, 8-1000μm).





Credit: M. Hamed

We have tools to study the galaxy evolution in cosmic time.

Do we have the data?

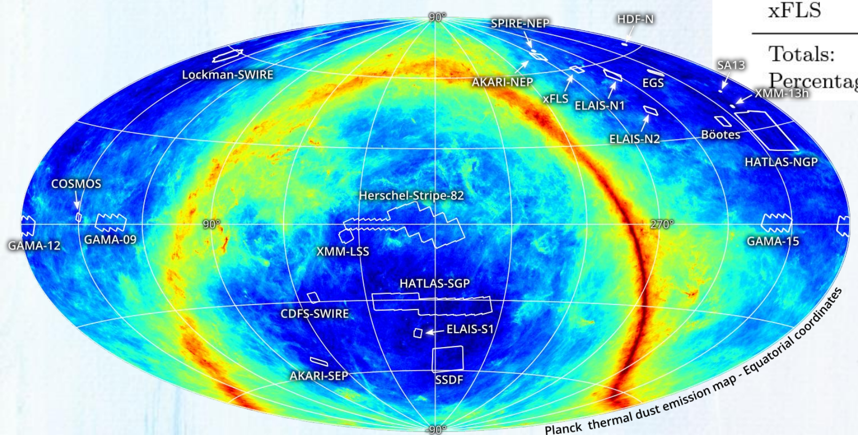
yes we have! new data - new results

the Herschel Extragalactic Legacy Project (HELP)

NEW DATA

HELP: the Herschel Extragalactic Legacy Project

Field	Objects	area deg.^{2}	XID+	photo-z	CIGALE	Blind	spec-z
AKARI-NEP	531 746	9.2	31 441	*107 228	1 239	9 848	1 243
AKARI-SEP	844 172	8.7	108 119	*139 059	566	20 169	362
Boötes	3 398 098	11.4	495 159	1 570 512	38 980	30 566	23 424
CDFS-SWIRE	2 171 051	13.0	283 406	136 944	9 308	40 880	29 063
COSMOS	2 599 374	5.1	25 898	691 502	15 747	12 603	36 686
EGS	1 412 613	3.6	223 598	1 182 503	4 159	9 551	19 799
ELAIS-N1	4 026 292	13.5	269 611	2 714 686	49 985	34 501	4 619
ELAIS-N2	1 783 240	9.2	86 591	*120 723	6 798	19 483	2 471
ELAIS-S1	1 655 564	9.0	194 276	1 013 582	25 393	22 743	10 396
GAMA-09	12 937 982	62.0	1 386 659	8 833 874	130 293	112 461	38 407
GAMA-12	12 369 415	62.7	1 099 477	8 569 951	108 139	112 471	41 149
GAMA-15	14 232 880	61.7	1 236 395	10 083 210	117 234	116 436	81 413
HATLAS-NGP	6 759 591	177.7	1 233 547	3 166 952	185 290	344 635	58 476
HATLAS-SGP	29 790 690	294.6	3 511 594	17 054 138	352 804	497 501	47 213
HDF-N	130 679	0.67	834	*7 435	0	0	3 360
Herschel-Stripe-82	50 196 455	363.2	2 976 447	21 509 448	250 644	232 589	132 358
Lockman-SWIRE	4 366 298	22.4	242 065	1 377 139	46 719	54 106	7 243
SA13	9 799	0.27	812	*2 884	70	315	188
SPIRE-NEP	2 674	0.13	562	*935	71	374	1
SSDF	12 661 903	111.1	4 395 253	9 250 727	305 576	196 895	1 417
XMM-13hr	38 629	0.76	3 563	*10 773	670	1 218	365
XMM-LSS	8 705 837	21.8	360 500	6 124 027	61 888	50 362	78 192
xFLS	977 148	7.4	52 187	*100 993	5 944	19 757	3 562
Totals:	171 602 130	1269.1	18 217 994	93 769 225	1 717 517	1 939 464	621 407
Percentages:			10.6%	54.6%	1.0%		0.4%

