SNR – YSO Interaction, CTB 109

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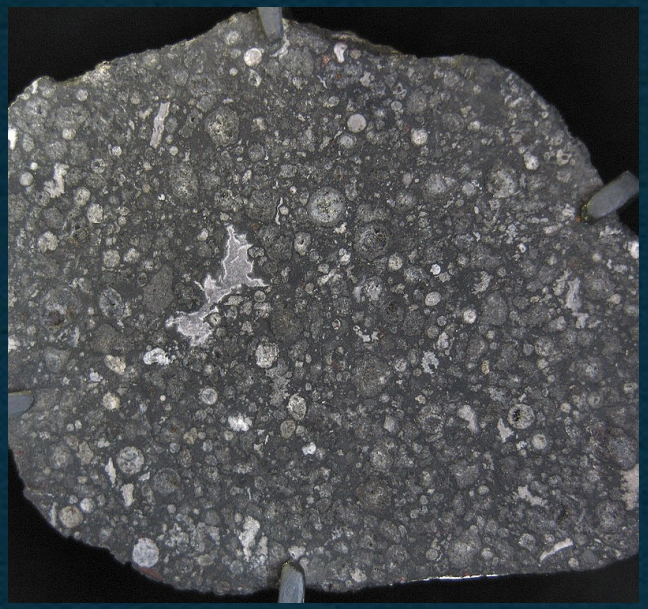
Introduction

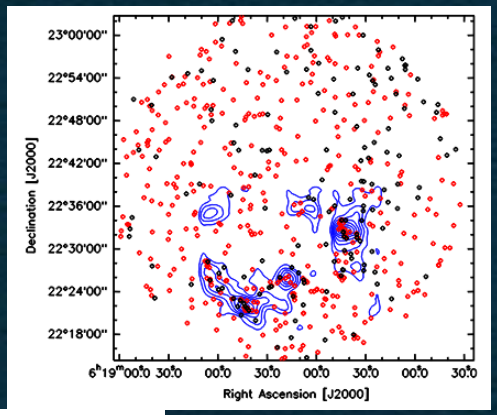
- Effects on SN Shock Waves on Star Formation
- Solar System
  - Al^{26} Isotopes on Allende Chondrite
  - Heat Source of Planet Formation
  - Nearby SN Explosion (1-2 pc)
- Effect of Shock on the Young Disk
  - Chevalier+, 2000
  - Ouellette+, 2007; 2010
  - Boss+, 2015
- Lack of Observational Evidences

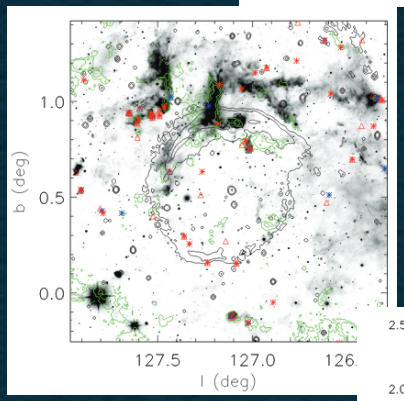


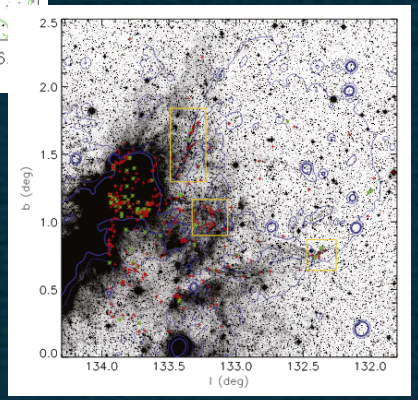
Allende Meteorite

Introduction

- Previous Works
  - Xu+, 2011, IC 443
  - Su+, 2014, IC 443
  - Zhou+, 2014, G127.1+0.5
  - Zhou+, 2016, HB 3
- Studying YSOs in Interaction with SNRs
  - Stellar Parameters
  - Accretion Properties
- Two YSOs in CTB 109
- Also SNRs IC 443, S 147, HB 9, G127.1+05

