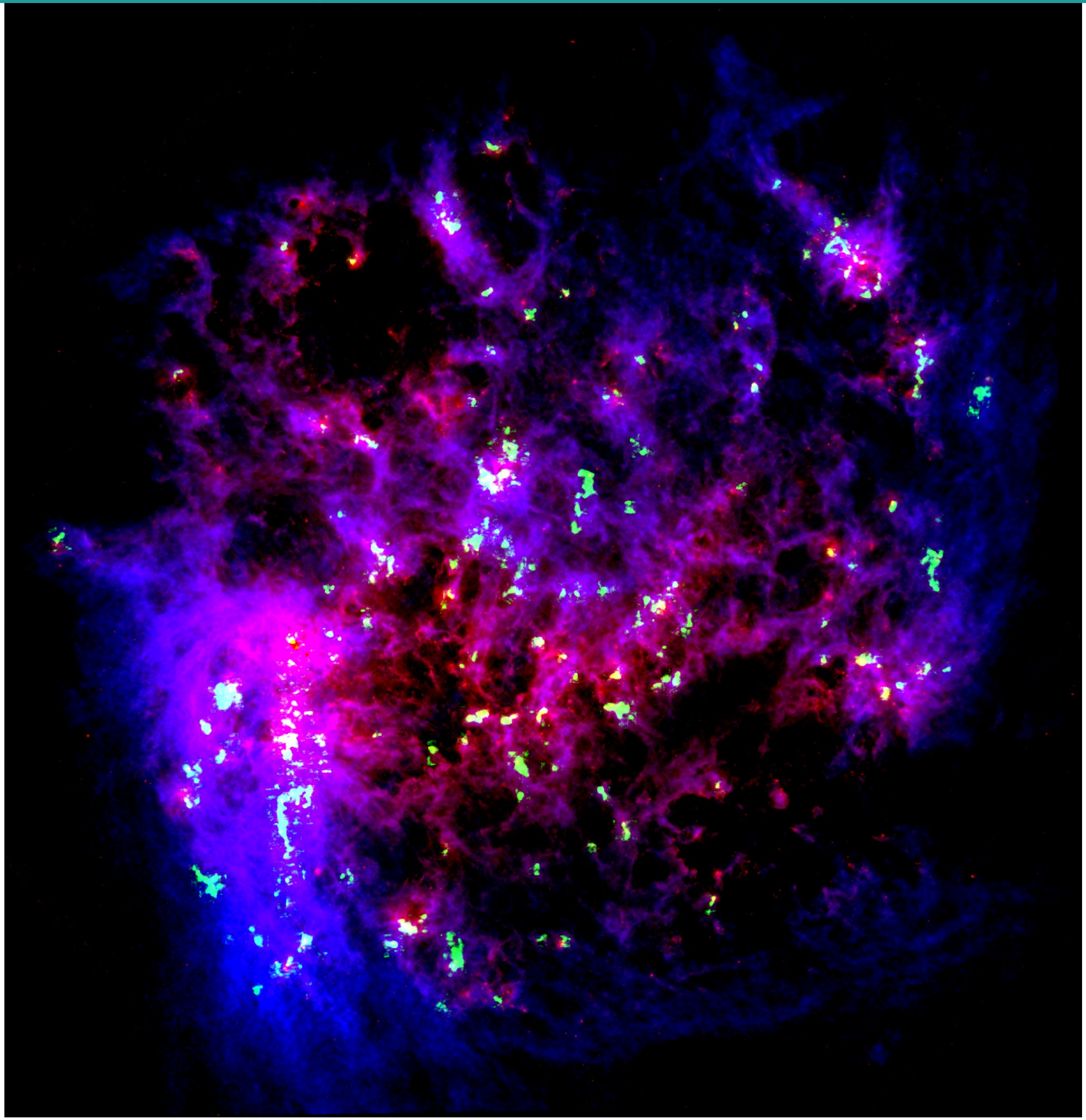
Molecular Gas Tracers in Galaxies



Juergen Ott
(NRAO)

How do stars form?

1)Atomic/ionized gas converts to molecular clouds

Star Formation

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1) Atomic/ionized gas converts to molecular clouds

2) A fraction of the molecular gas condenses to clumps

Star Formation

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5) Feedback that influences the parent ISM

Star Formation

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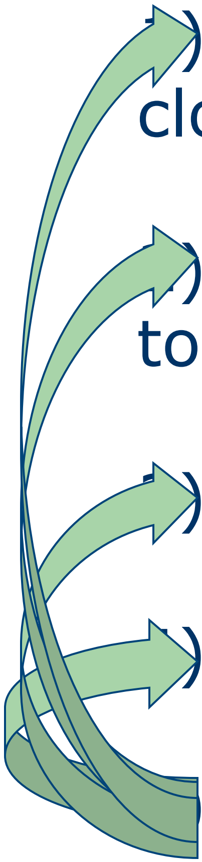


1)Atomic/ionized gas converts to molecular clouds

2)A fraction of the molecular gas condenses to clumps

3) Clumps break down into cores

4) Stars form within molecular cores

5) Feedback that influences the parent ISM
→ influences all of the above

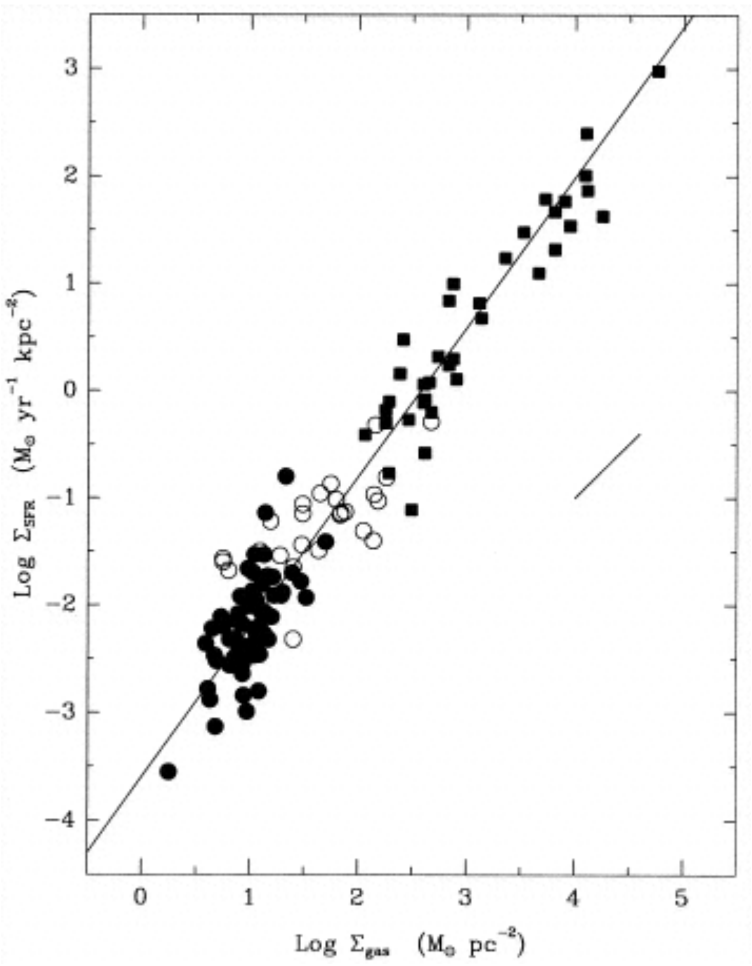
Relation of gas and star formation:

Schmidt-Kennicutt Law

$\Sigma_{SFR} \sim \Sigma_{gas}^{1.4}$

Valid for entire galaxies

→ Globally, the gas determines the SF that can happen in a galaxy



Kennicutt et al. (1998)

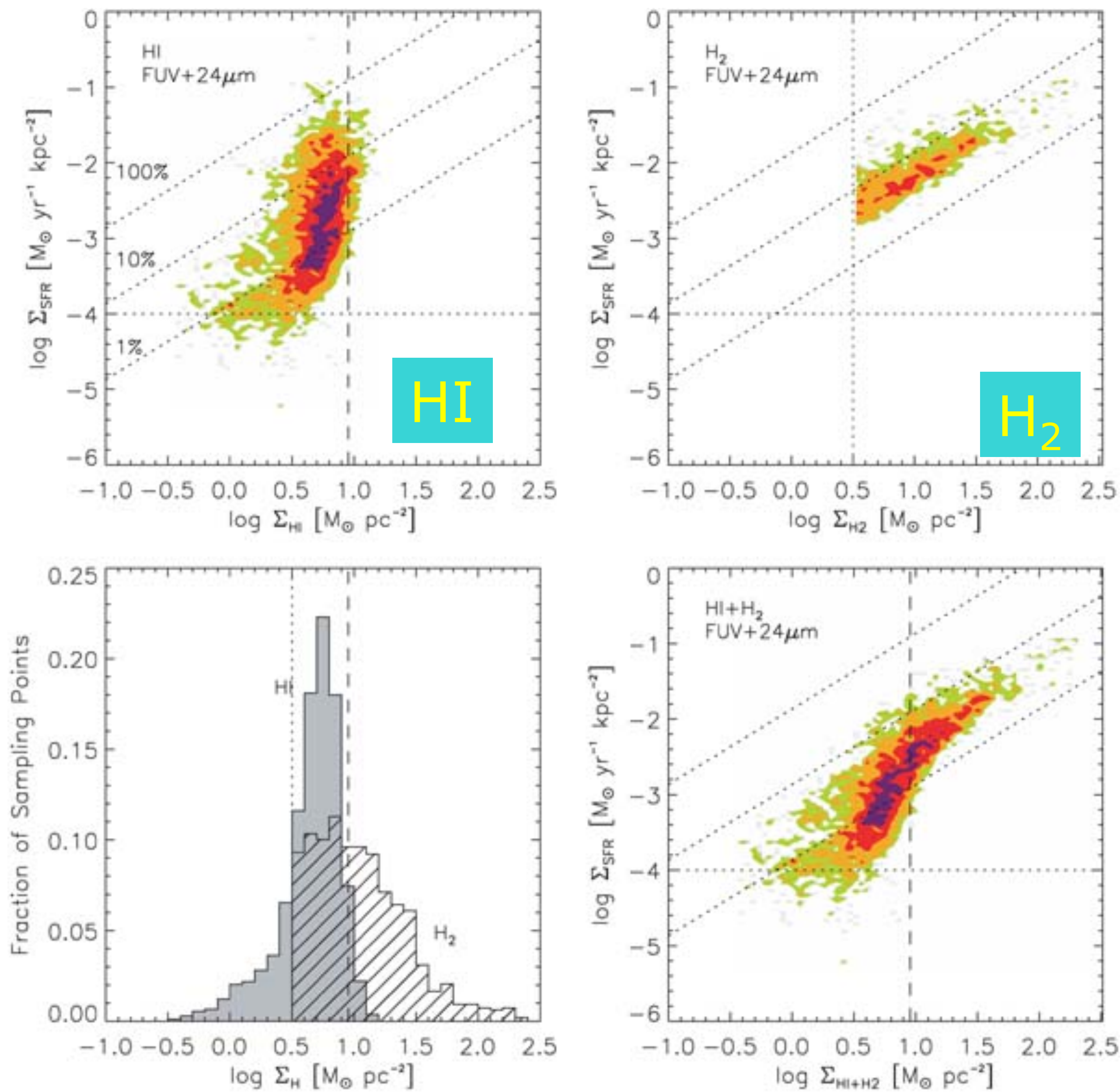
SF laws

HI has a different law than H_2

H_2 $\Sigma_{SFR} \sim \Sigma_{gas}^{1.0}$

HI: threshold at 10 M_o/yr

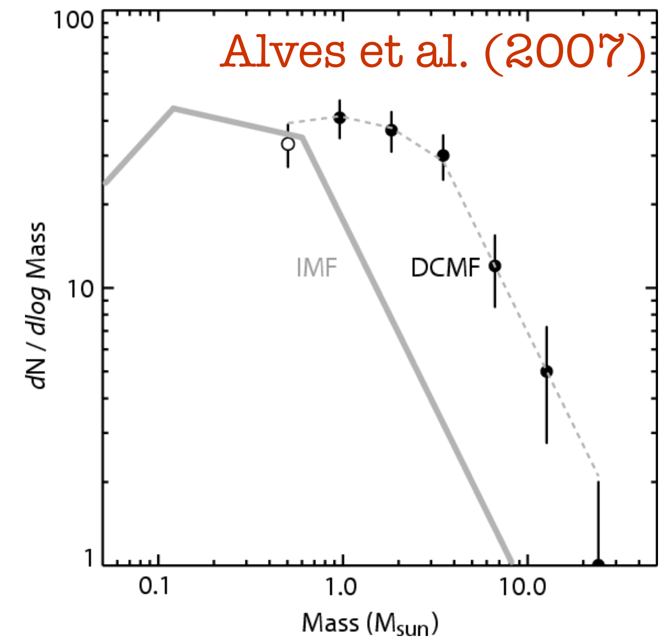
Molecular gas is directly responsible for SF

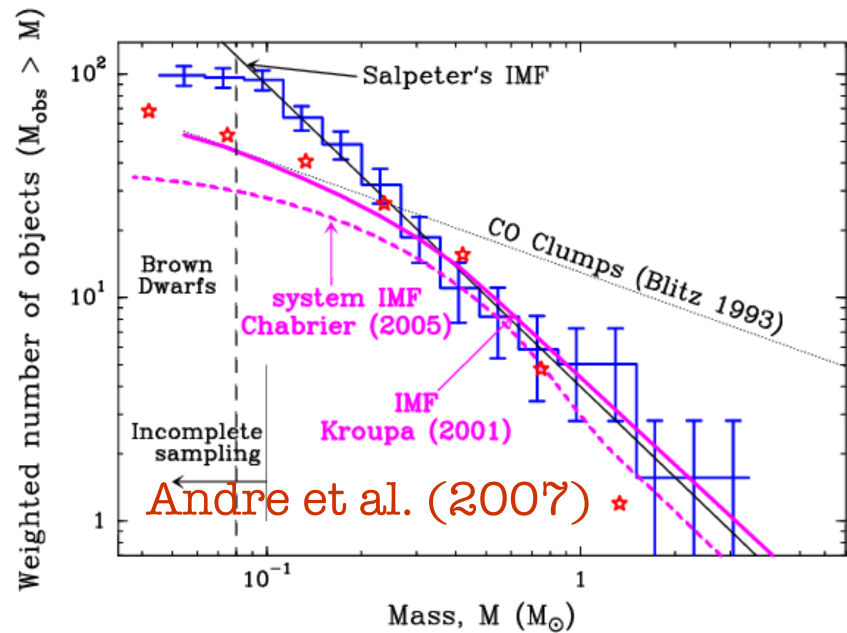


Bigiel et al. (2008)