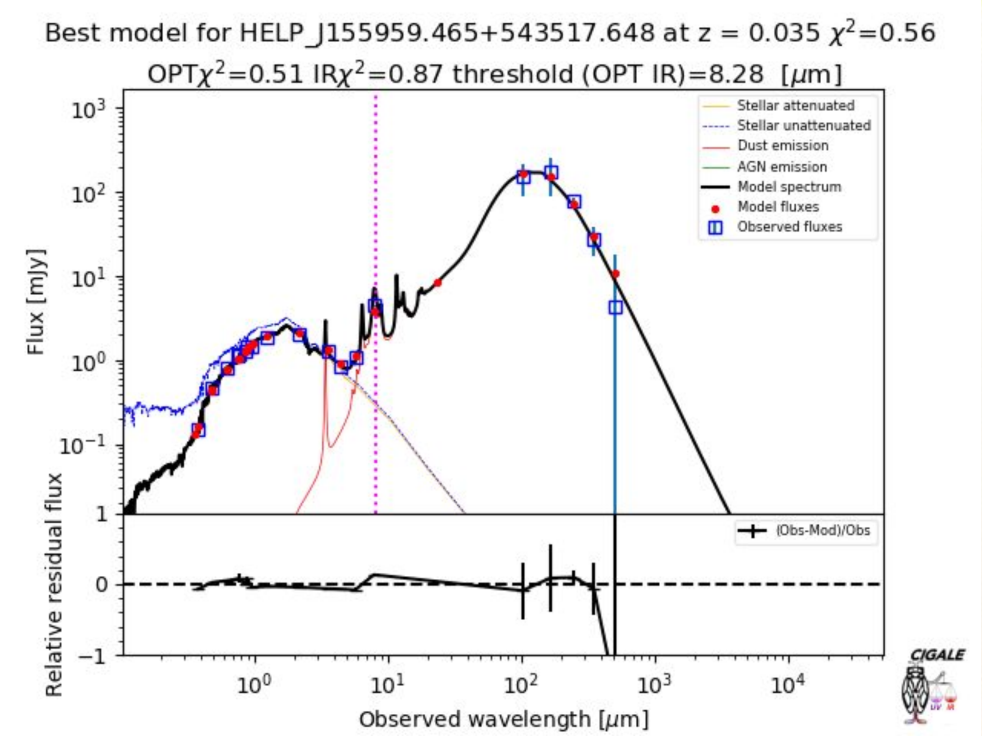


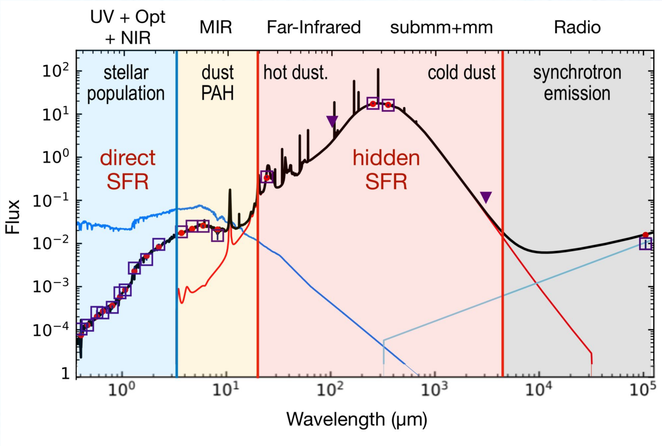
WG leader

Shirley, Duncan, Campos Varillas, Hurley, MK, et al., MNRAS, 2021, Vol. 507

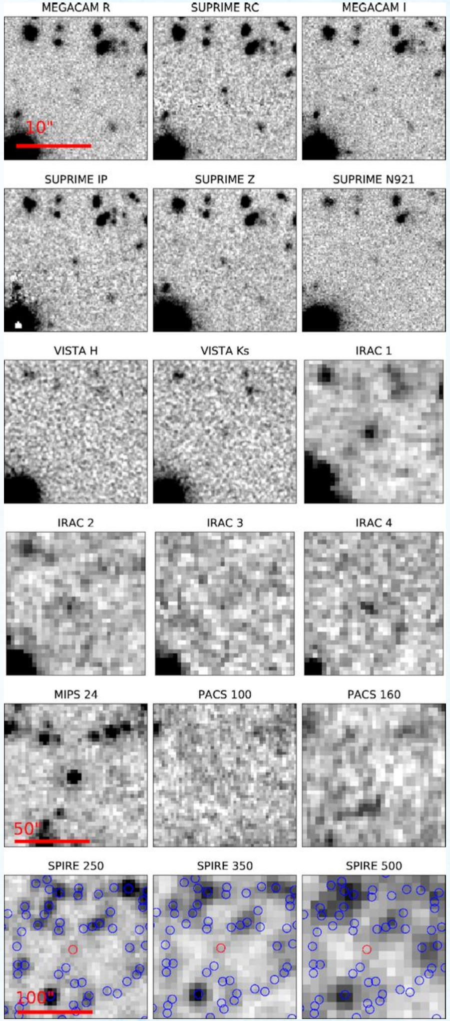
NEW DATA

HELP: the Herschel Extragalactic Legacy Project