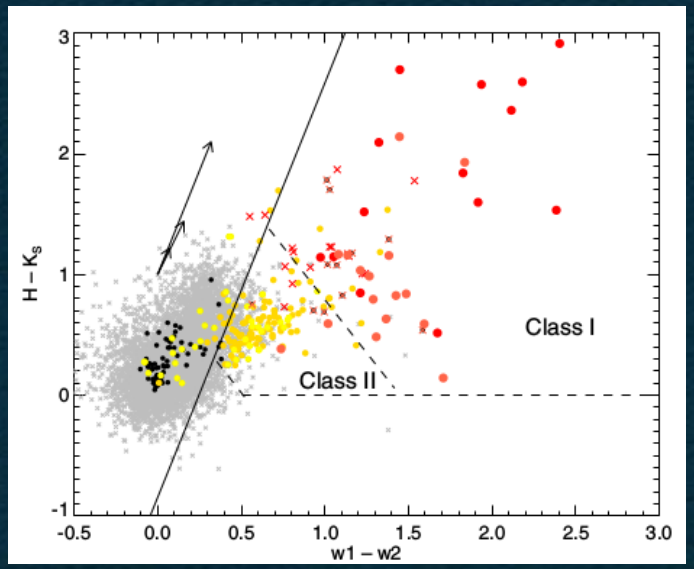




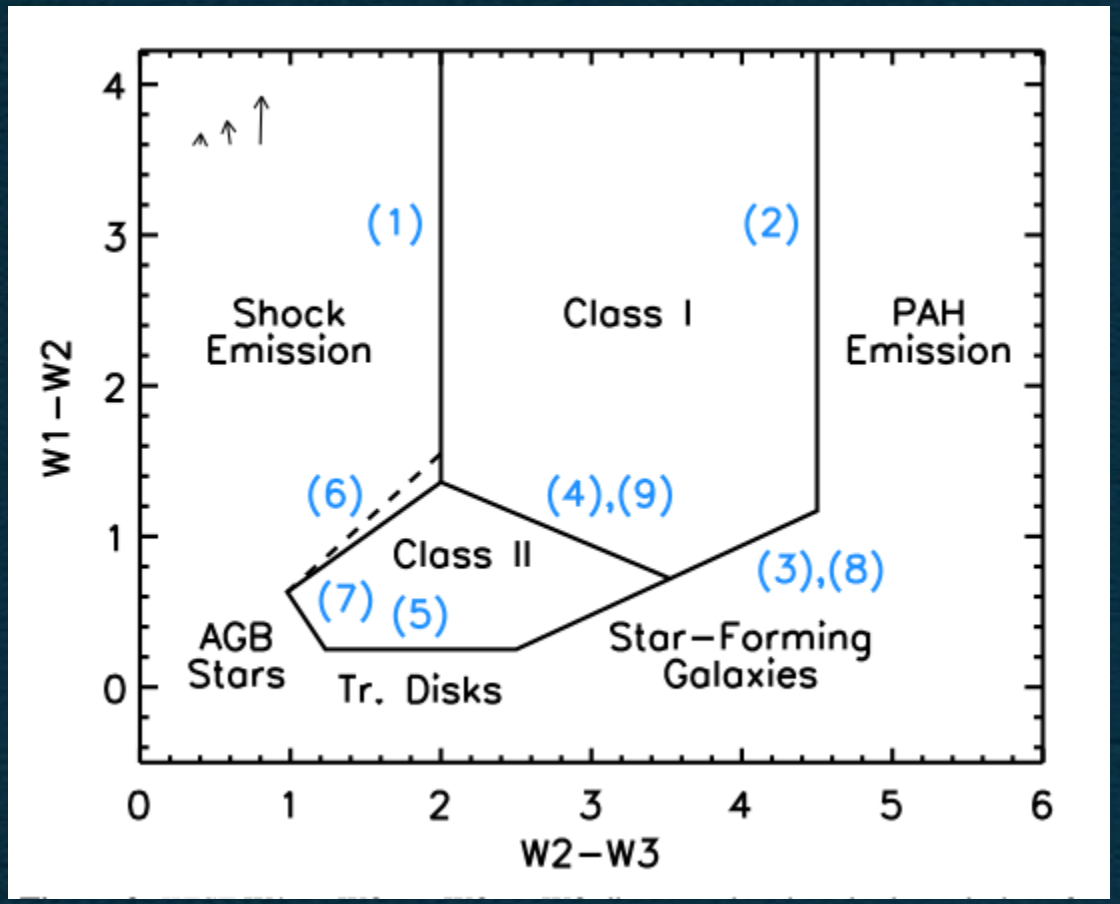


Candidate Selection

- All-WISE + 2Mass
- W1 < 13 mag