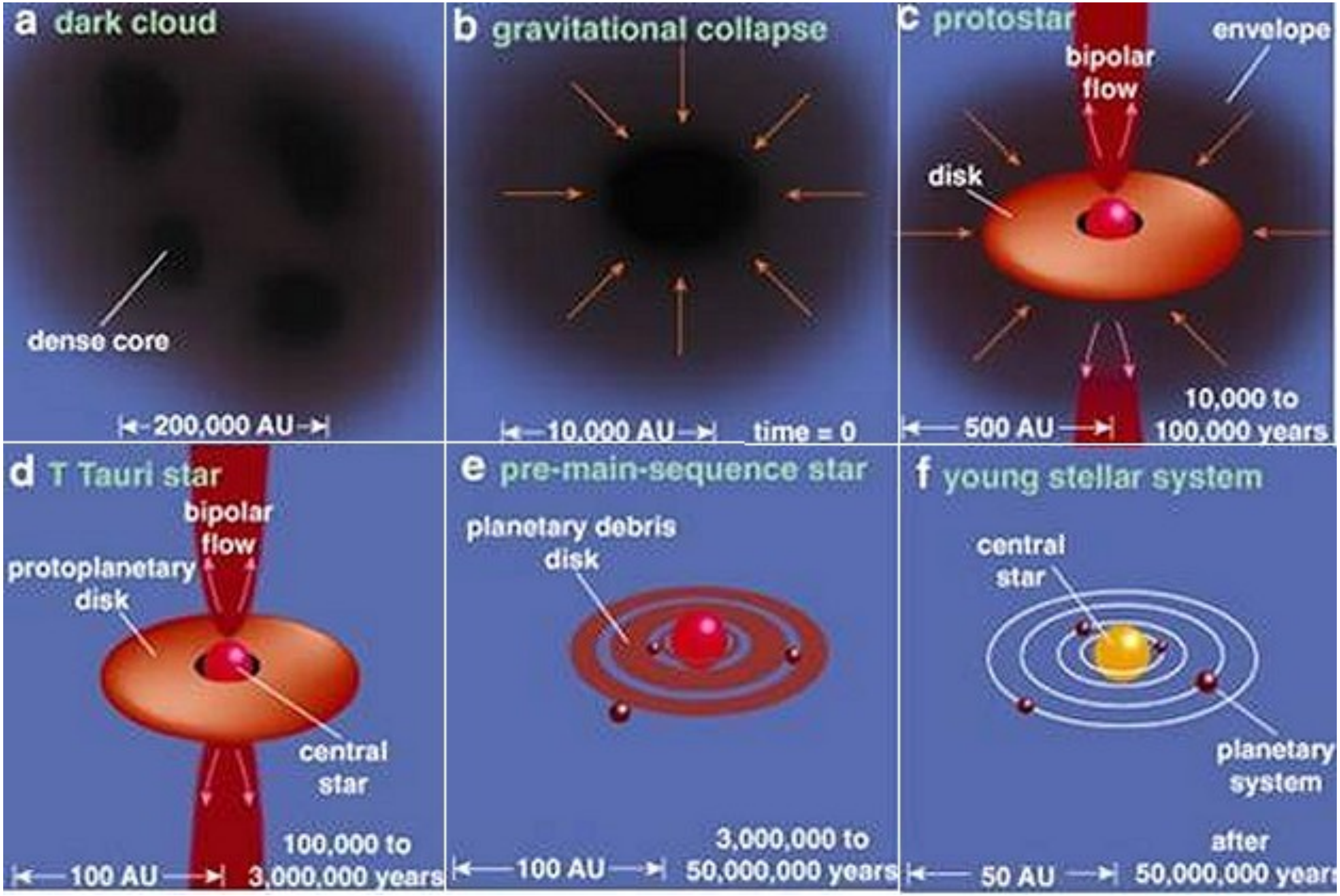
SF laws

The core mass function Determines the stellar IMF



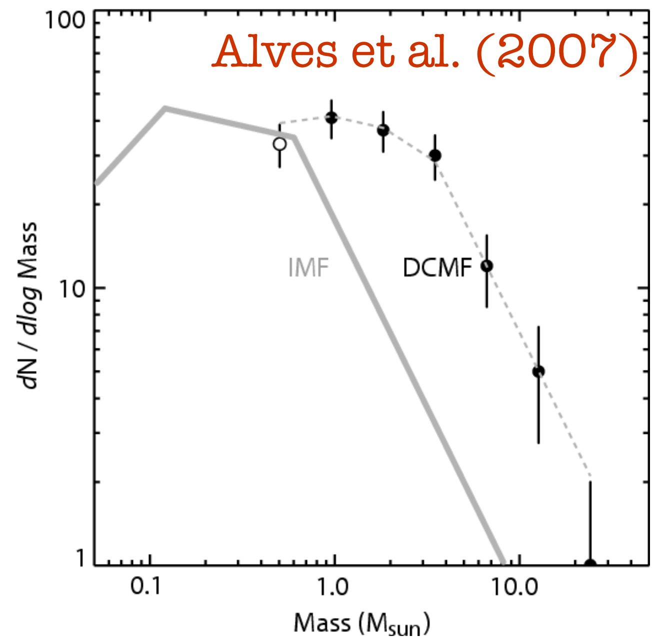


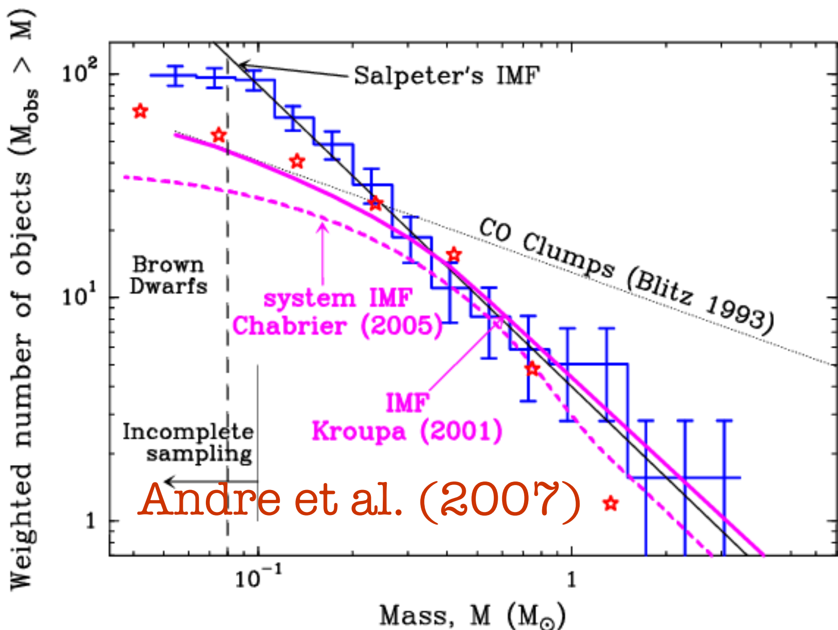
SF processes



Spitzer Science Center

The core mass function Determines the stellar IMF



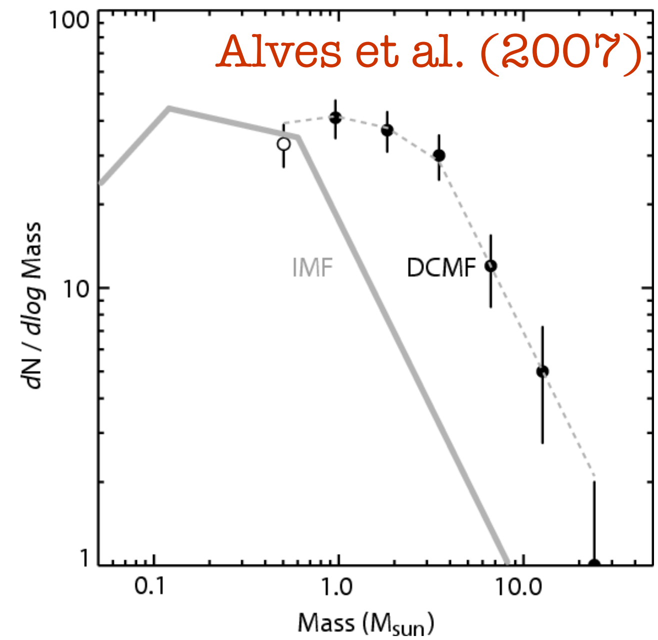


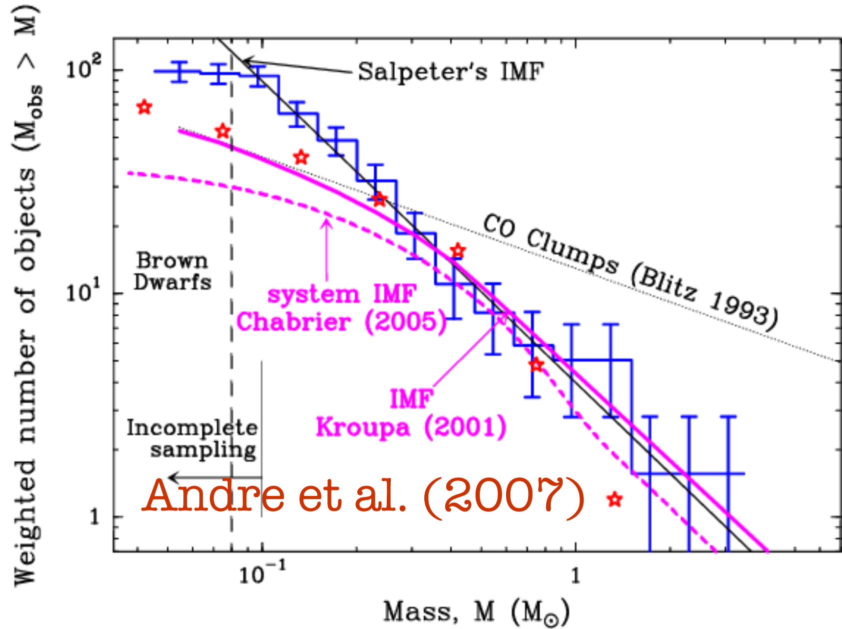
SF laws

The core mass function Determines the stellar IMF

So the main questions are:

How do we form molecular gas, how does it break up into molecular clumps, and how do the molecular cores obtain their size distribution?





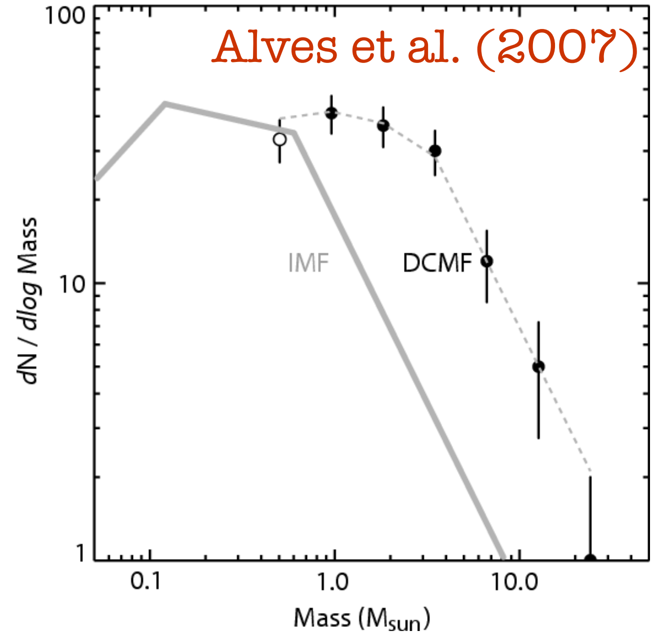
SF laws

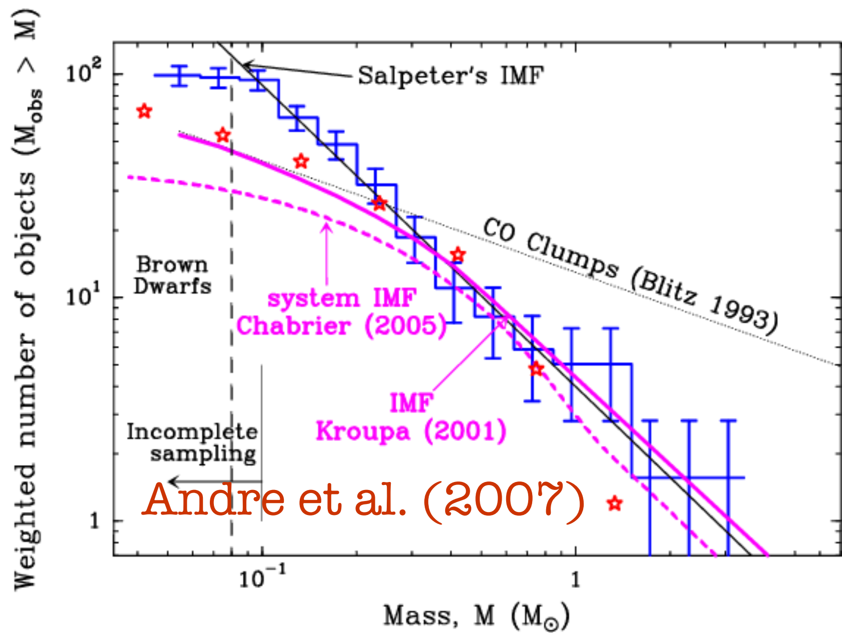
The core mass function
Determines the stellar IMF

So the main questions are:

How do we form molecular gas, how does it break up into molecular clumps, and how do the molecular cores obtain their size distribution?

Since the IMF is universal, is the fractionation process universal, too?

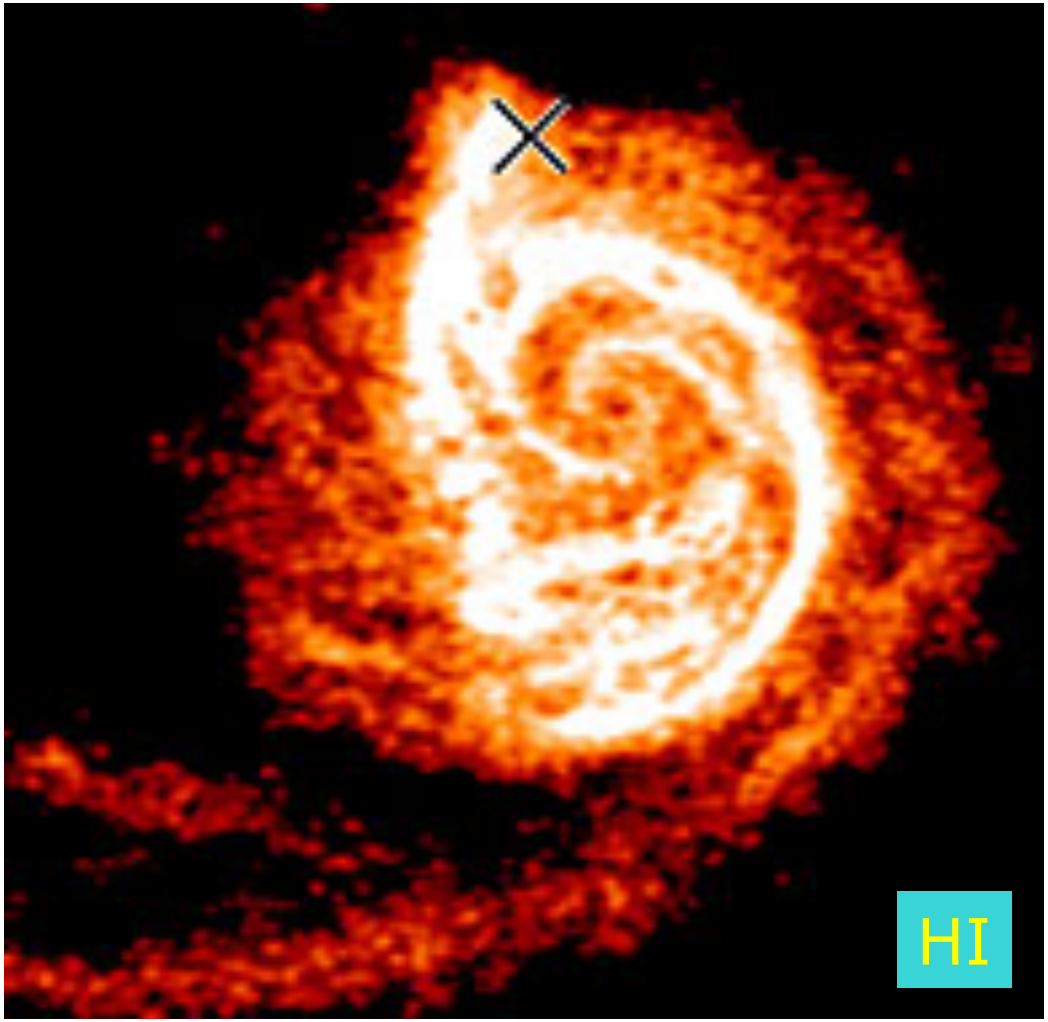




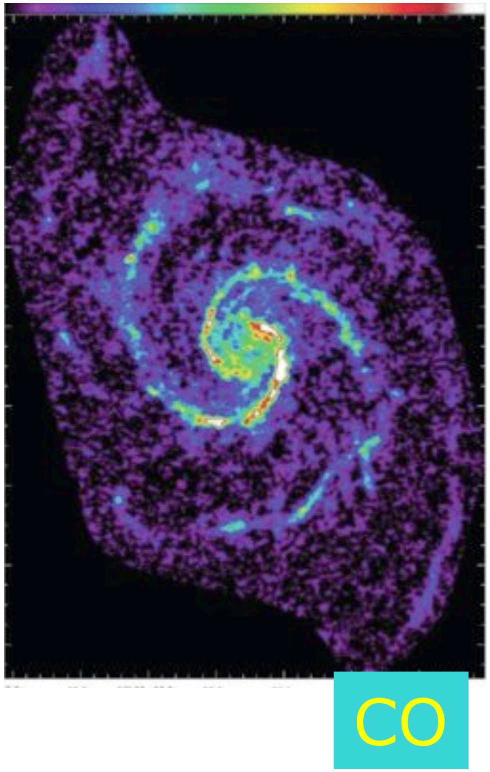
Molecular Gas Formation

Can we predict the location and amount of molecular gas from HI?

Molecular Gas Formation

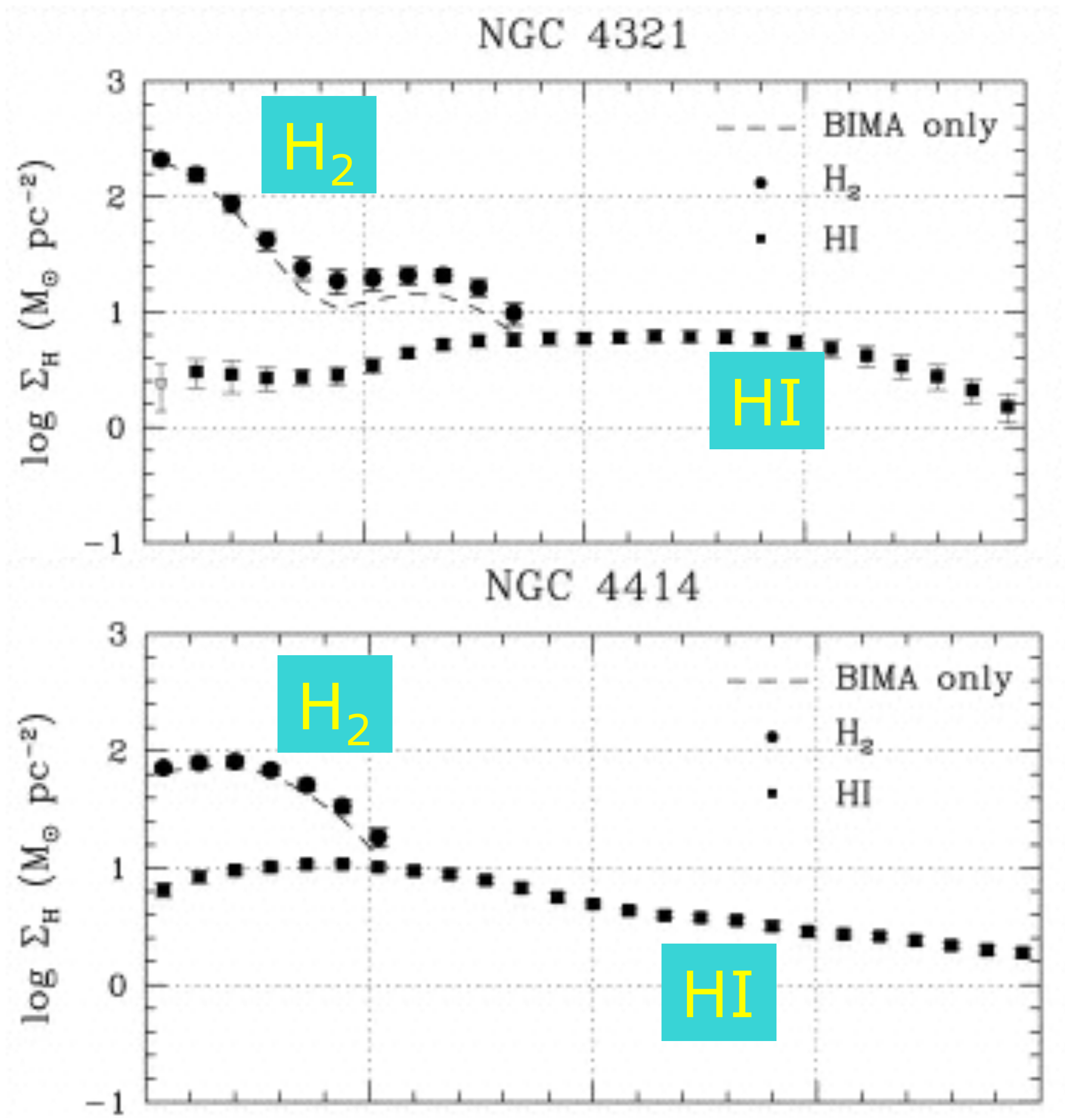


Walter et al. (2008)