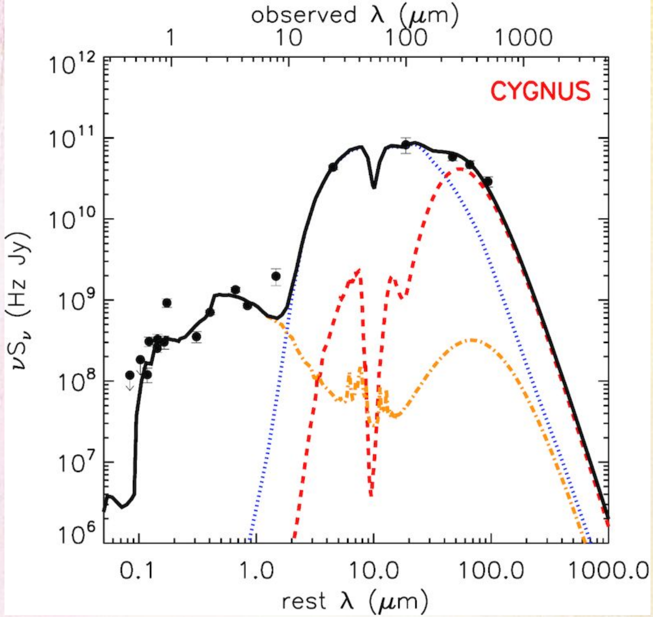




Shirley, Duncan, Campos Varillas, Hurley, MK, et al., MNRAS, 2021, Vol. 507

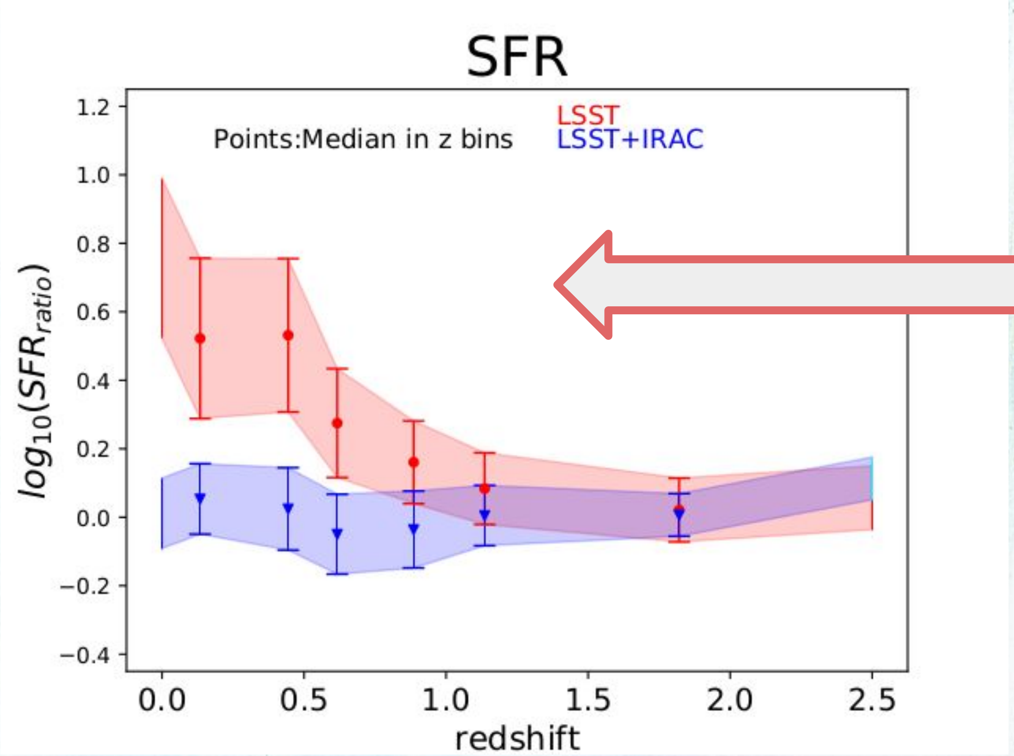


The discovery of a giant black hole hidden in a galaxy that existed 1,4 Gyr after the Bing Bang!