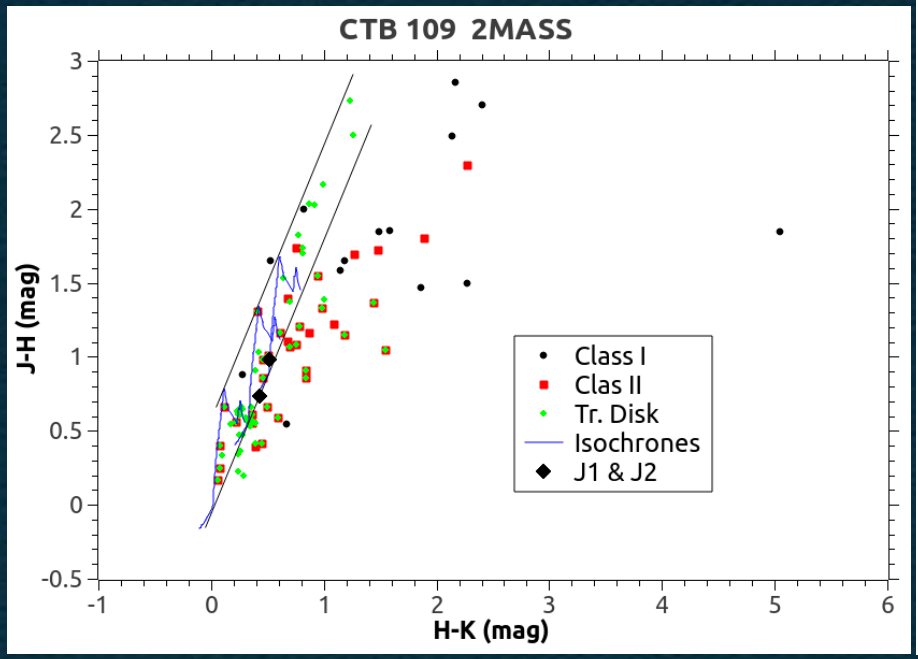
Koenig+ 2014

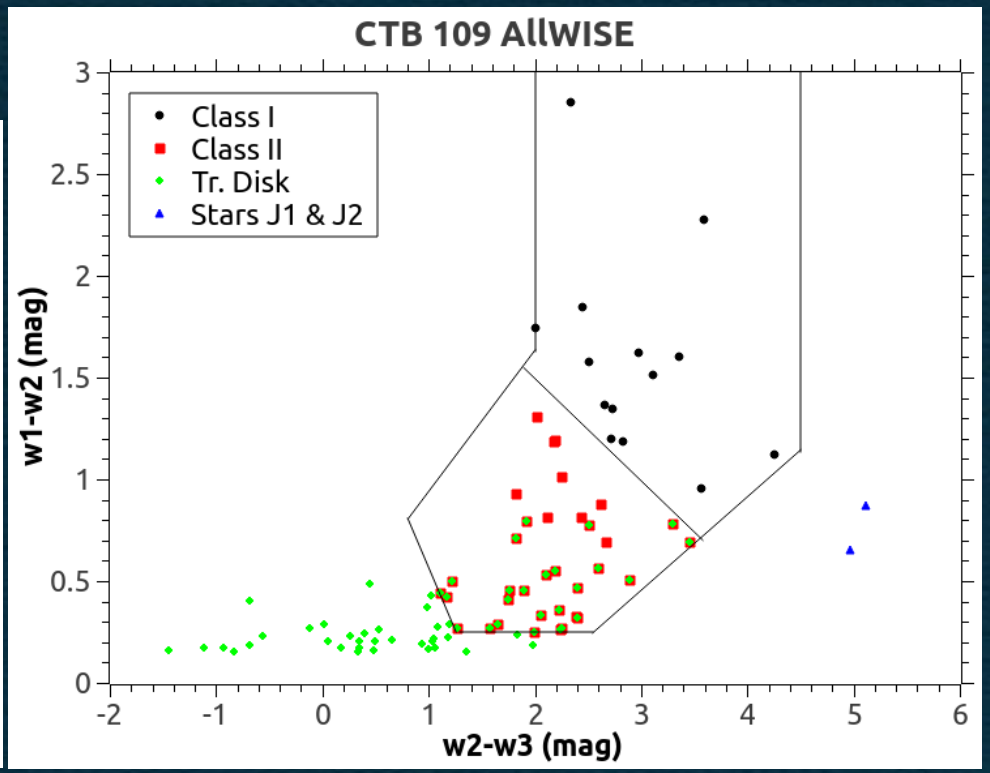


Fischer+ 2016

Candidates (CTB 109)