Koda et al. (2009)

Molecular Gas Formation



Wong et al. (2002)

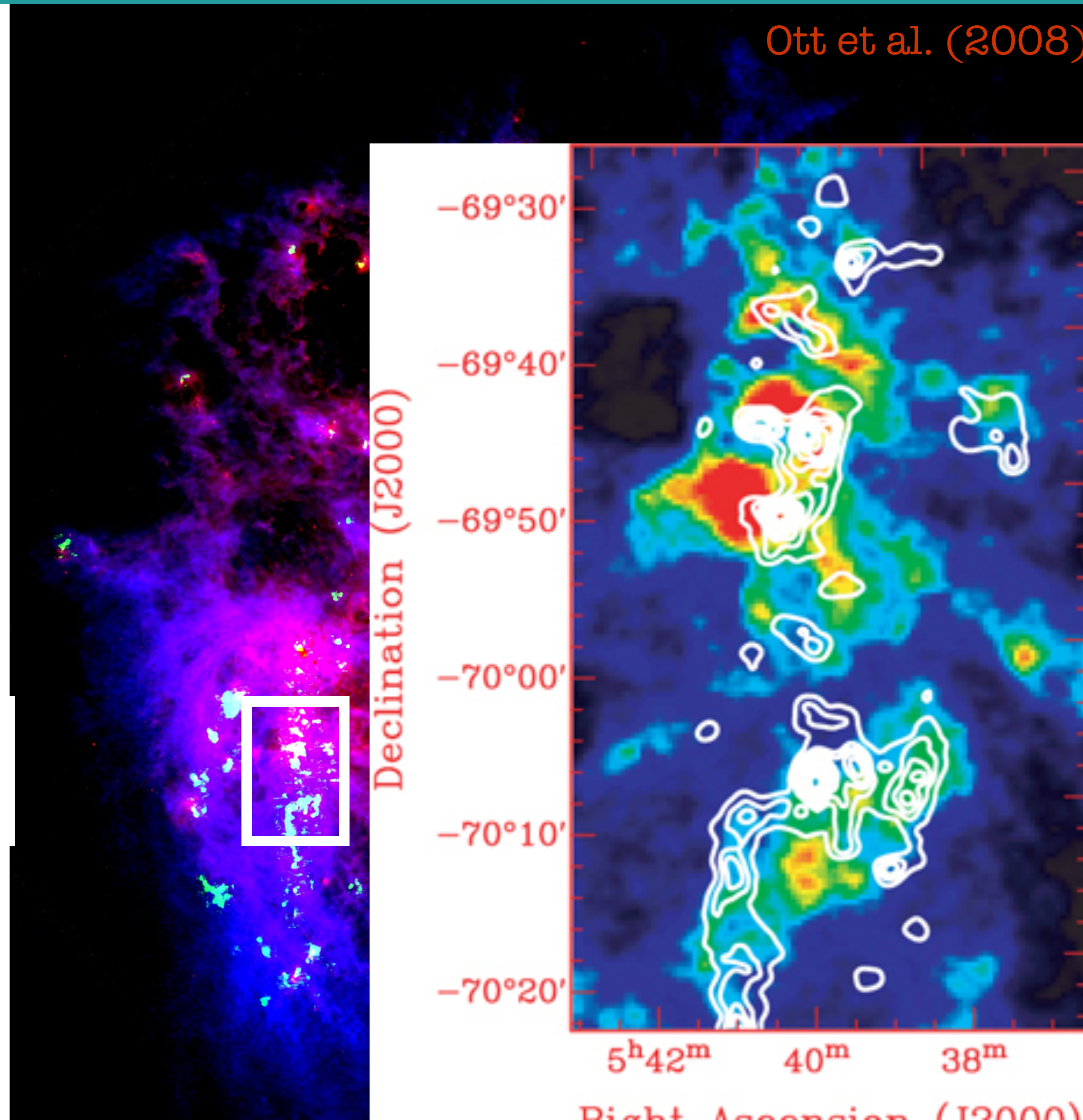
Molecular Gas Formation

MAGMA

LMC:
. Fav. Inclination
. Nearby
. Diverse conditons

Blue: HI
Red: Spitzer 70µ
Green: CO

Wong
Ott
Hughes
Pineda
Muller
+ others



Molecular Gas Formation

Can we predict the location and amount of molecular gas from HI?

-> No, but some HI threshold must be exceeded

Can we predict the location and amount of molecular gas from dust?

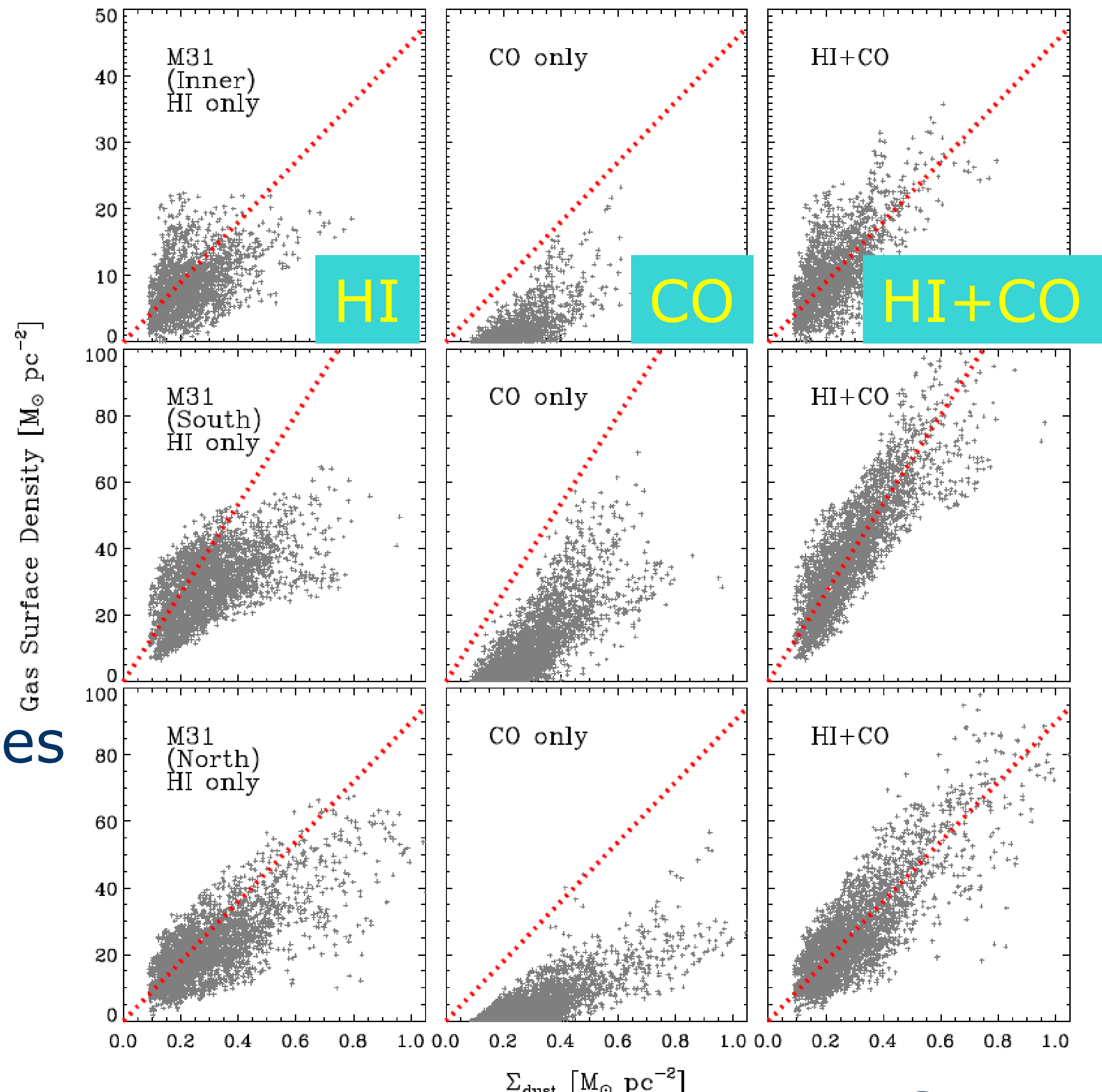
Molecular Gas Formation

Dust traces both, $HI+H_2$

So it can be used to some extent to find H_2 when HI is measured

But: still uncertainties In DGR and..

GAS

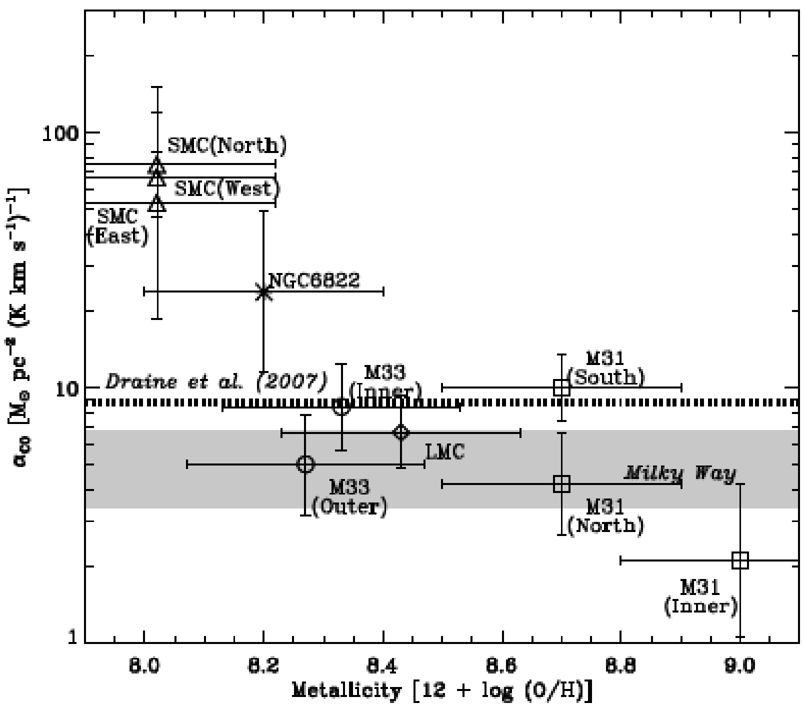


Leroy et al. (2011)

DUST

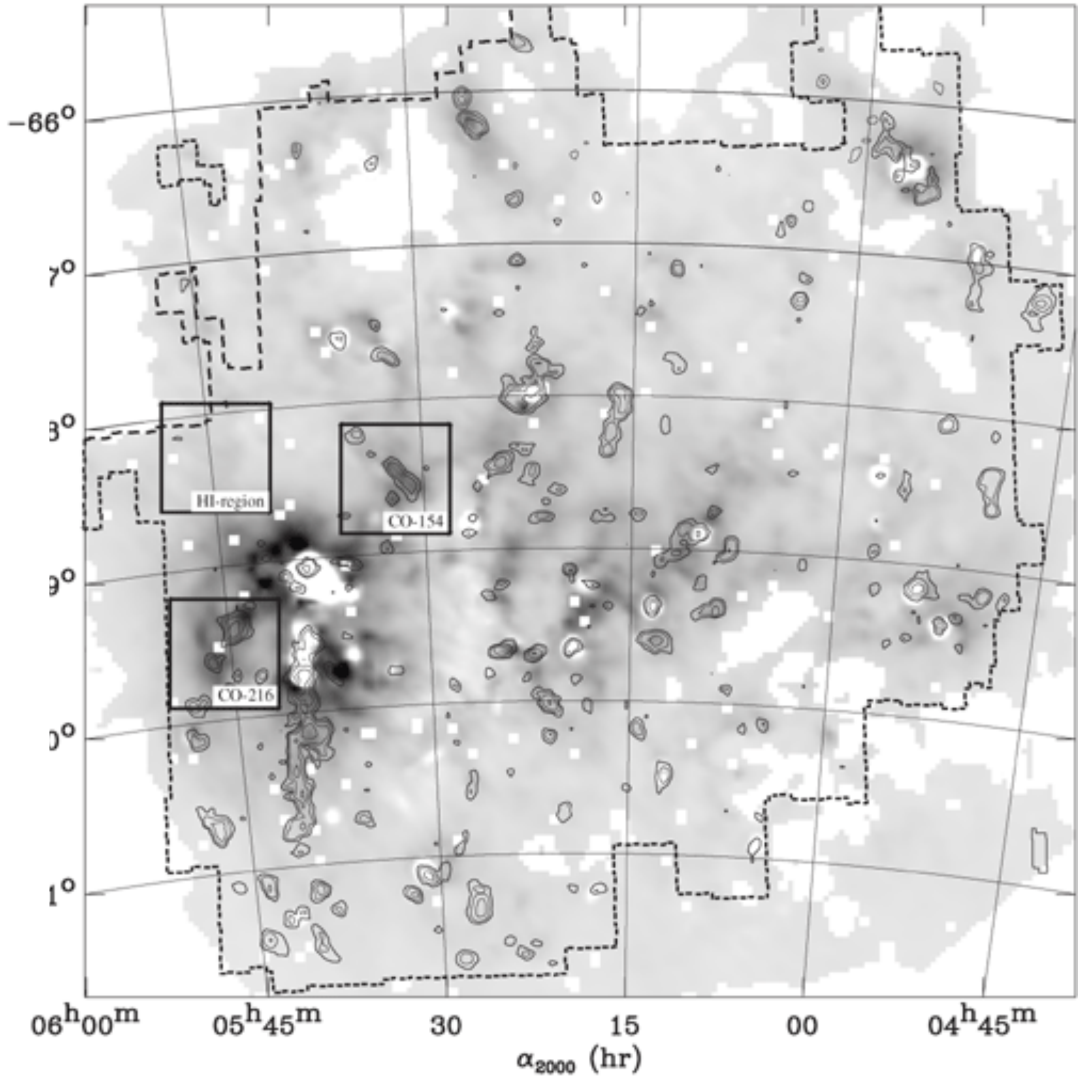
Molecular Gas Formation

DGR (based on CO) depends on Z



Leroy et al. (2011)

70μm excess



Bernard et al. (2008)

Molecular Gas Formation

Can we predict the location and amount of molecular gas from HI?
-> No, but some HI threshold must be exceeded

Can we predict the location and amount of molecular gas from dust? -> to some extent, in particular when in combination with HI, but still not perfect

- H_2 formation depends on the environment (metals, UV, ...)

- Turbulent medium and its properties (Elmegreen, Krumholz, Glover, etc)

- Needs some sort of shocks propagating trough the medium (to convert warm to cold HI, to compress gas; spiral arms, galaxy collisions, colliding gas sheets, shocks from SNe/starburst)

Molecular Clumps and the Environment

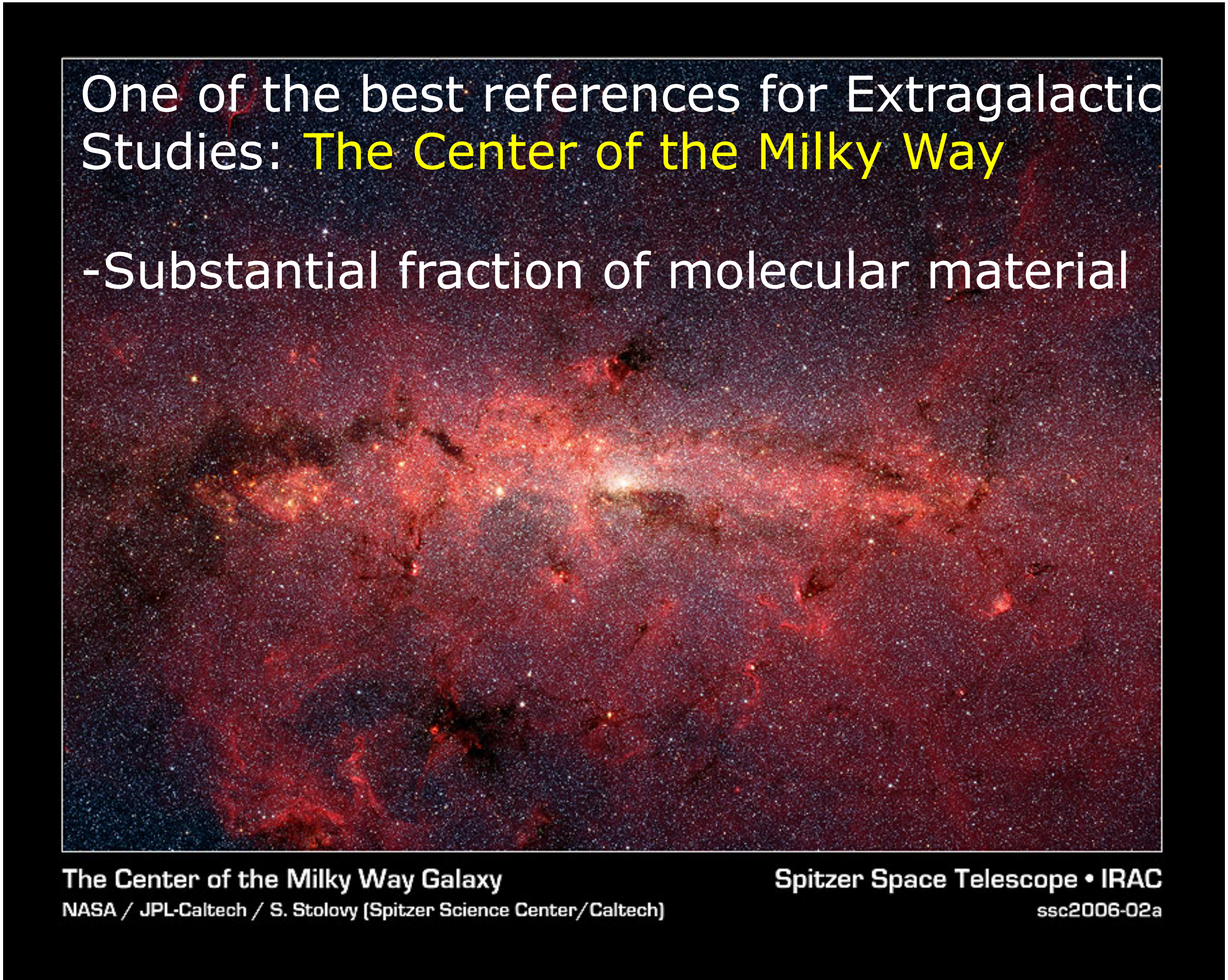
How do molecular clumps and cores get their size distribution, what is the influence of the environment?