A hyperluminous obscured quasar at a redshift of z = 4.3

Efstathiou, KM et al, MNRAS, 2021

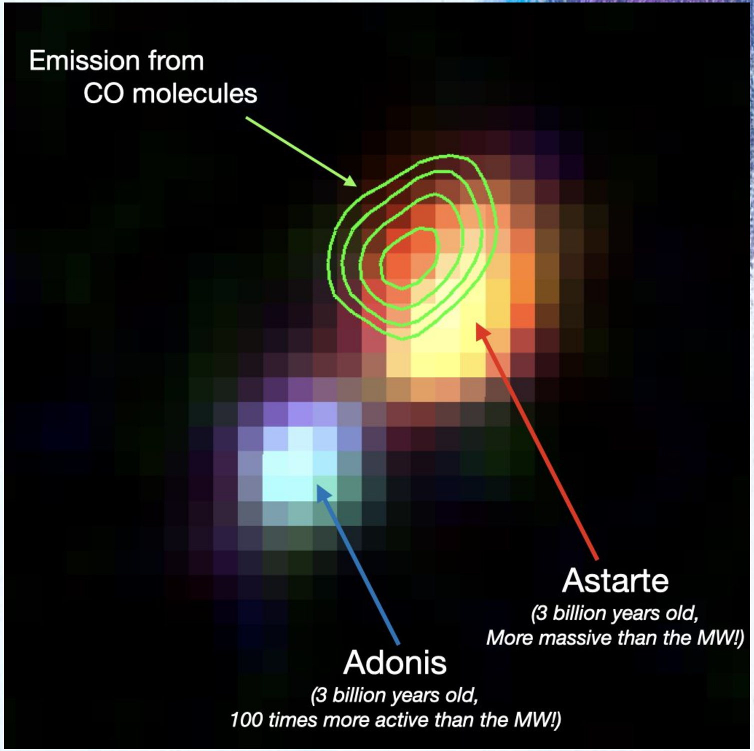


large overestimation of SFR obtained without using other wavelengths than optical to observe

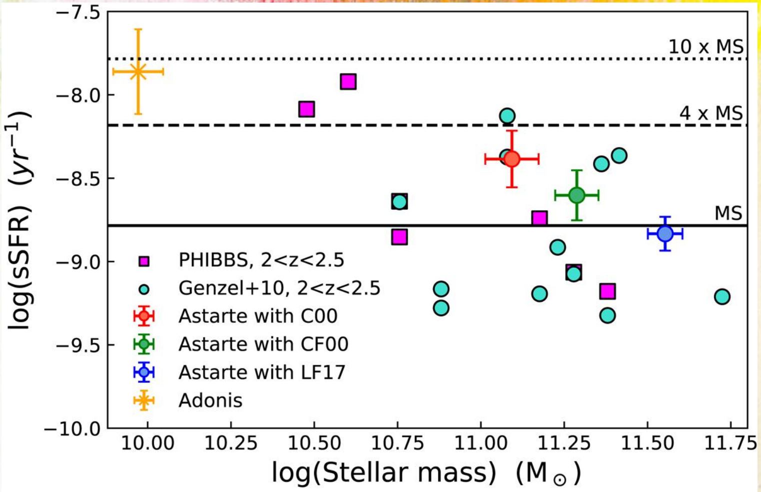
Preparing for LSST data. Estimating the physical properties of z < 2.5 main-sequence galaxies

Legacy Survey of Space and Time:
starting 2022 - 10 years of observations, ~60 petabytes of pictures and 15-petabytes of data, 20 terabytes of data/night