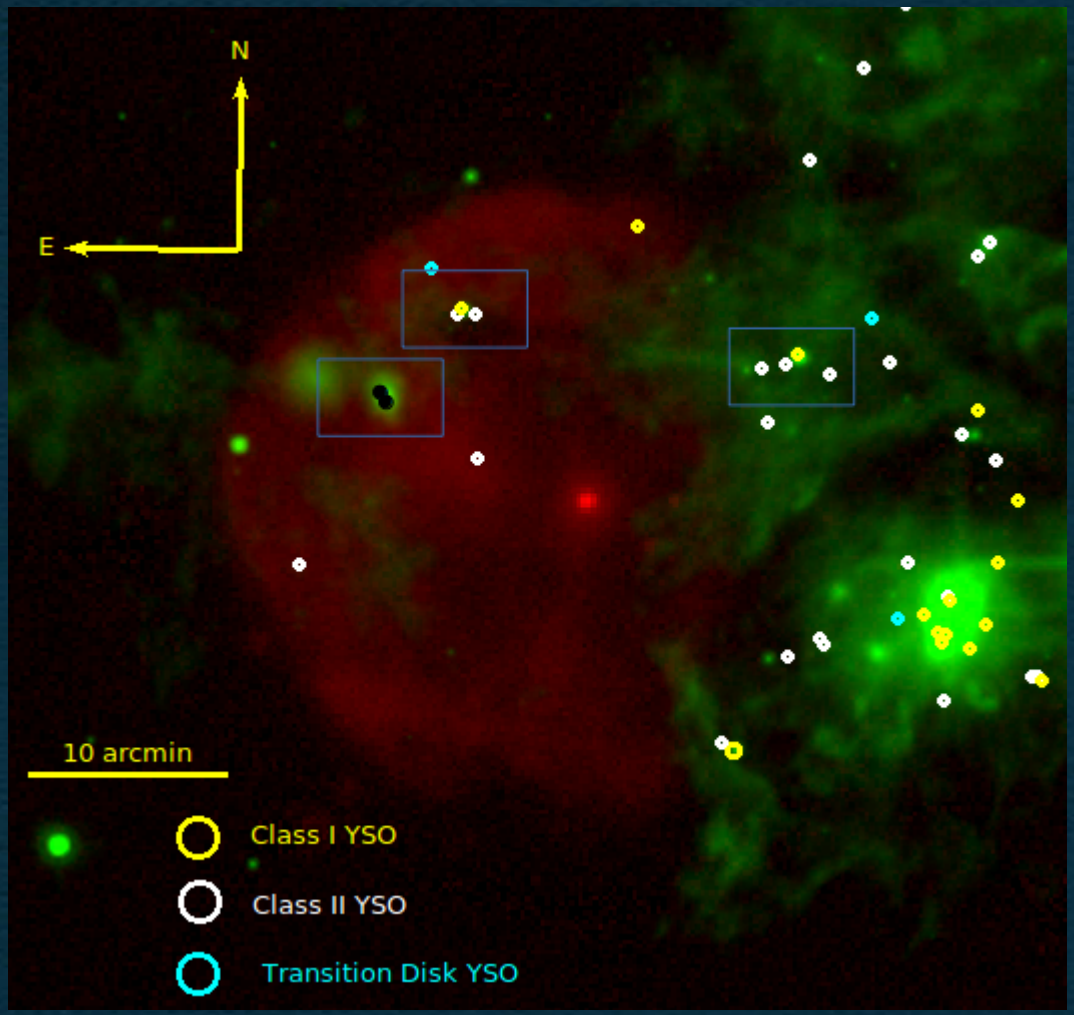
- All-WISE + 2MASS





CTB 109

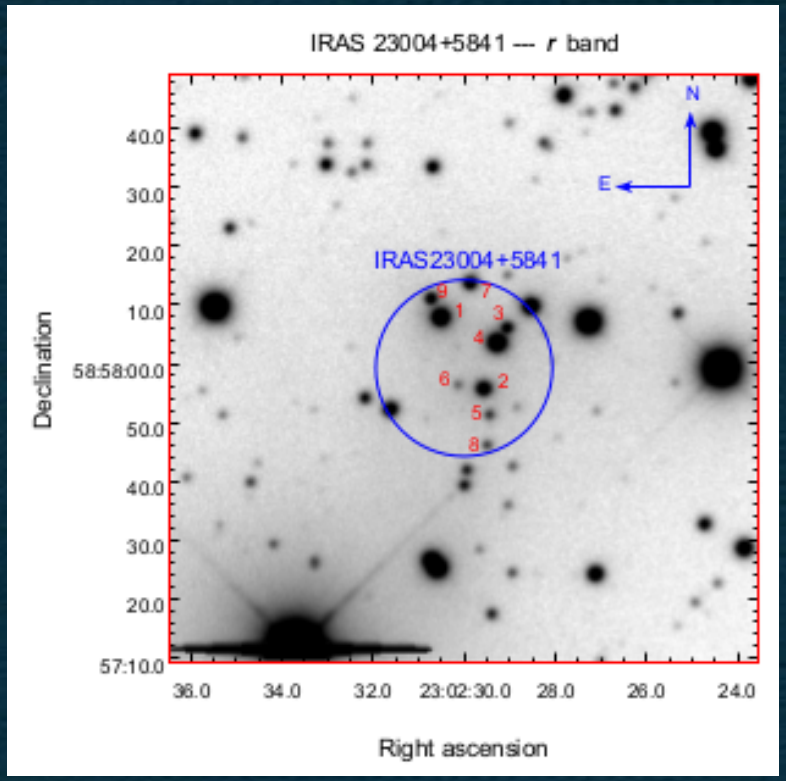
- Shell Type SNR[1]
- MC Interaction[2]
- Dist: 3.2+/-0.2 kpc[3]
- τ: 15 kyr[4]
- NS: Magnetar
- Bright in X-ray & Radio



[1]Green+, 2014, [2]Sasaki+, 2004

[3]Kothes+ 2012, [4]Sasaki+, 2006

CTB 109 (The Cloud)



Knies, 2015 Bachelor Thesis

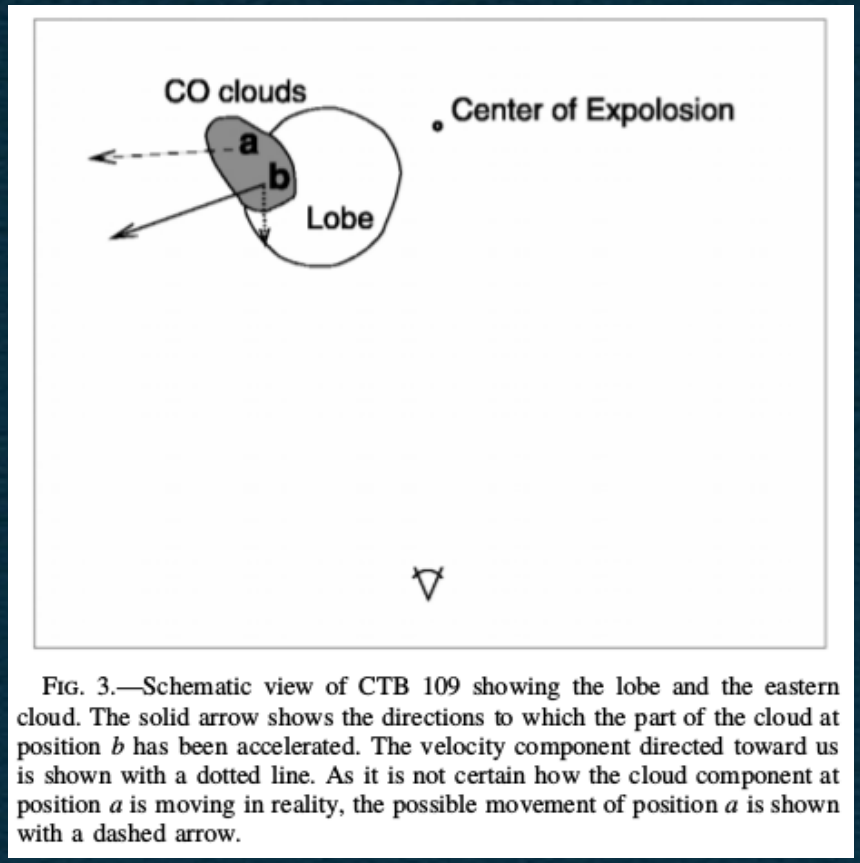


FIG. 3.—Schematic view of CTB 109 showing the lobe and the eastern cloud. The solid arrow shows the directions to which the part of the cloud at position *b* has been accelerated. The velocity component directed toward us is shown with a dotted line. As it is not certain how the cloud component at position *a* is moving in reality, the possible movement of position *a* is shown with a dashed arrow.