Can we image the physical parameters of this influence?

Molecular Clumps and the Environment

One of the best references for Extragalactic Studies: The Center of the Milky Way

-Substantial fraction of molecular material



Molecular Clumps and the Environment

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- Large variation of different environments
  - . High SF rate with SNe

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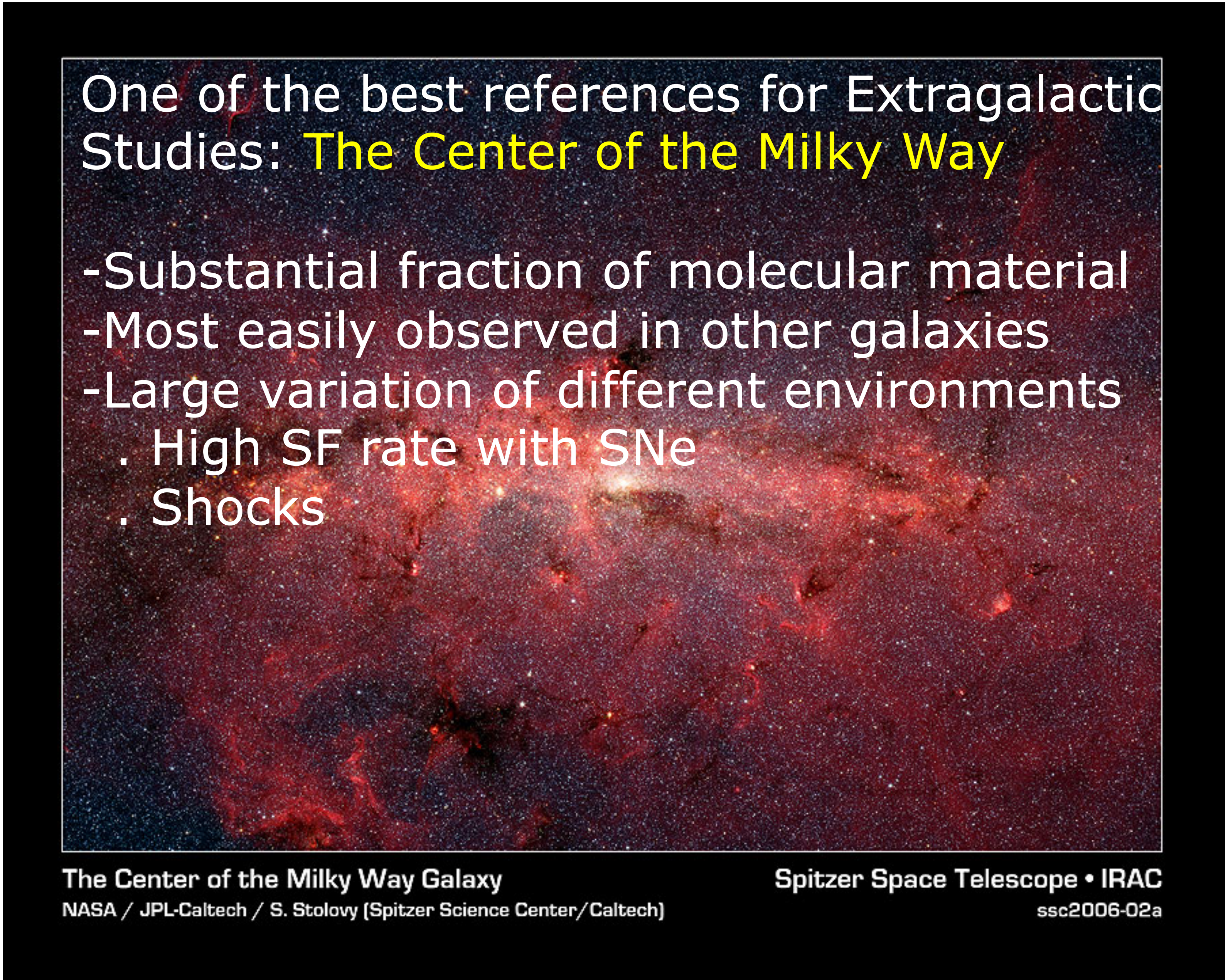
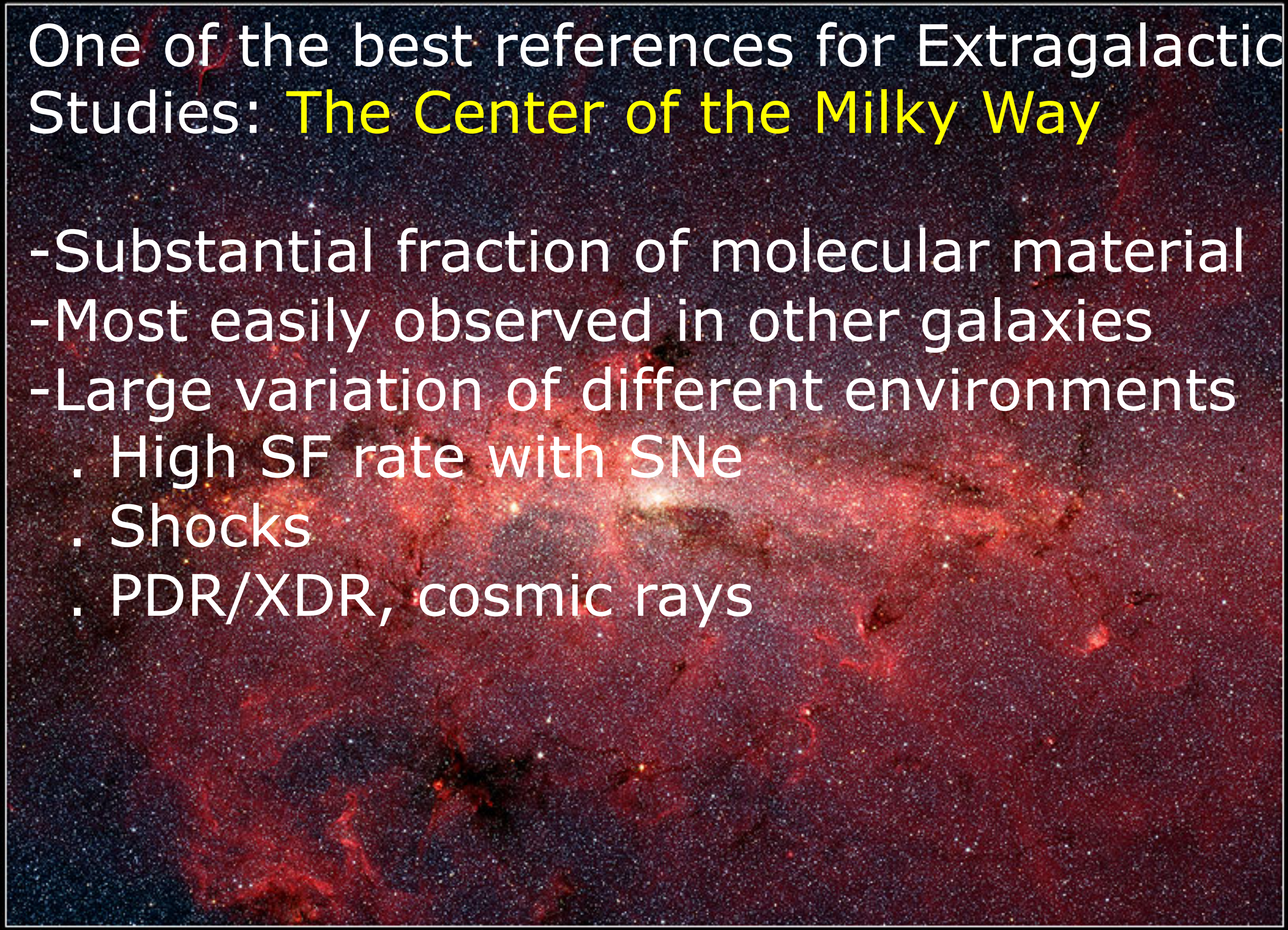


Molecular Clumps and the Environment



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The Center of the Milky Way Galaxy
NASA / JPL-Caltech / S. Stolovy (Spitzer Science Center/Caltech)

Spitzer Space Telescope • IRAC
ssc2006-02a

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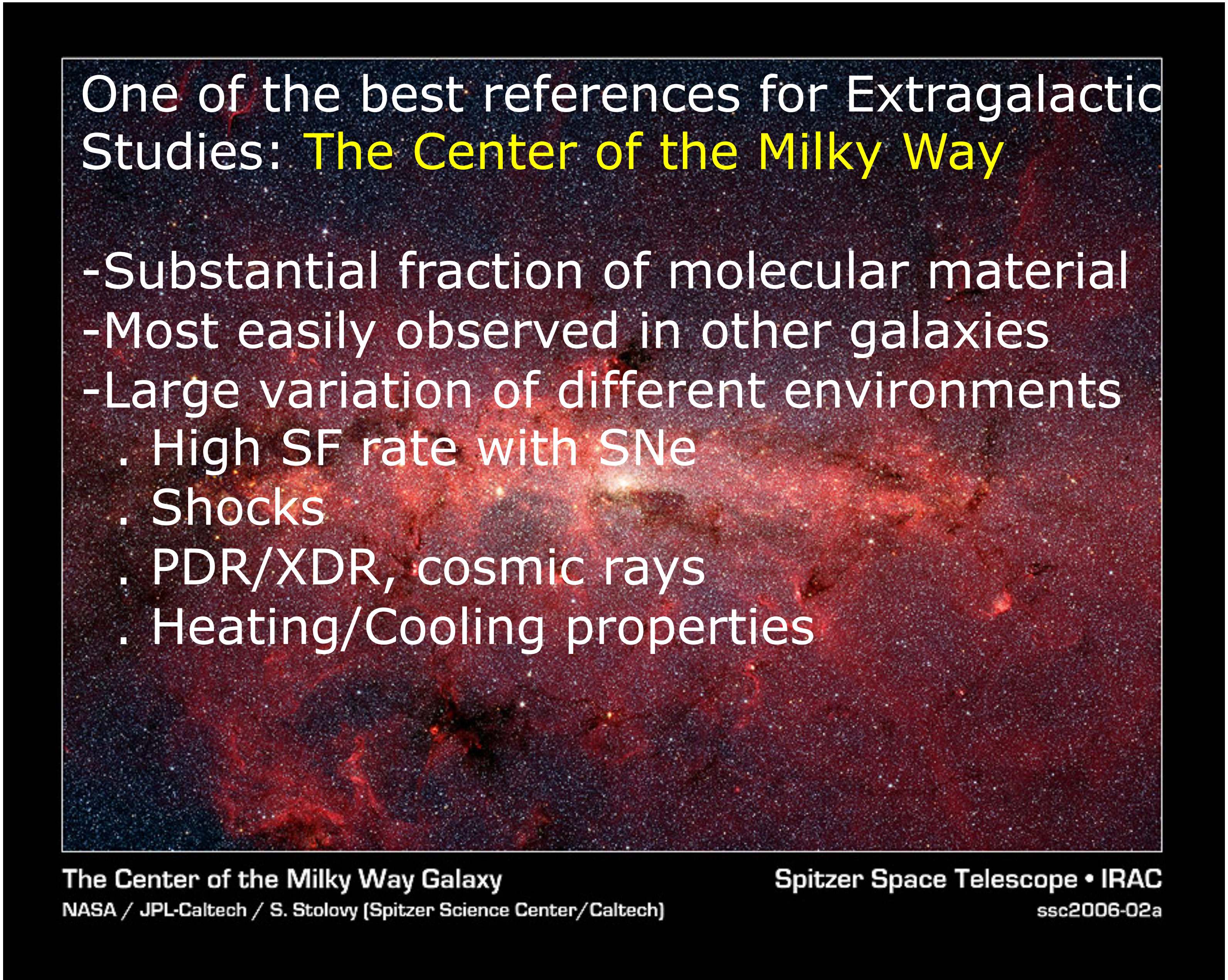
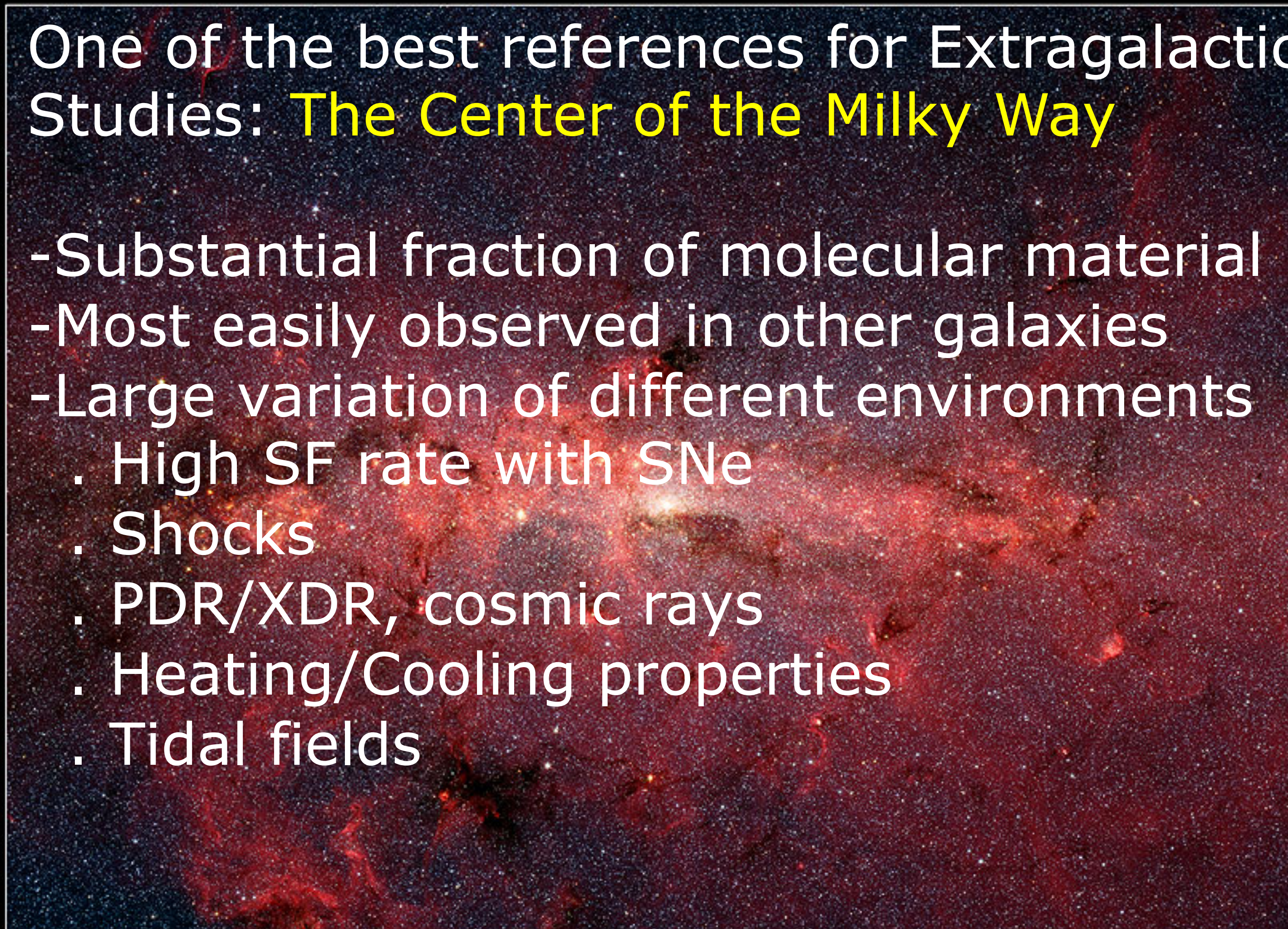


Molecular Clumps and the Environment



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  - . Tidal fields

The Center of the Milky Way Galaxy
NASA / JPL-Caltech / S. Stolovy (Spitzer Science Center/Caltech)

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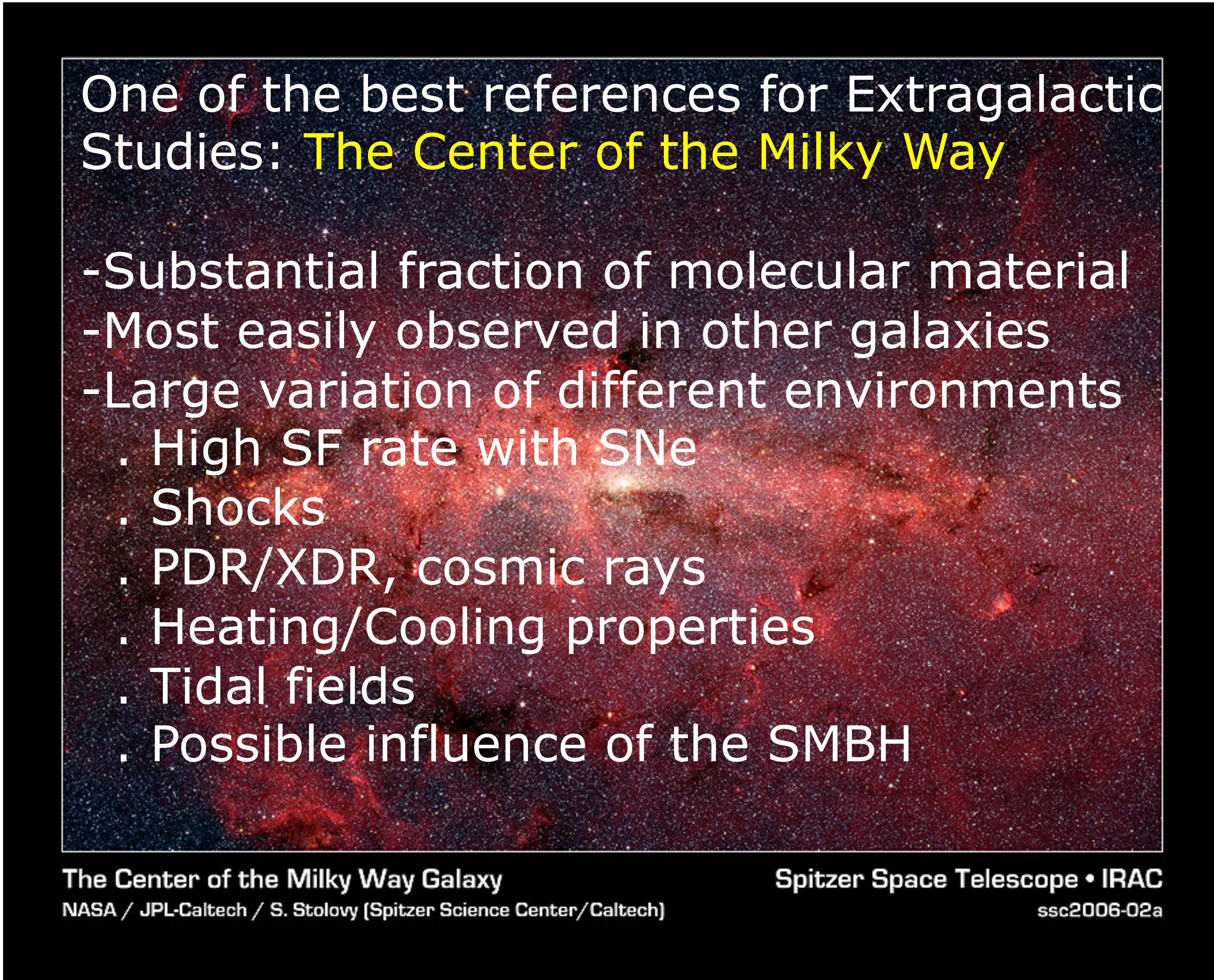
  - . Tidal fields
  - . Possible influence of the SMBH