Riccio, KM, Nanni, Hamed, Pollo et al, A&A, 2021



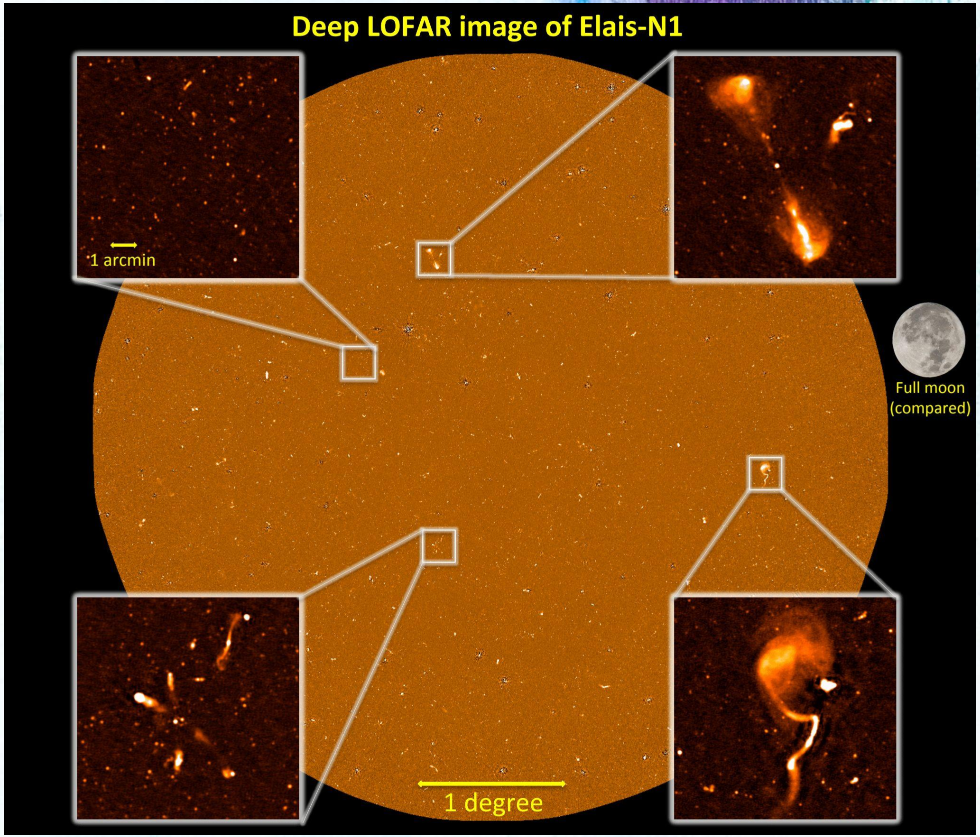
Astarte & Adonis (z~2, the age of the Universe at that time~3.316 Gyr).

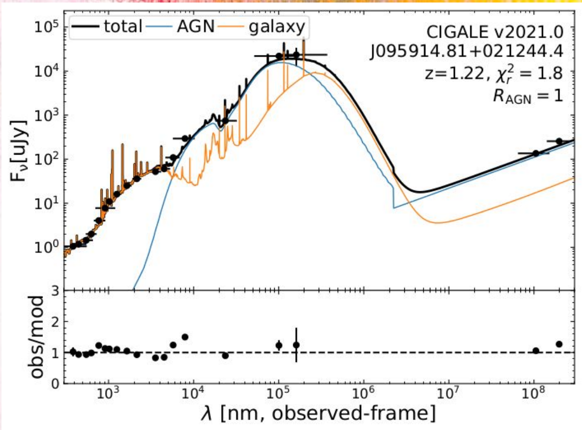


Multiwavelength dissection of a massive heavily dust-obscured galaxy and its blue companion at z~2

M. Hamed, KM et al., A&A, 2021

The Low Frequency Array (LOFAR)