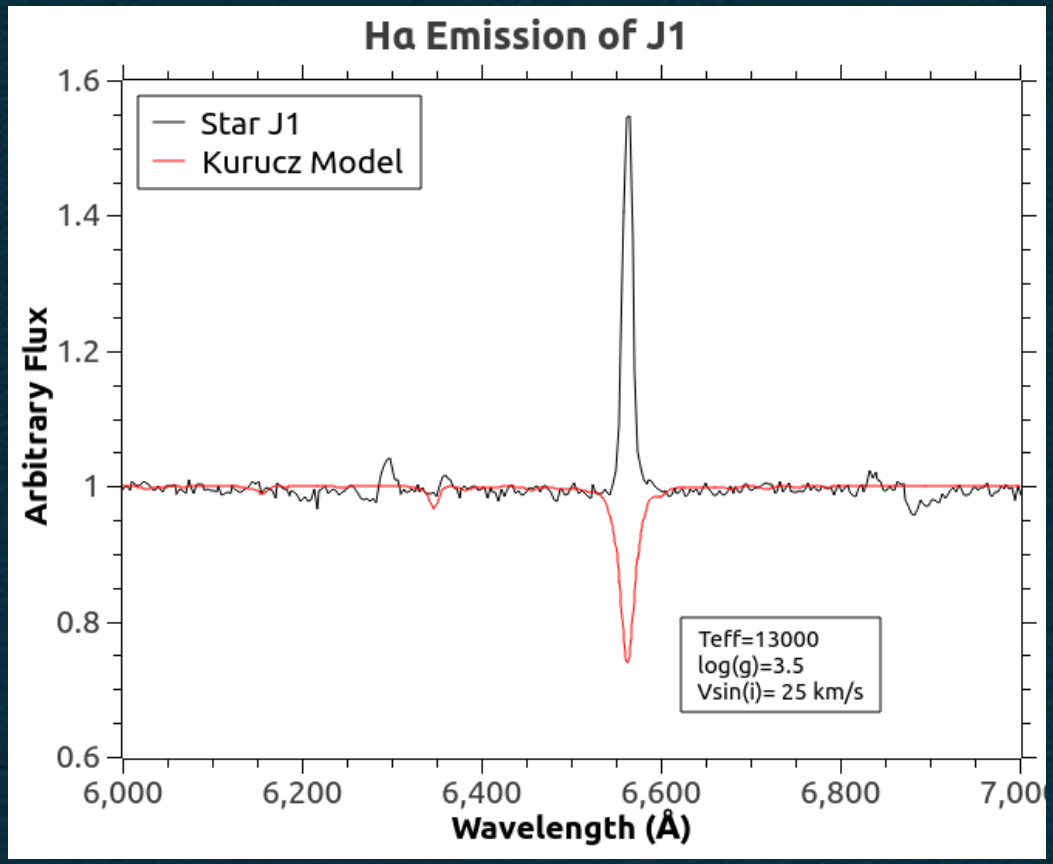
Sasaki+ 2006

Observations

Observation	Date	Telescope	Instrument	Site
Spectroscopy	Sep 2016	RTT–150	TFOSC	TUG
VRI-Hα	Oct 2017	T–100	SI 1100	TUG
VRI-Hα	Nov 2017	T–100	SI 1100	TUG
BVRI-Hα	Dec 2017	T–100	SI 1100	TUG
JHK-Brγ	Aug 2016	2.2 meter	PANIC	Calar Alto
JHK-Brγ	Feb 2018	2.2 meter	PANIC	Calar Alto