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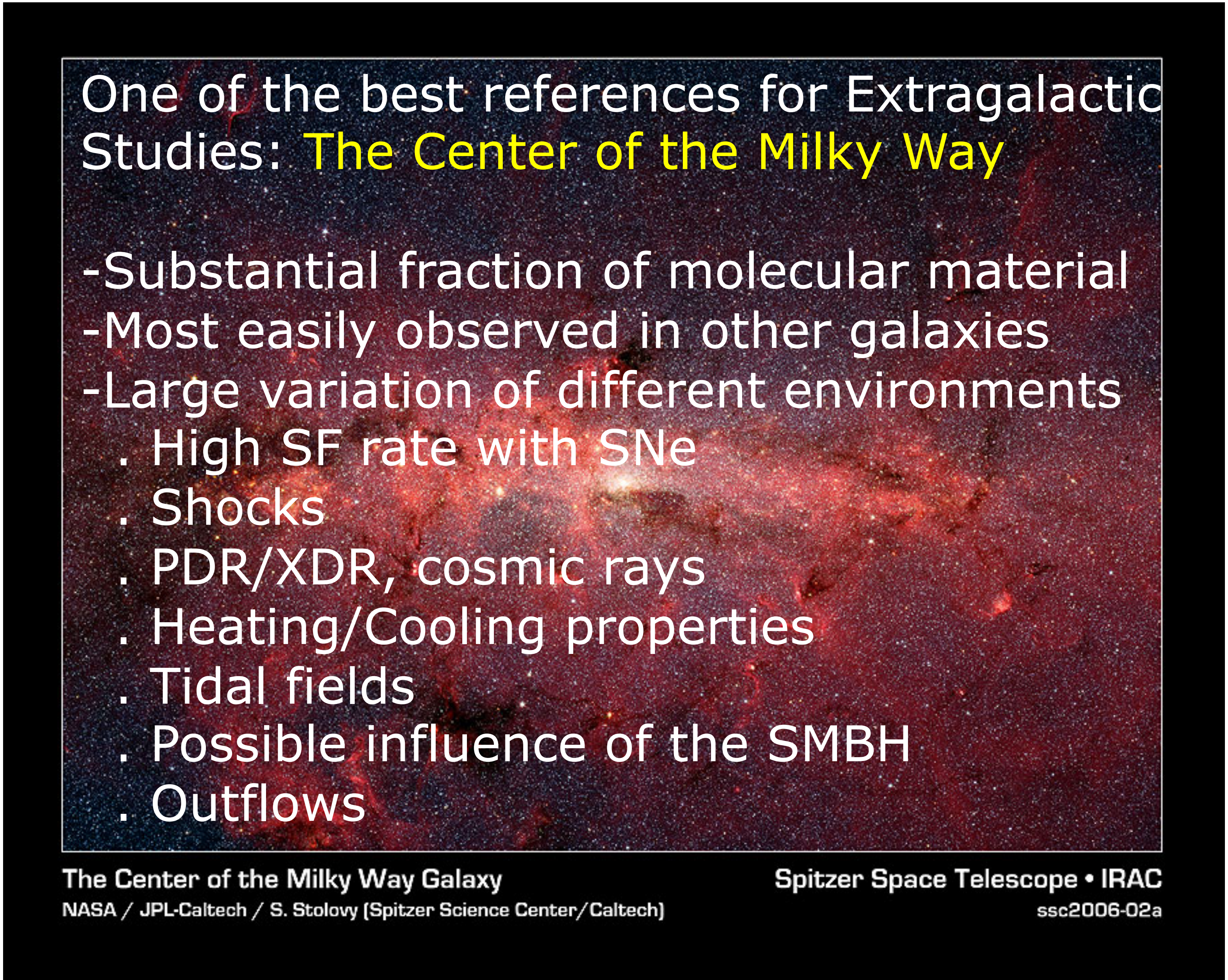
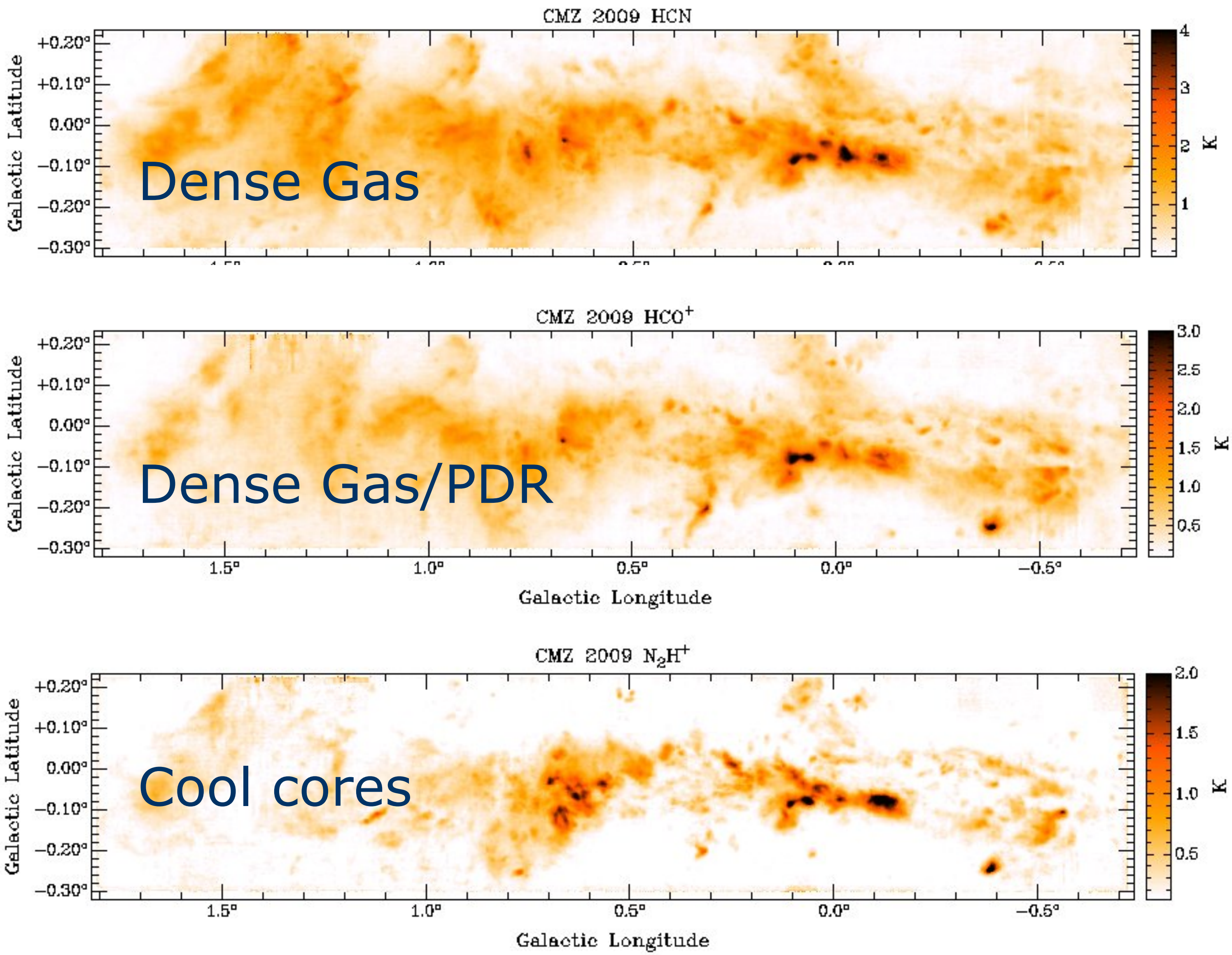
  - . Shocks
  - . PDR/XDR, cosmic rays
  - . Heating/Cooling properties
  - . Tidal fields
  - . Possible influence of the SMBH
  - . Outflows

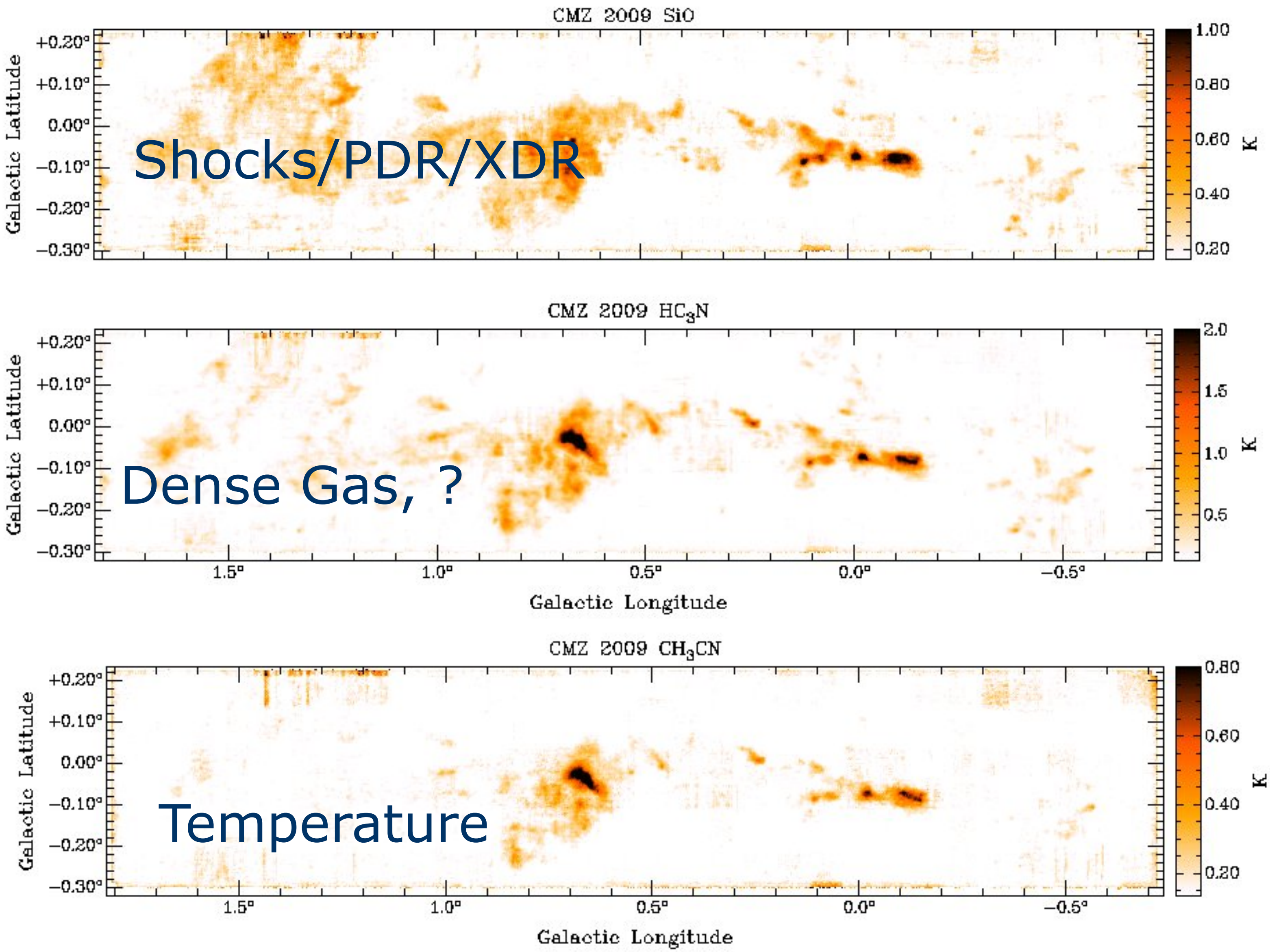


Molecular Clumps and the Environment



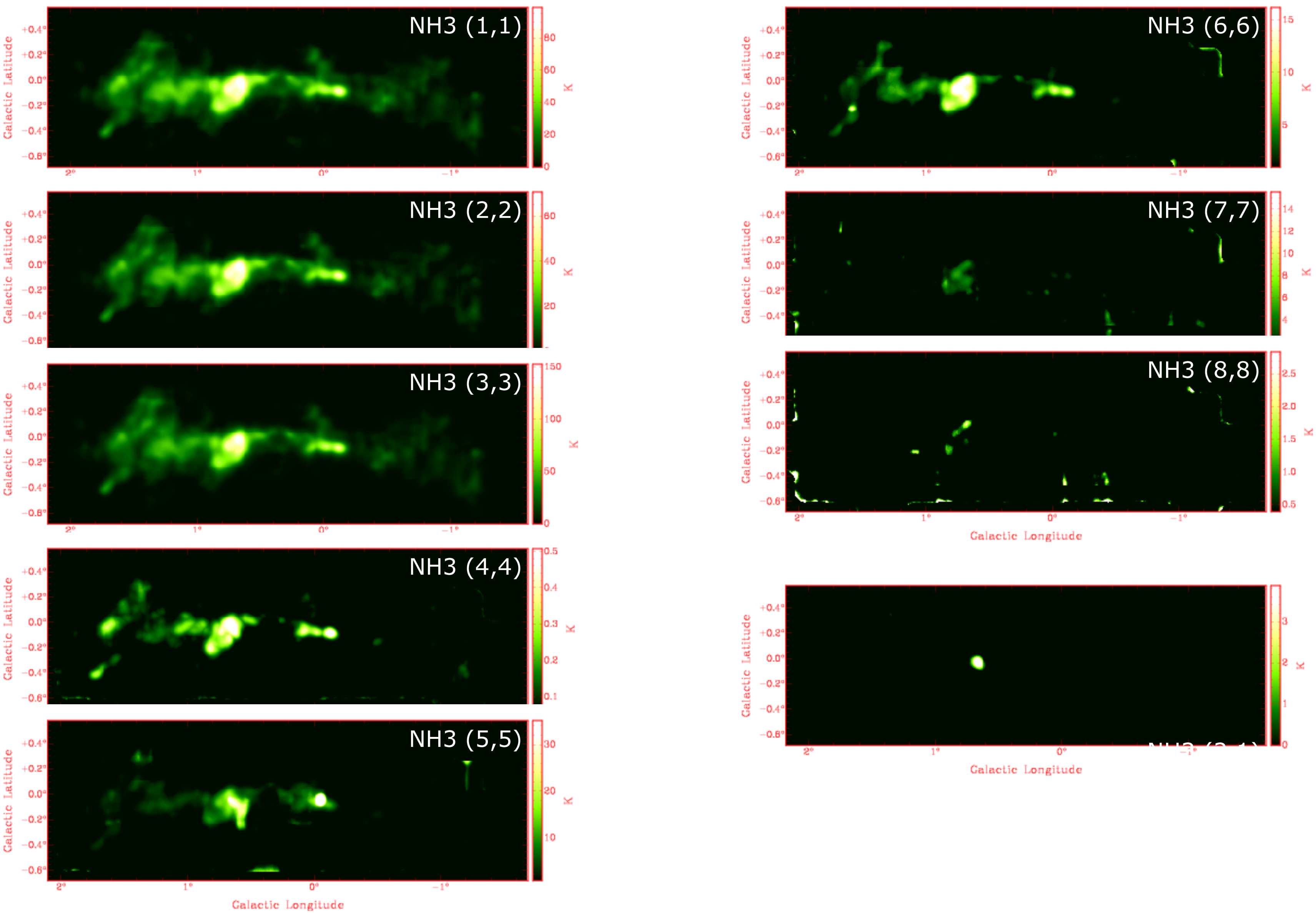
Burton, JO et al. (2011)

Molecular Clumps and the Environment



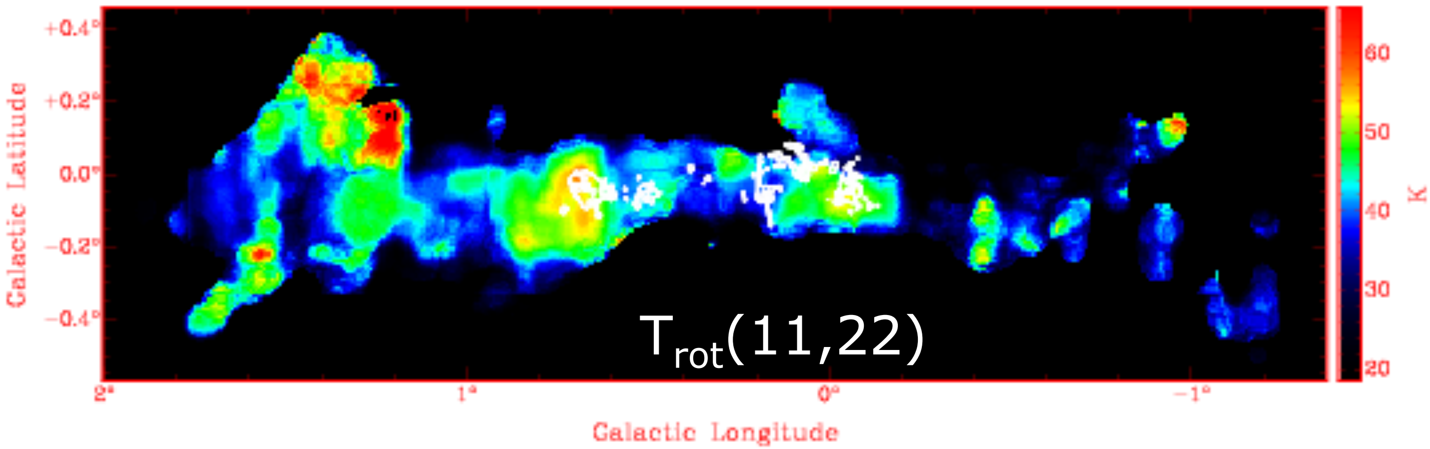
Burton, JO et al. (2011, in prep)