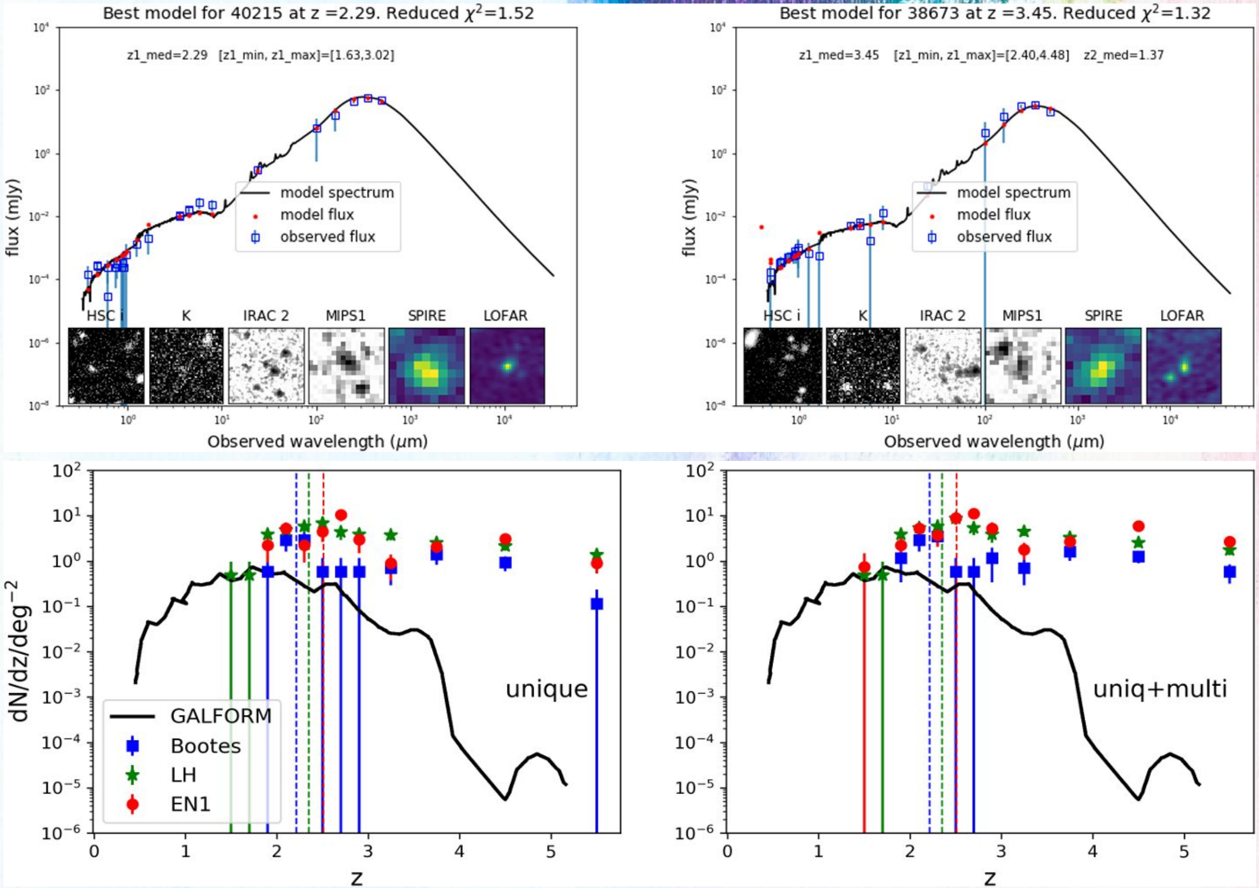
Guang, KM, et al., submitted

The LOFAR Two-meter Sky Survey: Deep Fields Data Release 1. IV. Photometric redshifts and stellar masses

Duncan, Kondapally, Brown, Bonato, Best, .. , KM, et al, A&A, 2021

HELP+LOFAR

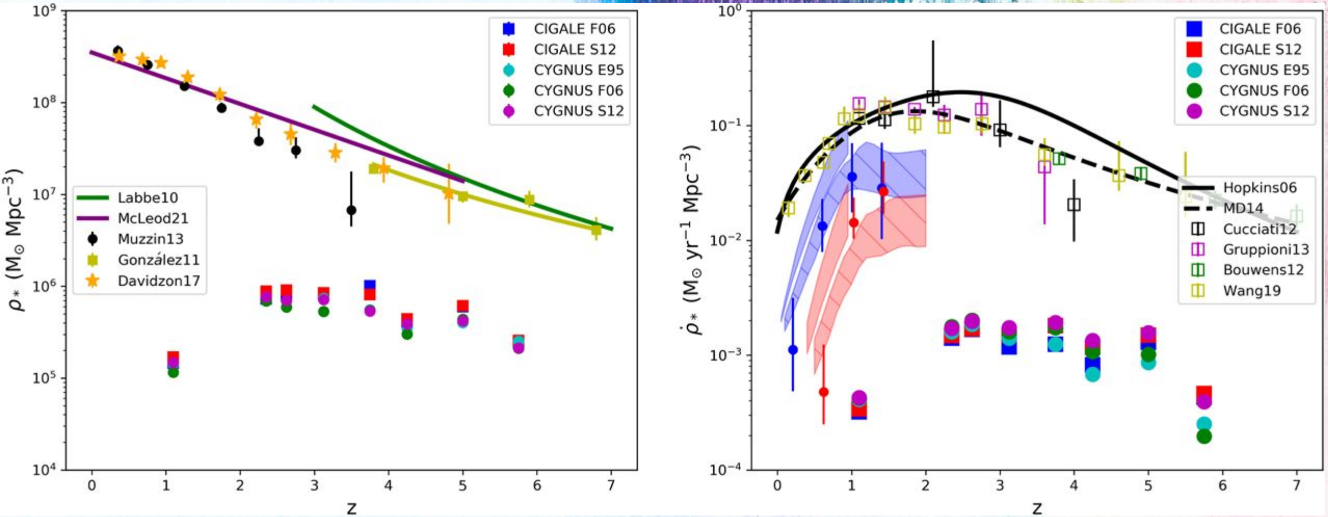
FIR+radio



The bright end of the infrared luminosity functions and the abundance of hyperluminous infrared galaxies

Wang, Gao, Best, Duncan, Hardcastle, Kondapally, MK, McCheyne, Pearson et al, A&A, 2021

The strongest and cleanest (complete SPIRE250 at the level of 92%) indication that the population of HLIRGs has surface densities of ~5 to ~18/deg2. In comparison, the semi-analytic model significantly under-predicts the abundance of HLIRGs.