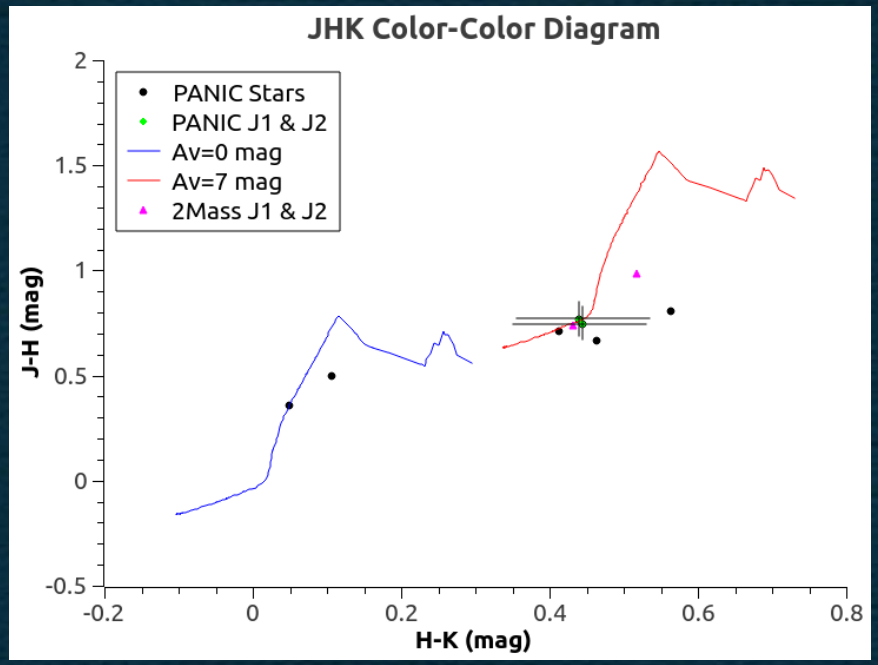
Star	B	V	R	I	Hα	J	H	K
J1	18.92±0.03	17.46±0.03	16.31±0.02	14.94±?	15.57±0.03	13.032±0.033	12.288±	11.843±
J2	20.09±0.04	18.59±0.03	17.38±0.02	15.98±?	17.16±0.05	13.979±0.032	13.211±	12.770±