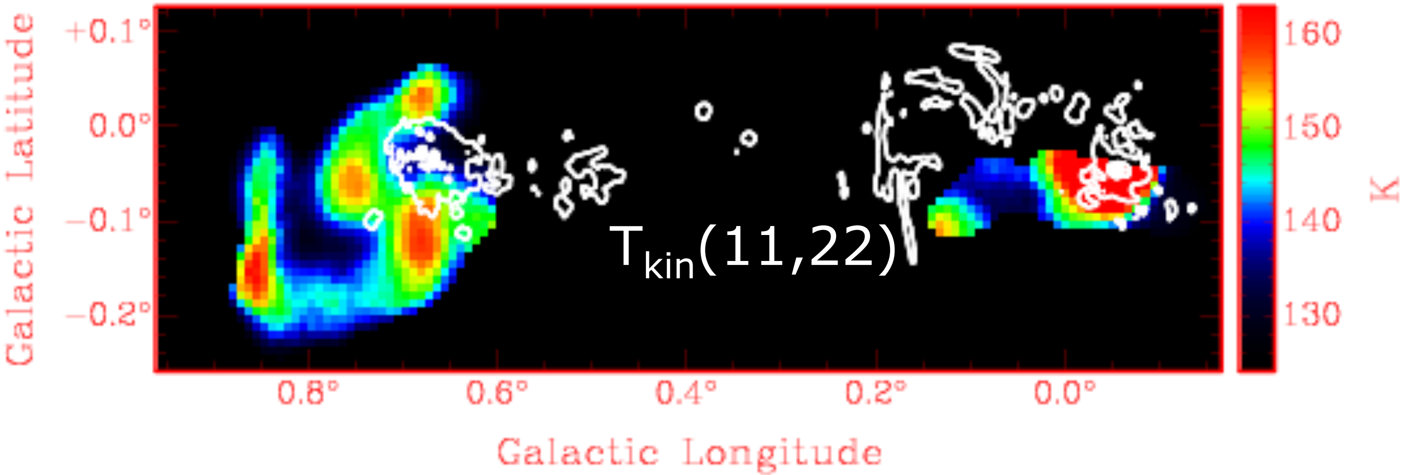
Molecular Clumps and the Environment



Henkel & Ott (2009)

Molecular Clumps and the Environment





Typical Temperatures: 30-150K

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID molecule	Transition	Exact rest frequency (GHz)
81.88	HC3N	9−8	81.881 462	
84.52	CH3OH	5(−1,5)−4(0,4) E	84.521 206	
85.14	OCS	7−6	85.139 104	Z
85.27	CH3CH2OH	6(0,6)−5(1,5) 85.265 507		
85.34	c-C3H2	2(1,2)−1(0,1) 85.338 906		
85.46	CH3CCH	5(3)−4(3)	85.442 600	
		5(2)−4(2)	85.450 765	
		5(1)−4(1)	85.455 665	
		5(0)−4(0)	85.457 299	
85.53	HOCO+	4(0,4)−3(0,3) 85.531 480	Z	
86.09	SO	2(2)−1(1)	86.093 983	Z
86.34	H13CN	1−0 F = 1−1	86.338 735	
		1−0 F = 2−1	86.340 167	
		1−0 F = 0−1	86.342 256	
86.75	H13CO+	1−0	86.754 330	
86.85	SiO	2−1 v= 0	86.847 010	Z
87.09	HN13C	1−0 F = 0−1	87.090 735	
		1−0 F = 2−1	87.090 859	
		1−0 F = 1−1	87.090 942	
87.32	C2H	1−0 3/2−1/2 F = 2−1	87.316 925	Z
		1−0 3/2−1/2 F = 1−0	87.328 624	
87.40	C2H	1−0 −1−1/2 F = 1−1	87.402 004	Z
		1−0 −1−1/2 F = 0−1	87.407 165	
87.93	HNCO	4(0,4)−3(0,3) 87.925 238	Z	
88.63	HCN	1−0 F = 1−1	88.630 4157	Z
		1−0 F = 2−1	88.631 8473	
		1−0 F = 0−1	88.633 9360	
89.19	HCO+	1−0	89.188 526	Z
90.66	HNC	1−0 F = 0−1	90.663 450	Z
		1−0 F = 2−1	90.663 574	
		1−0 F = 1−1	90.663 656	
90.98	HC3N	10−9	90.978 989	Z
91.99	CH3CN	5(3)−4(3) F = 6−5	91.971 310	Z
		5(3)−4(3) F = 4−3	91.971 465	
		5(2)−4(2) F = 6−5	91.980 089	
		5(1)−4(1)	91.985 316	
		5(0)−4(0)	91.987 089	
92.49	13CS	2−1	92.494 303	

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID molecule	Transition	Exact rest frequency (GHz)
93.17	N2H+	1–0 F1= 1–1 F = 0–1	93.171 621	Z
		1–0 F1= 1–1 F = 2–2	93.171 917	
		1–0 F1= 1–1 F = 1–0	93.172 053	
		1–0 F1= 2–1 F = 2–1	93.173 480	
		1–0 F1= 2–1 F = 3–2	93.173 777	
		1–0 F1= 2–1 F = 1–1	93.173 967	
		1–0 F1= 0–1 F = 1–2	93.176 265	
94.41	13CH3OH	2(−1,2)–1(−1,1) E	94.405 223	Z
		2(0,2)–1(0,1) A+	94.407 129	
		2(0,2)–1(0,1) E	94.410 895	
		2(1,1)–1(1,0) E	94.420 439	
95.17	CH3OH	8(0,8)–7(1,7) A+	95.169 516	
95.91	CH3OH	2(1,2)–1(1,1) A+	95.914 310	
96.41	C34S	2–1	96.412 961	
96.74	CH3OH	2(−1,2)–1(−1,1) E	96.739 393	Z
		2(0,2)–1(0,1) A+	96.741 377	
		2(0,2)–1(0,1) E	96.744 549	
		2(1,1)–1(1,0) E	96.755 507	
97.30	OCS	8–7	97.301 209	Z
97.58	CH3OH	2(1,1)–1(1,0) A−	97.582 808	
97.98	CS	2–1	97.980 953	Z
99.30	SO	3(2)–2(1)	99.299 905	Z
100.08	HC3N	11–10	100.076 385	Z
100.63	NH2CN	5(1,4)–4(1,3)	100.629 50	Z
101.48	H2CS	3(1,3)–2(1,2)	101.477 764	
102.07	NH2CHO	5(1,5)–4(1,4)	102.064 263	Z
	H2COH+	4(0,4)–3(1,3)	102.065 856	
102.55	CH3CCH	6(3)–5(3)	102.530 346	Z
		6(2)–5(2)	102.540 143	
		6(1)–5(1)	102.546 023	
		6(0)–5(0)	102.547 983	
103.04	H2CS	3(0,3)–2(0,2)	103.040 416	Z
104.03	SO2	3(1,3)–2(0,2)	104.029 410	
104.62	H2CS	3(1,2)–2(1,1)	104.616 988	Z
105.79	CH2NH	4(0,4)–3(1,3)	105.794 057	
106.91	HOCO+	5(0,5)–4(0,4)	106.913 524	
108.89	CH3OH	0(0,0)–1(−1,1) E	108.893 929	
109.17	HC3N	12–11	109.173 638	

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID molecule	Transition	Exact rest frequency (GHz)
109.25	SO	2(3)–1(2)	109.252 212	
109.46	OCS	9–8	109.463 063	
109.78	C18O	1–0	109.782 173	
109.91	HNCO	5(0,5)–4(0,4) 109.905 753		
110.20	13CO	1–0	110.201 353	
110.38	CH3CN	6(3)–5(3) F = 7–6	110.364 469	
		6(3)–5(3) F = 5–4	110.364 524	
		6(2)–5(2) F = 7–6	110.375 052	
		6(1)–5(1) F = 7–6	110.381 404	
		6(0)–5(0) F = 7–6	110.383 522	
112.36	C17O	1–0	112.358 988	
113.17	CN	1–0 1/2–1/2 F = 1/2–3/2	113.144 192	
		1–0 1/2–1/2 F = 3/2–1/2	113.170 528	
		1–0 1/2–1/2 F = 3/2–3/2	113.191 317	
113.49	CN	1–0 3/2–1/2 F = 3/2–1/2	113.488 140	
		1–0 3/2–1/2 F = 5/2–3/2	113.490 982	
		1–0 3/2–1/2 F = 1/2–1/2	113.499 639	
		1–0 3/2–1/2 F = 3/2–3/2	113.508 944	

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID	Transition molecule		Exact Rest frequency (GHz)
82.46	CH3OCH3	11(1,10)−11(0,11) AE + EA		82.456 986	N
	CH3CH2CN	9(1,8)−8(1,7)	82.458 611		
	CH3OCH3	11(1,10)−11(0,11) EE		82.458 660	
	CH3OCH3	11(1,10)−11(0,11) AA		82.460 334	
83.69	SO2	8(1,7)−8(0,8)	83.688 086	M	
85.09	NH2CHO	4(2,2)−3(2,1)	85.093 268	N	
85.69	U			85.686	B
87.85	NH2CHO	4(1,3)−3(1,2)	87.848 871	E	
88.17	H13CCCN	10−9		88.166 808	N
88.24	HNCO	4(1,3)−3(1,2)	88.239 027	N	
89.32	CH3OCHO	8(1,8)−7(1,7) E		89.314 589	N
	CH3OCHO	8(1,8)−7(1,7) A		89.316 668	
89.57	CH3CH2CN	10(6)−9(6)		89.562 318	N
	CH3CH2CN	10(7)−9(7)		89.565 034	
	CH3CH2CN	10(5)−9(5)		89.568 100	
	CH3CH2CN	10(8)−9(8)		89.573 057	
89.59	CH3CH2CN	10(4,7)−9(4,6)		89.590 033	N
	CH3CH2CN	10(4,6)−9(4,5)		89.591 017	
90.45	CH3CH2CN	10(2,8)−9(2,7)		90.453 354	N
90.60	HC13CCN	10−9		90.593 059	E
	HCC13CN	10−9		90.601 791	
91.20	HC3N	10−9 v6= 1 l= 1 f		91.199 796	N
	HC3N	10−9 v7=l l= 1 e		91.202 607	
91.33	HC3N	10−9 v7= 1 l= 1 f		91.333 308	N
91.55	CH3CH2CN	10(1,9)−9(1,8)		91.549 117	N
	SO2	18(5,13)−19(4,16)		91.550 442	
91.60	Unidentified			91.603	N
91.84	Unidentified			91.848	N
92.04	U			92.035	M
92.26	CH3CN	5(0)−4(0) v8= 1 l= 1		92.261 440	N
	CH3CN	5(2)−4(2) v8= 1 l= 1		92.263 992	
92.43	CH2CHCN	10(1,10)−9(1,9)		92.426 260	N
93.60	CH3CHO	5(−1,5)−4(−1,4) E		93.595 238	E
93.87	CCS	8(7)−7(6)		93.870 098	E
	NH2CHO	3(2,2)−4(1,3)	93.871 700		

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID	Transition molecule	Exact Rest frequency (GHz)
94.28	CH2CHCN	10(0,10)–9(0,9)	94.276 640	N
94.54	CH3OH	8(3,5)–9(2,7) E	94.541 806	N
94.76	U		94.759	N
94.91	CH2CHCN	10(4,7)–9(4,6)	94.913 139	N
	CH2CHCN	10(4,6)–9(4,5)	94.913 250	
94.92	U		94.924	N
94.94	U		94.940	N
95.15	Unidentified		95.145	E
95.33	CH2CHCN	10(2,8)–9(2,7)	95.325 490	N
95.44	CH3CH2CN	11(1,11)–10(1,10)	95.442 479	N
	t-CH3CH2OH	16(2,14)–16(1,13)	95.444 067	
95.95	CH3CHO	5(0,5)–4(0,4) E	95.947 439	E
95.96	CH3CHO	5(0,5)–4(0,4) A++	95.963 465	E
96.49	CH3OH	2(1,2)–1(1,1) E	96.492 164	N
		vt= 1		
CH3OH	2(0,2)–1(0,1)	E	96.493 553	
		vt= 1		
96.98	O13CS	8–7	96.988 123	E
97.70	SO2	7(3,5)–8(2,6) 97.702 340	M	
97.72	34SO	3(2)–2(1)	97.715 401	M
98.18	CH3CH2CN	11(2,10)–10(2,9)	98.177 578	N
	CH3OCHO	8(7,1)–7(7,0) E	98.182 199	
98.90	CH3CHO	5(1,4)–4(1,3) A–	98.900 951	E
99.02	U		99.021	M
99.65	HC13CCN	11–10	99.651 863	N
	HCC13CN	11–10	99.661 471	
99.68	CH3CH2CN	11(2,9)–10(2,8)	99.681 511	N
100.03	SO	4(5)–4(4)	100.029 565	B
100.32	HC3N	11–10 v7= 1 l= 1 e	100.322 349	N
100.41	U		100.406	M
100.46	CH3OCH3	6(2,5)–6(1,6) 100.460 412	N	
		EA + AE		
	CH3OCH3	6(2,5)–6(1,6) EE	100.463 066	
	CH3OCH3	6(2,5)–6(1,6) AA	100.465 708	
100.61	CH3CH2CN	11(1,10)–10(1,9)	100.614 291	N
100.71	HC3N	11–10 v7= 2 l= 0	100.708 837	N
	HC3N	11–10 v7= 2 l= 2 e	100.710 972	
	HC3N	11–10 v7= 2 l= 2 f	100.714 306	

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID	Transition molecule		Exact Rest frequency (GHz)
100.88	SO2	2(2,0)–3(1,3)	100.878 105	M	
101.03	CH2CO	5(2,4)–4(2,3)	101.024 438	N	
CH3SH	4(−1)–3(−1) E			101.029 750	
101.14	CH3SH	4(0)–3(0) A		101.139 160	E
CH3SH	4(0)–3(0) E			101.139 650	
101.33	H2CO	6(1,5)–6(1,6)	101.332 987	N	
101.98	CH2CO	5(1,4)–4(1,3)	101.981 426	E	
103.57	CH2CHCN	11(0,11)–10(0,10)		103.575 401	N
104.05	CH3CH2CN	12(1,12)–11(1,11)		104.051 278	N
104.21	CH2CHCN	11(2,10)–10(2,9)		104.212 655	N
104.24	SO2	10(1,9)–10(0,10)		104.239 293	B
104.30	CH3OH	11(−1,11)–10(−2,9)		104.300 396	N
E					
104.35	CH3OH	10(4,7)–11(3,8)		104.354 861	N
A−					
104.41	CH2CHCN	11(5,*)–10(5,*)		104.408 903	N
CH3OH	10(4,6)–11(3,9)			104.410 489	
A+					
CH2CHCN	11(4,8)–10(4,7)			104.411 262	
CH2CHCN	11(4,7)–10(4,6)			104.411 485	
104.49	t-CH3CH2OH	7(0,7)–6(1,6)	104.487 254	E	
104.80	t-CH3CH2OH	5(1,5)–4(0,4)	104.808 618	E	
104.96	CH2CHCN	11(2,9)–10(2,8)		104.960 550	N
105.06	CH3OH	13(1,13)–12(2,10)		105.063 761	N
A+					
105.30	U			105.299	M
105.46	NH2CHO	5(0,5)–4(0,4)	105.464 216	E	
CH3CH2CN	12(0,12)–11(0,11)			105.469 300	
105.54	U			105.537	N
105.57	CH3OH	14(-2,13)–14(1,13)		105.576 385	N
E					
105.77	CH3OCH3	13(1,12)–13(0,13)		105.768 276	N
EA + AE					
CH3OCH3	13(1,12)–13(0,13)			105.770 340	
EE					
CH3OCH3	13(1,12)–13(0,13)			105.772 403	
AA					
105.97	NH2CHO	5(2,4)–4(2,3)	105.972 593	N	