HELP+LOFAR

FIR+radio

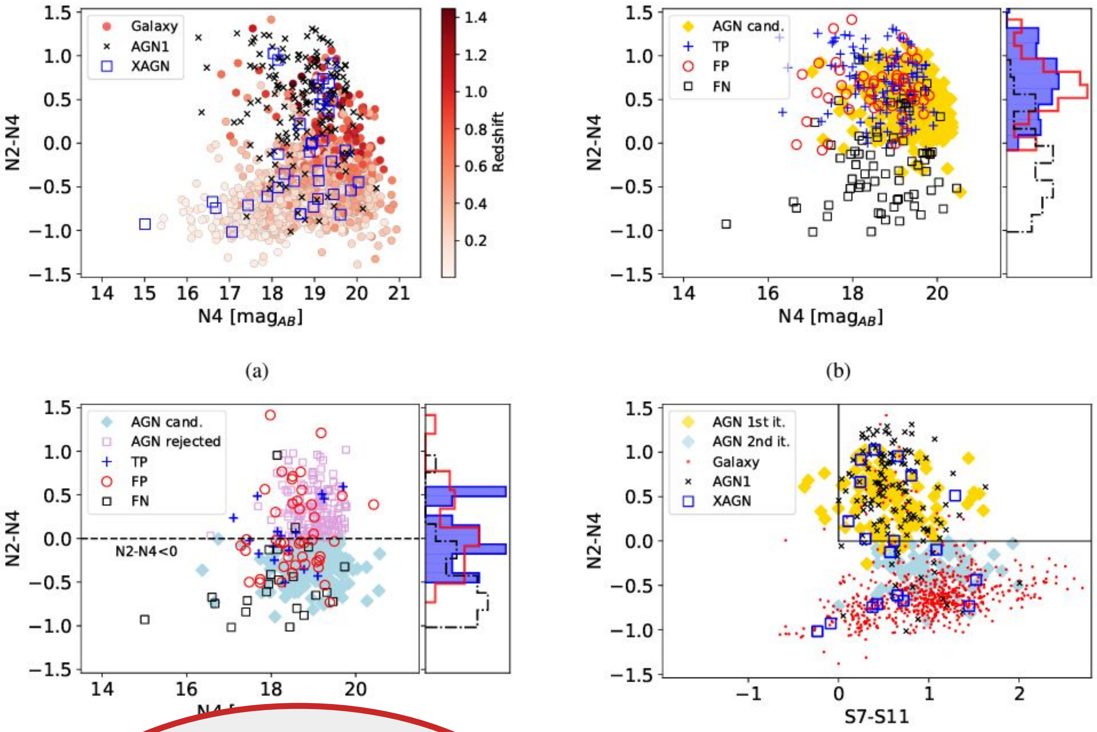
The nature of hyperluminous infrared galaxies

Gao, Wang, Efstathiou, MK, Best, Bonato, Farrah, Kondapally, McCheyne, Röttgering, A&A, 2021

526 HLIRGs in three deep LOFAR fields

- a higher space density of ultra-massive galaxies than what was found by previous surveys or predicted via simulations.
- HLIRGs contributes more to the cosmic SFR density as redshift increases..

The North Ecliptic Pole field



NEP ARARI

NIR+MIR

Active galactic nuclei catalog from the AKARI NEP-Wide field

Poliszczuk, Pollo, MK, Durkalec, Pearson, Goto, Kim, Malkan, Oi, Ho, Shim, Pearson Ch., Hwang, Toba, Kim E.
A&A, 2021

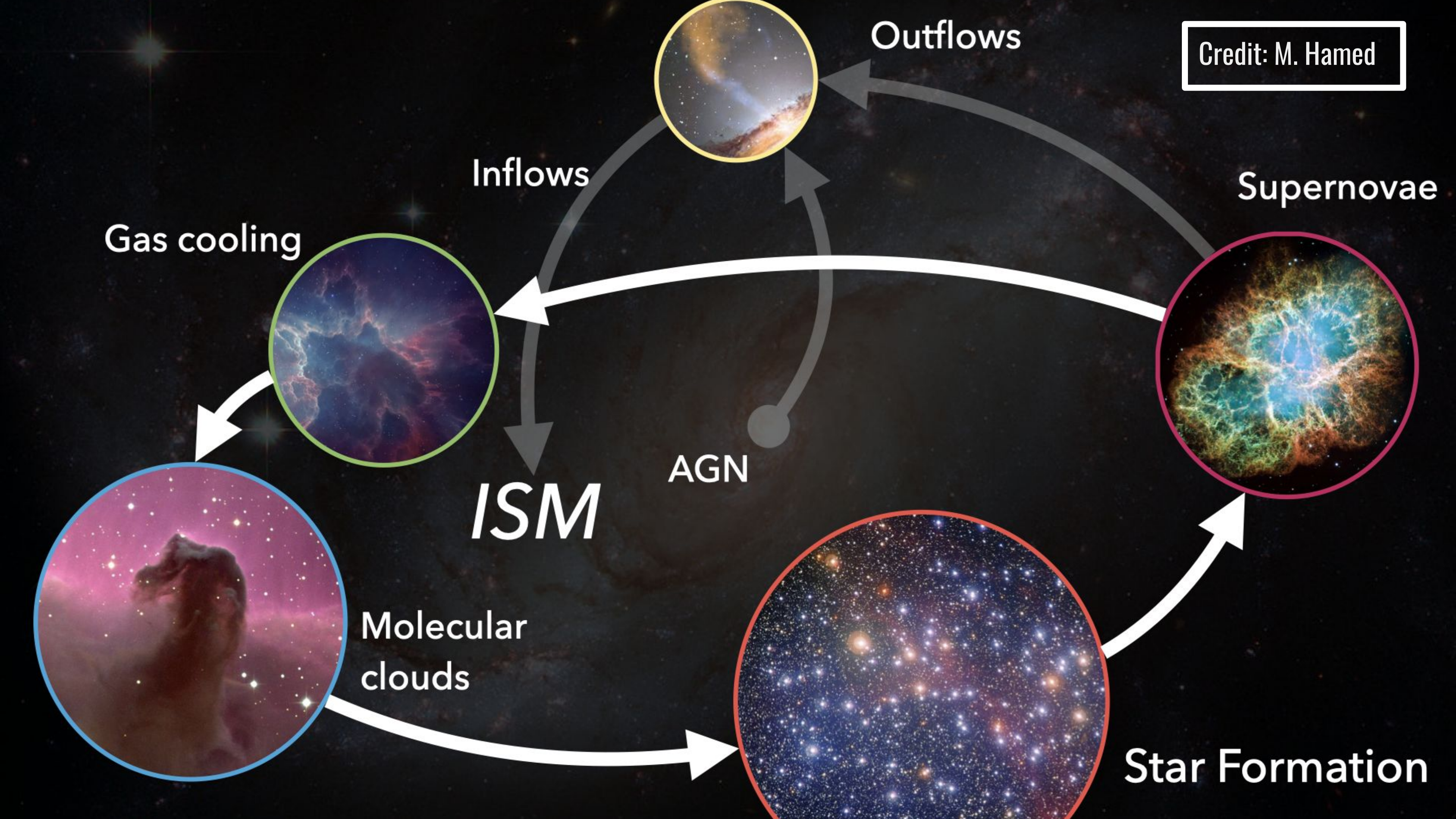
465 objects, positions, optical, near-IR and mid-IR photometry

set of supervised machine learning algorithms used to obtain a reliable AGN candidates catalog using optical+NIR data (alternative for the MIR-based selection) technique.

SUMMARY

- this year we published new state-of-art catalogues at very difficult wavelengths (infrared, radio, and mixed),
- we have found that these catalogues used together open a new window for the high-quality galaxy evolution analysis,
- we have found particularly interesting sources (as a HOT DOG at z~4.3, a pair of galaxies at z~2, a sample of HLIRGs at high z) but also we delivered a new method to analyse data from the new coming surveys (as LSST),
- taking into account the number of observed galaxies, and the number of the photometric bands, the ML techniques are now essential to use.

Thank you very much for your attention


Outflows
Credit: M. Hamed
Inflows
Supernovae
Gas cooling
AGN
ISM
Molecular
clouds
Star Formation