Molecular Clumps and the Environment

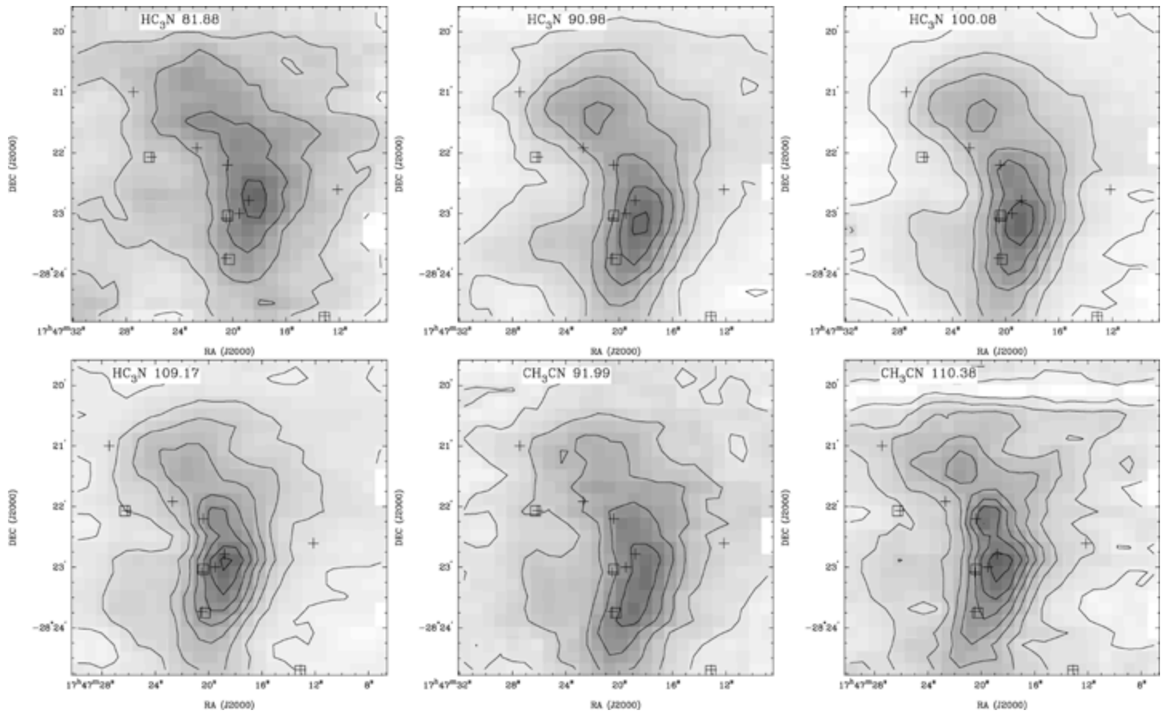
Rough frequency (GHz)		Line ID	Transition molecule		Exact Rest frequency (GHz)
106.11	U		106.107	N	
106.13	NH2CHO	5(3,3)−4(3,2)	106.134 418	B	
106.35	CCS	9(8)−8(7)		106.347 740	E
106.54	NH2CHO	5(2,3)−4(2,2)	106.541 674	N	
106.64	CH2CHCN	11(1,10)−10(1,9)		106.641 394	N
106.74	34SO	2(3)−1(2)		106.743 374	M
107.01	CH3OH	3(1,3)−4(0,4) A+		107.013 770	B
107.04	U			107.042	N
107.06	SO2	27(3,25)−26(4,22)		107.060 225	M
107.10	Unidentified			107.1032	E
107.16	CH3OH	15(−2,14)−15(1,14)		107.159 915	N
E					
107.19	13CH3CN	6(1)−5(1)		107.194 547	N
	13CH3CN	6(0)−5(0)		107.196 564	
107.48	CH3CH2CN	17(2,16)−17(1,17)		107.481 465	N
CH3CH2CN	12(7,*)−11(7,*)			107.485 181	
CH3CH2CN	12(6,*)−11(6,*)			107.486 962	
CH3CH2CN	12(8,*)−11(8,*)			107.491 579	
107.50	CH3CH2CN	12(5,8)−11(5,7)		107.502 426	N
CH3CH2CN	12(5,7)−11(5,6)			107.502 473	
107.54	CH3CH2CN	12(11,*)−11(11,*)		107.539 857	N
CH3OCHO	9(2,8)−8(2,7) A			107.543 746	
CH3CH2CN	12(4,9)−11(4,8)			107.543 924	
CH3CH2CN	12(4,8)−11(4,7)			107.547 599	
107.59	CH3CH2CN	12(3,10)−11(3,9)		107.594 046	N
107.63	CH3CH2CN	v= 1, multiple	107.636	N	
107.73	CH3CH2CN	12(3,9)−11(3,8)		107.734 738	N
107.84	SO2	12(4,8)−13(3,11)		107.843 478	M
108.65	13CN	1/2−1/2 F = 2−1, F1= 0, F 2= 1−0		108.651 297	E
	13CN	1/2−1/2 F = 2−2, F1= 0, F 2= 1−1		108.657 646	
	13CN	1/2−1/2 F = 1−2, F1= 1, F 2= 1−1		108.658 948	
108.71	HC13CCN	12−11	1	08.710 523	N
	HCC13CN	12−11		108.721 008	
108.78	13CN	3/2−1/2 F = 3−2, F1= 1, F 2= 2−1		108.780 201	E

Molecular Clumps and the Environment

Rough frequency (GHz)		Line ID	Transition molecule		Exact Rest frequency (GHz)
	13CN	3/2–1/2 F = 2–1		108.782 374	
		F1= 1, F 2= 2–1			
	13CN	3/2–1/2 F = 1–0		108.786 982	
		F1= 1, F 2= 2–1			
108.94	CH3CH2CN	12(2,10)–11(2,9)		108.940 596	N
109.14	CH3OH	26(0,26)–26(-1,26)		109.137 570	N
E					
109.15	CH3OH	16(-2,15)–16(1,15)		109.153 210	N
E					
109.44	HC3N	12–11 v6= 1 l= 1 f		109.438 572	N
	HC3N	12–11 v7= 1 l= 1 e		109.441 944	
109.49	HNCO	5(1,5)–4(1,4)	109.496 007	E	
109.60	HC3N	12–11 v7= 1 l= 1 f		109.598 751	B
109.65	CH3CH2CN	12(1,11)–11(1,10)		109.650 301	N
109.75	NH2CHO	5(1,4)–4(1,3)	109.753 499	E	
	SO2	17(5,13)–18(4,14)		109.757 587	
109.87	HC3N	12–11 v7= 2 l= 2 f		109.870 188	B
	HNCO	5(1,5)–4(1,4) v6= 1		109.870 278	
	HNCO	5(2,4)–4(2,3)	109.872 366		
	HNCO	5(2,3)–4(2,2)	109.872 773		
110.29	HNCO	5(1,4)–4(1,3)	110.298 098	E	
110.33	CH 133CN	6(2)–5(2)	110.320 438	N	
	CH 133CN	6(1)–5(1)	110.326 795		
	CH 133CN	6(0)–5(0)	110.328 914		
	CH3CN	6(5)–5(5) F = 7–6		110.330 627	
	CH3CN	6(5)–5(5) F = 5–4		110.330 872	
110.35	CH3CN	6(4)–5(4) F = 7–6		110.349 659	E
	CH3CN	6(4)–5(4) F = 5–4		110.349 797	
110.69	CH3CN	6(2)–5(2) v8= 1		110.695 506	N
		l=−1			
CH3CN	6(4)–5(4) v8= 1			110.698 701	
		l= 1			
110.71	CH3CN	6(1)–5(1) v8= 1		110.706 251	N
		l=−1			
CH3CN	6(3)–5(3) v8= 1			110.709 313	
		l=+1			
CH3CN	6(0)–5(0) v8= 1			110.712 166	
		l= 1			

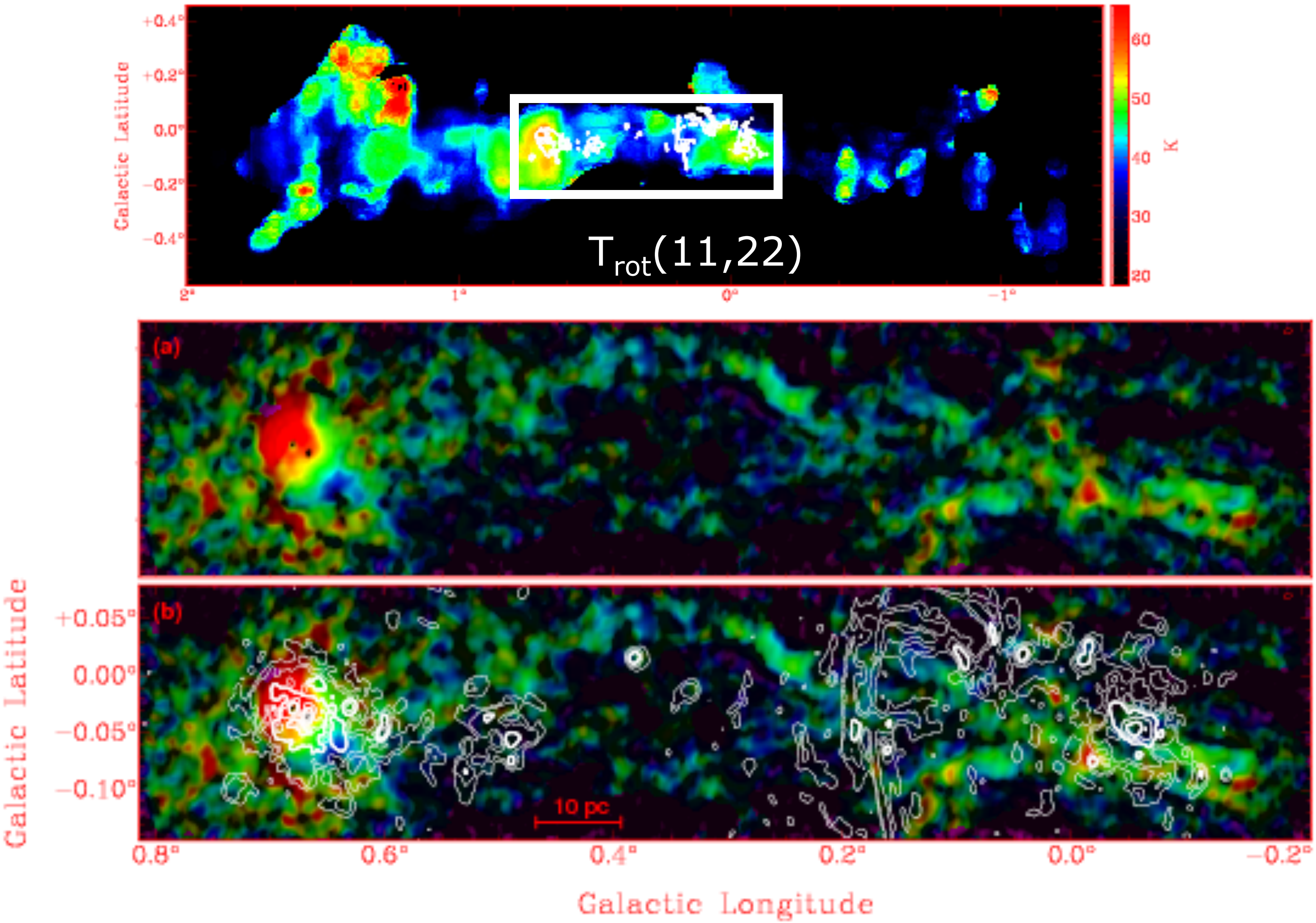
Molecular Clumps and the Environment

Rough frequency (GHz)	Line ID	Transition molecule	Exact Rest frequency (GHz)	
	CH3CN	6(2)−5(2) v8= 1 l= 1	110.716 212	
111.29	CH3OH	7(2,5)−8(1,8) A+	111.289 601	N
112.64	CH3CH2CN	13(1,13)−12(1,12)	112.646 233	N
112.84	U		112.839	N
113.12	CN	1−0 J= 1/2−1/2 F = 1/2−1/2	113.123 337	E

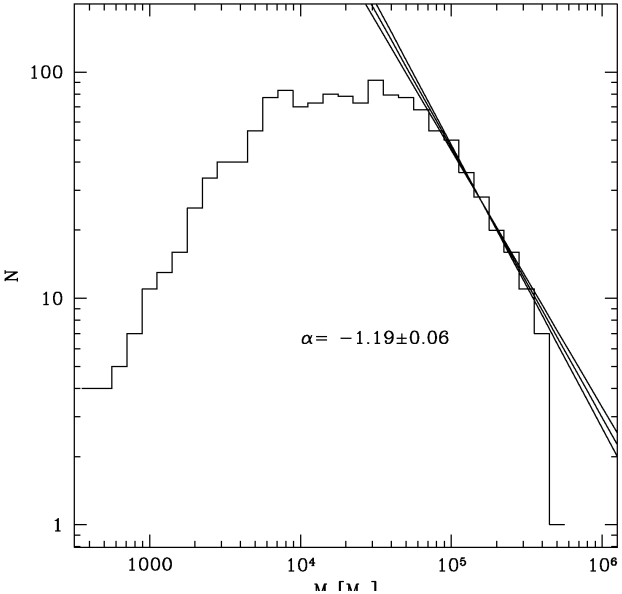


Jones, JO et al. (2006)

Molecular Clumps and the Environment

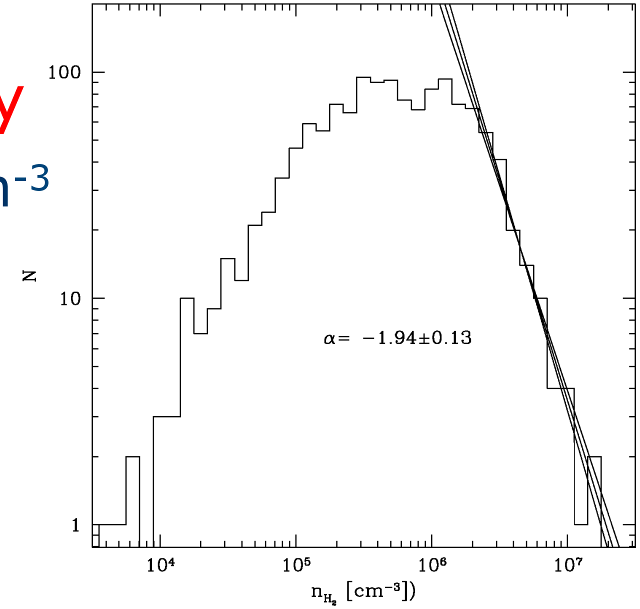


Molecular Clumps and the Environment



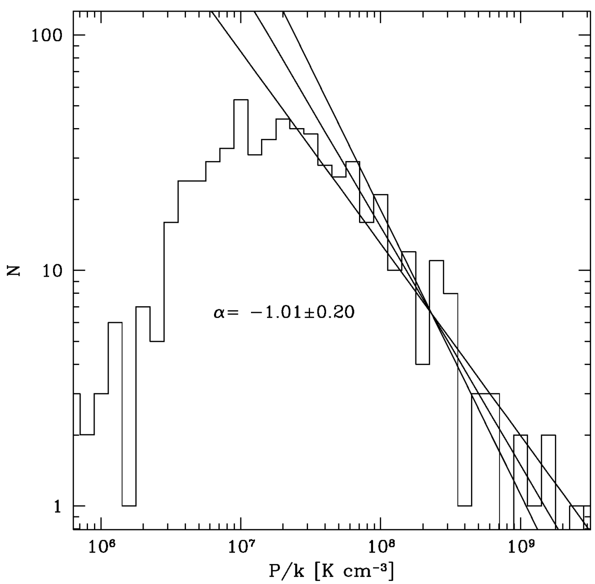
density

n_{H2}: $10^4 \ldots 10^7$ cm^{-3}



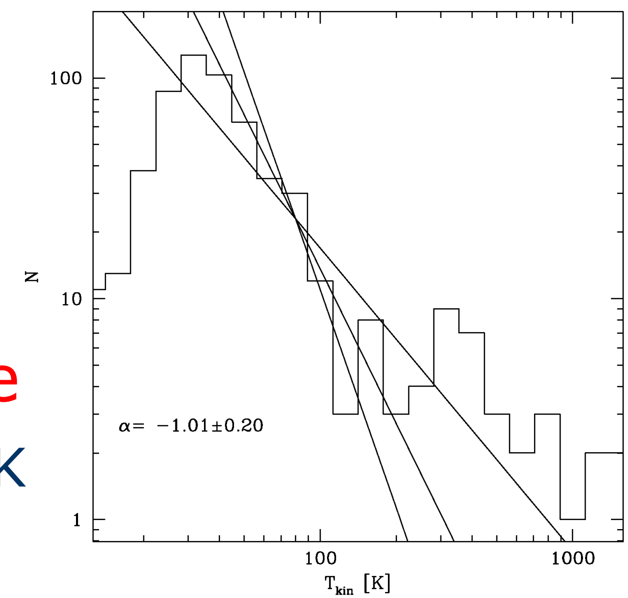
mass

M: $10^3 \ldots 10^{5.5}$ M_o



pressure

P/K: $10^7 \ldots 10^9$ K cm^{-3}



temperature

T_{kin}: 5…100 K

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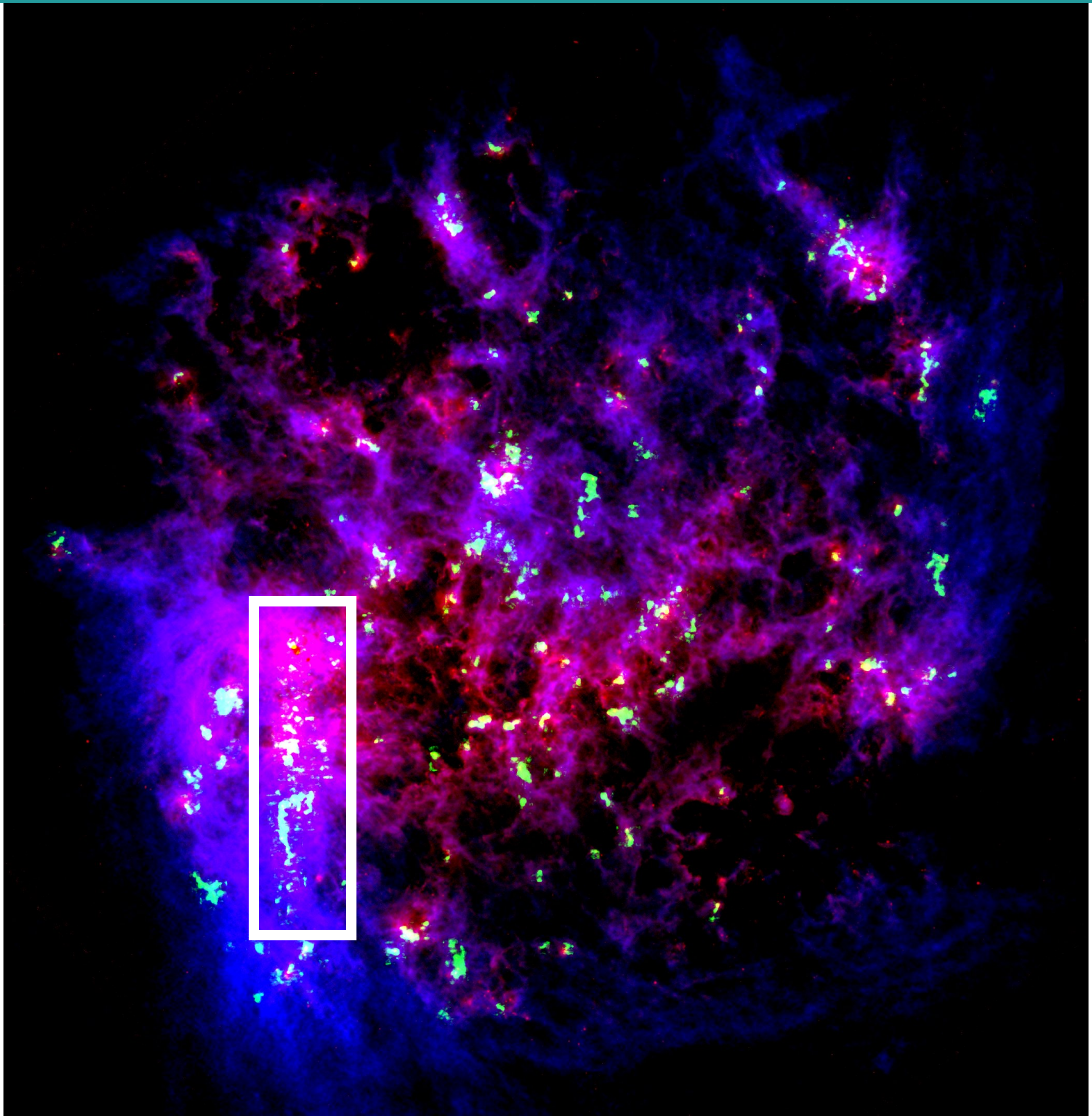
MAGMA:



Wong
Ott
Hughes
Pineda
Muller

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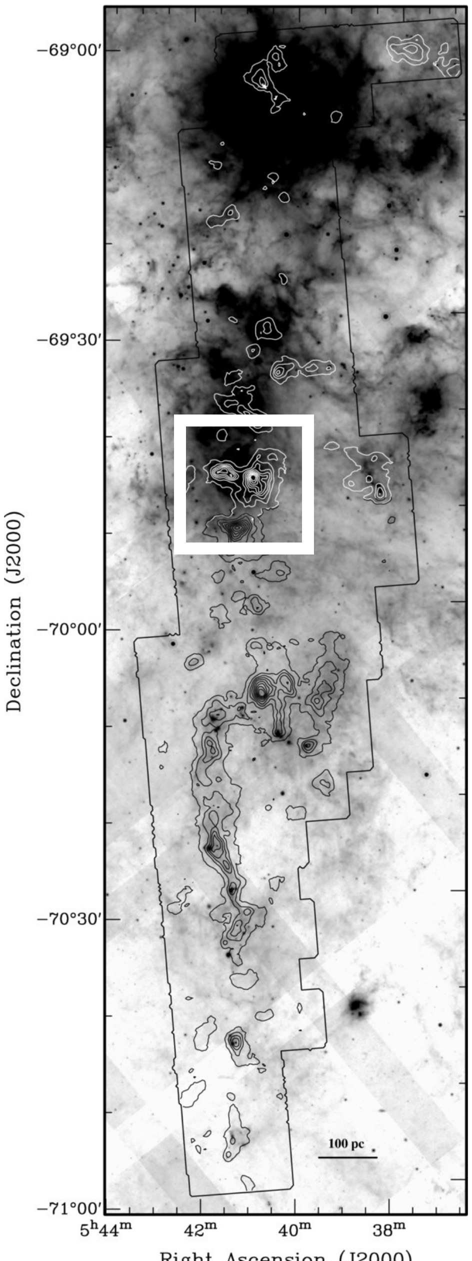

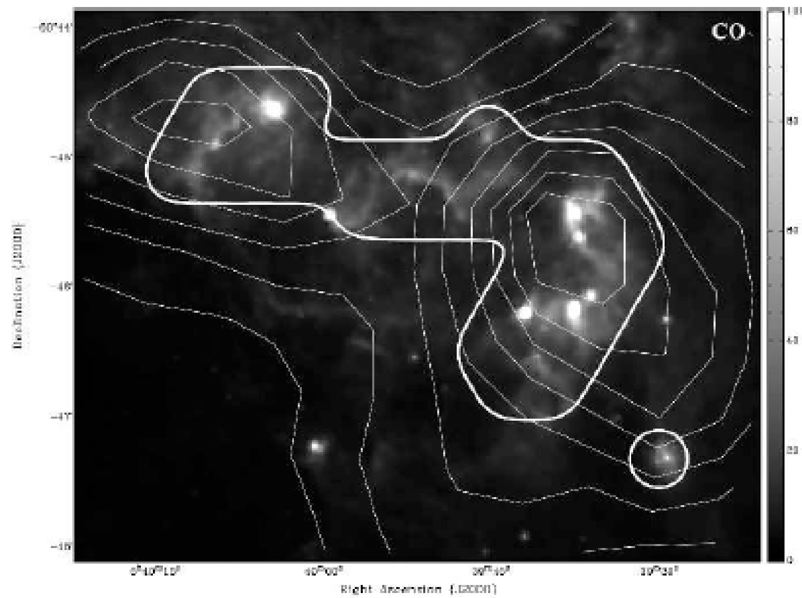

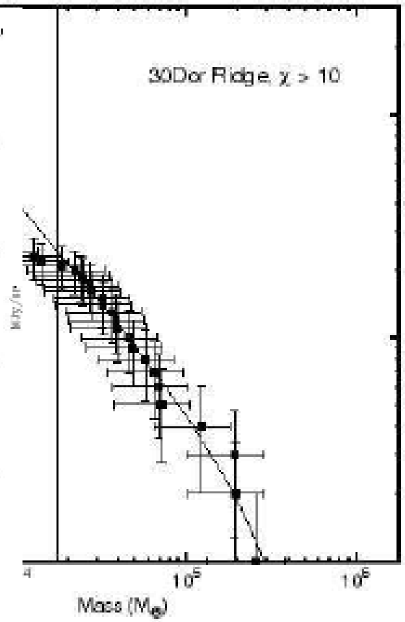

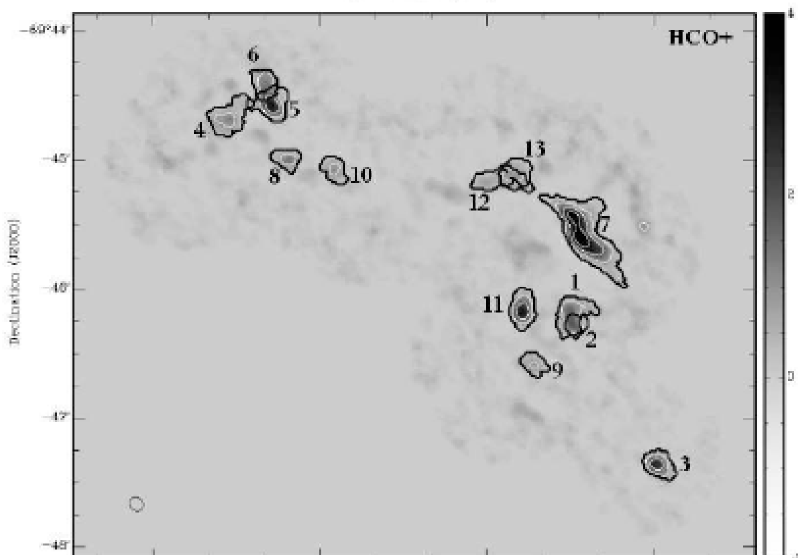

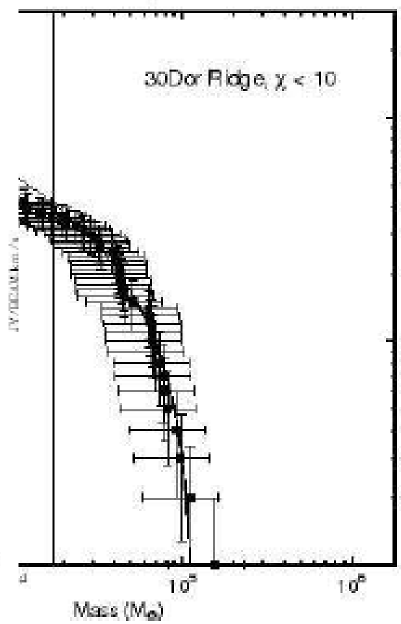

Seale, JO et al. (2011, in prep)

Molecular Clumps and the Environment

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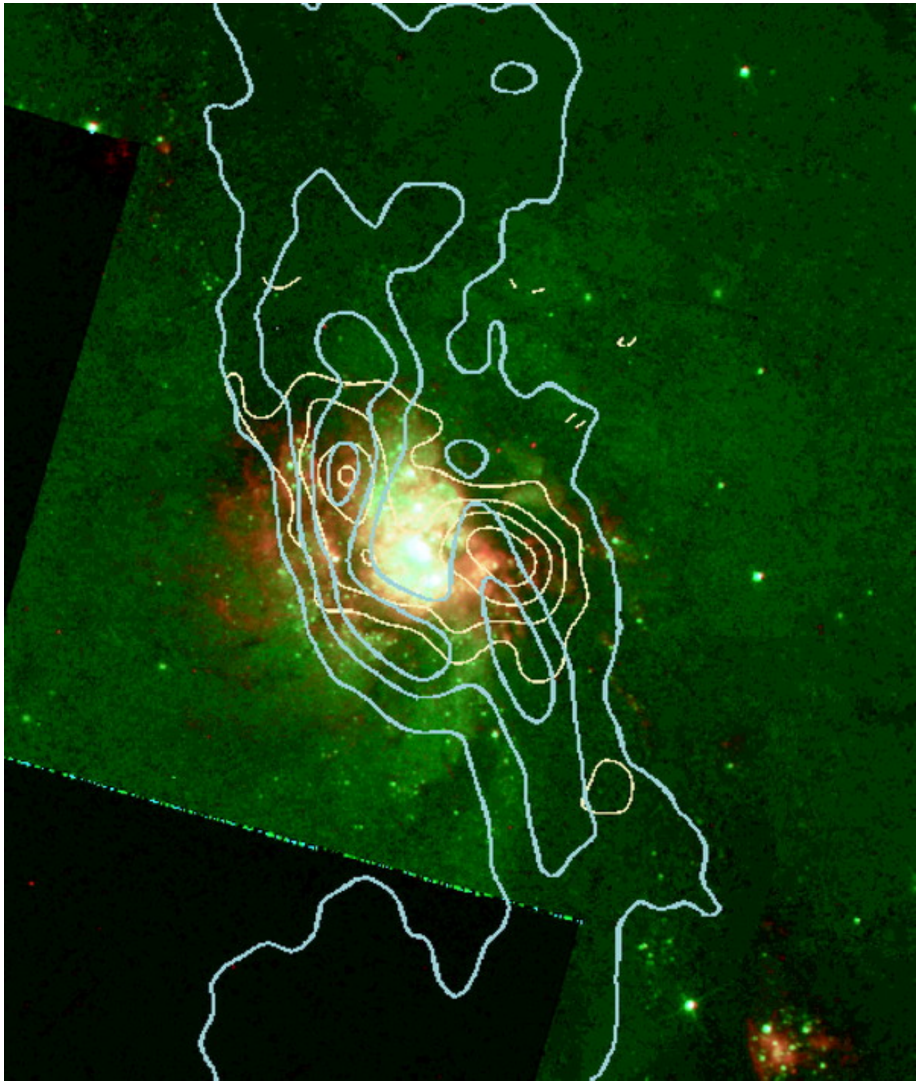

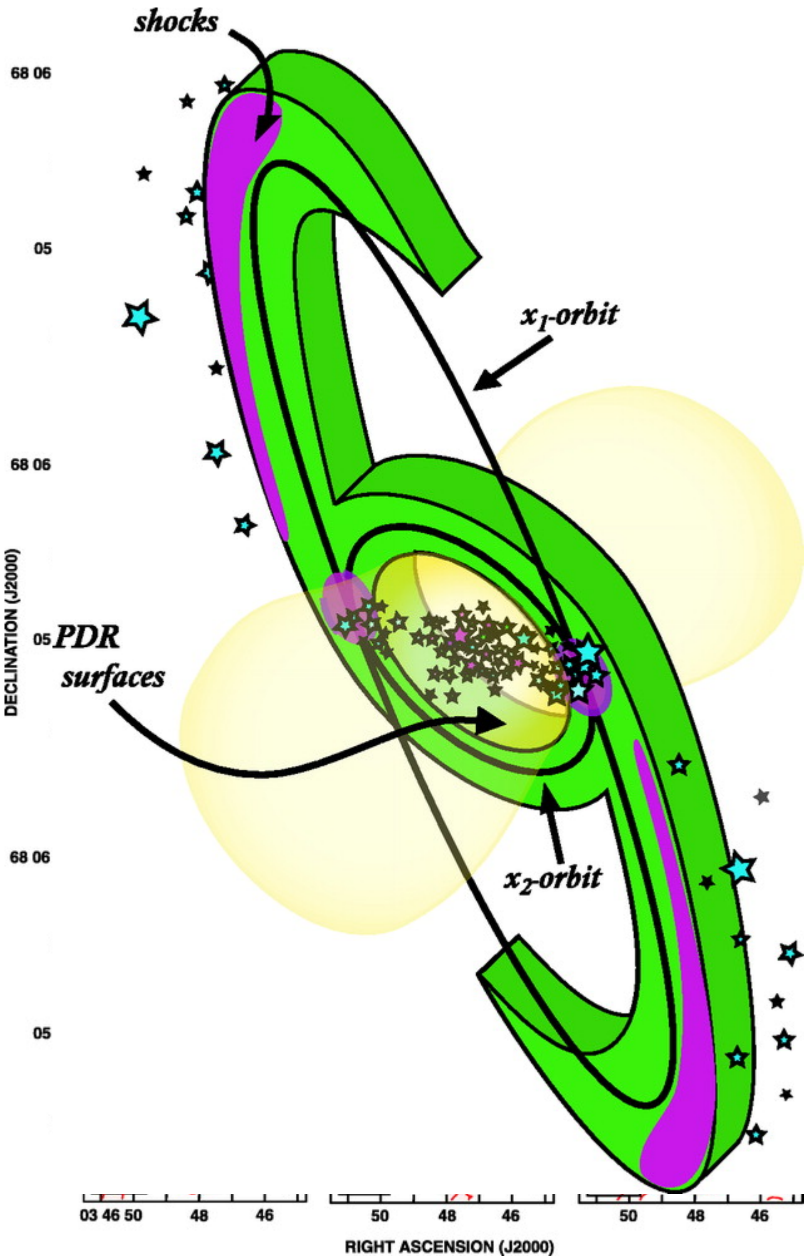

Meier & Turner (2005)

Conclusions

The formation of molecular clouds and the break-down into clumps and cores are still unknown, but they determine the star formation properties of galaxies

-> dynamical formation
-> environmental influence

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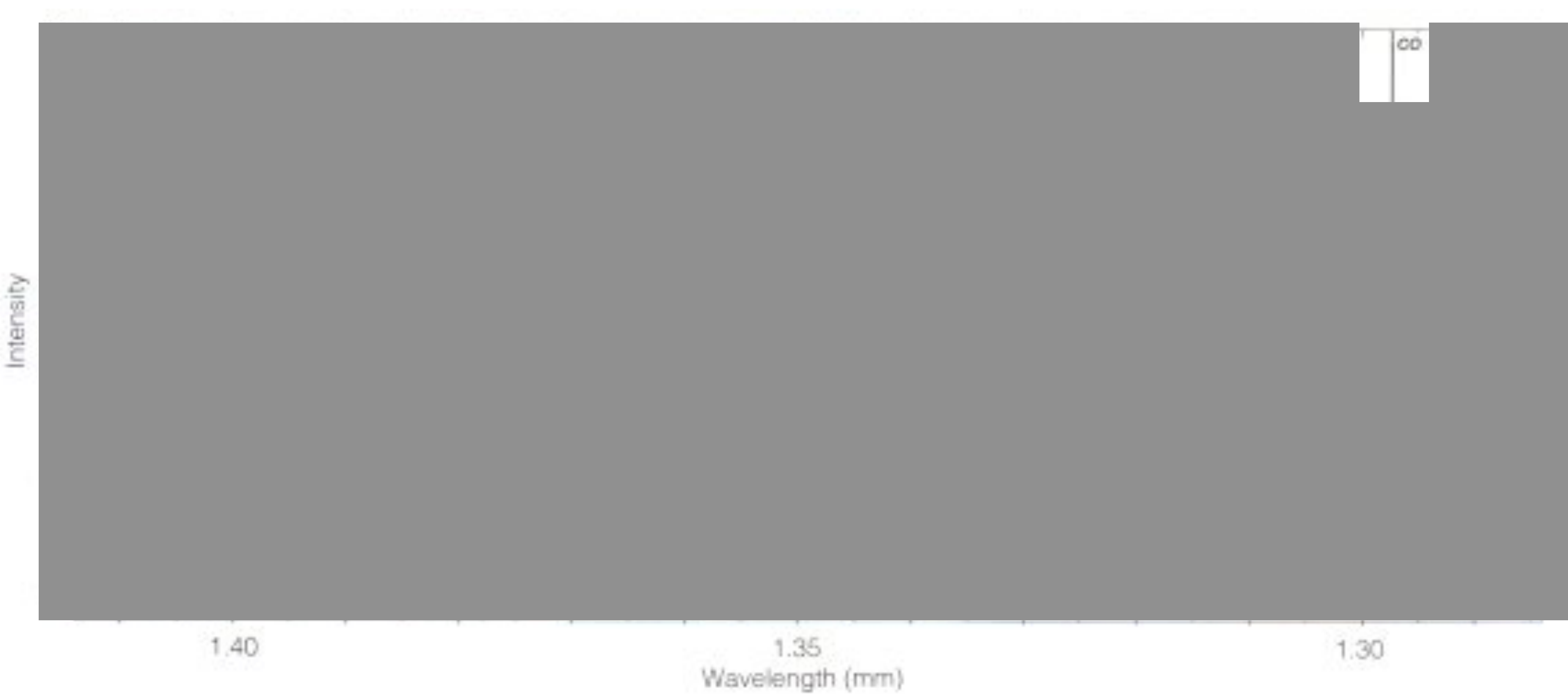
-> need for reliable, robust molecular tracers to map physical parameters

Future



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NAA and ultimately the SKA-high will allow to do Galactic-like line analyses on remote galaxies on the same scale and sensitivity as we do in the Milky Way and nearby galaxies right now, we can then use our set of tracers to map physical quantities such as temperature, density, ionization fraction, shocks, …