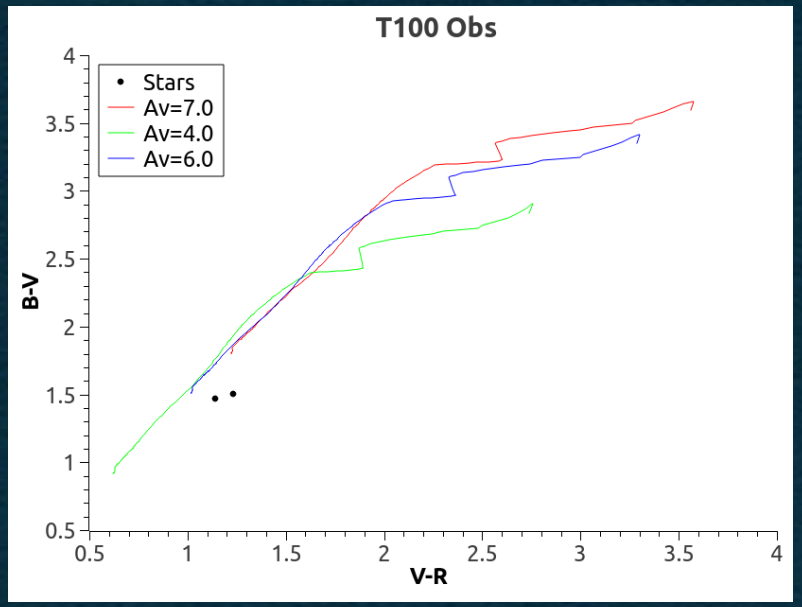
Observations



EW > 16 Å Flux > 2.4 x 10^{-14} erg/s/cm/Å

Observations





zJHK--BVRI

SDSS u,g,r,i,z

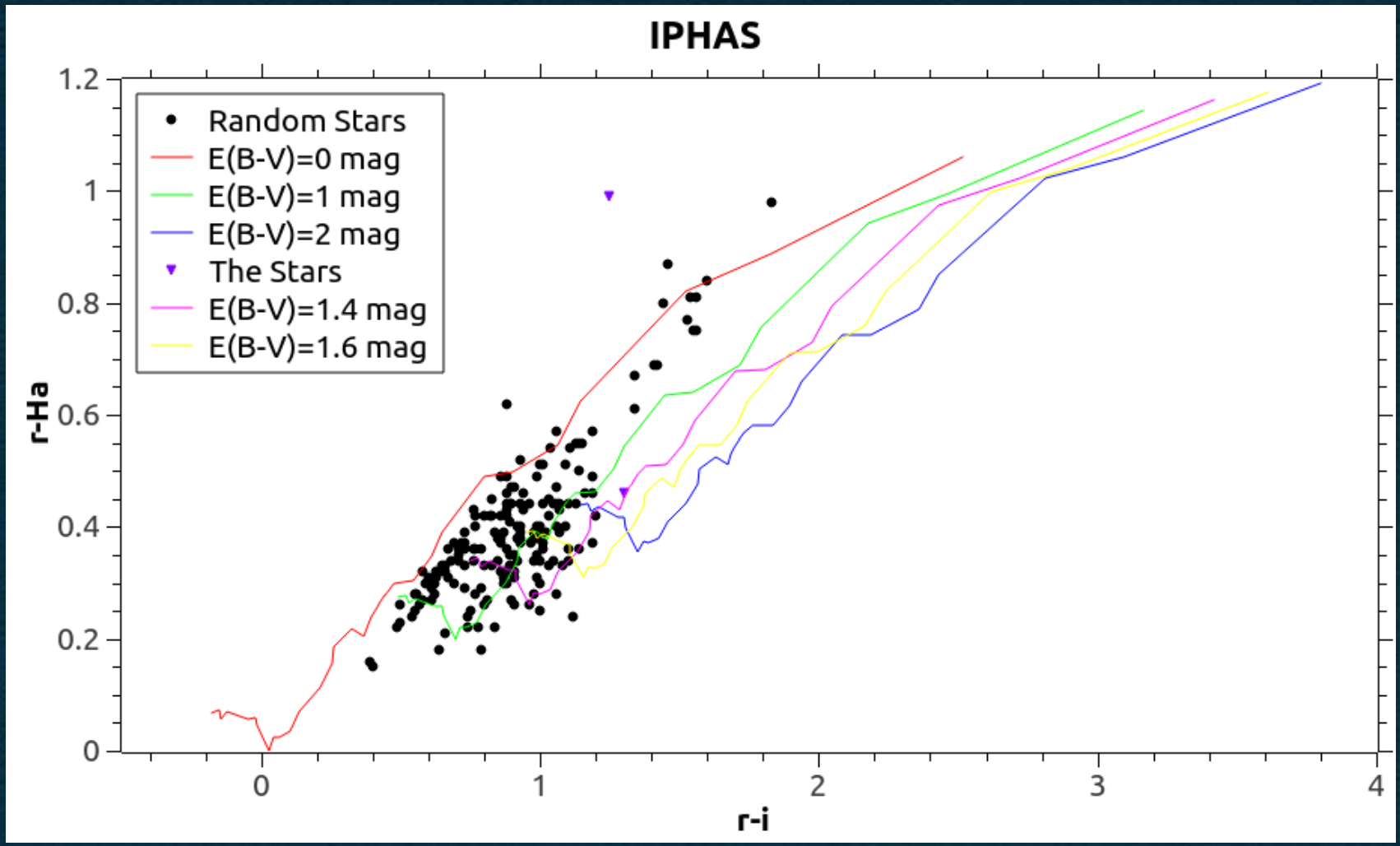
J1, Rv = 4.35+/-0.1

J2, Rv = 4.42+/-0.1

Stellar Parameters

Stars	Log(Age) (yr)	Mass ($M_\odot$)	Log(T_{eff}) (K)	Log(g) (in cgs)	A_v (mag)
J1	5.55	5.90-6.00	4.14-4.19	3.61-3.74	7.4
J2	5.55	6.40-7.00	4.27-4.34	4.13-4.28	7.7-7.9
J1	5.60	5.59-5.77	4.11-4.19	3.56-3.76	7.2-7.3
J2	5.60	6.09-7.07	4.26-4.34	4.10-4.33	7.7-7.9
J1	5.65	5.35-5.45	4.09-4.13	3.55-3.66	7.1-7.2
J2	5.65	5.79-6.17	4.25-4.29	4.08-4.20	7.7
J1	5.70	5.09-5.20	4.06-4.11	3.52-3.63	7.1-7.2
J2	5.70	5.54-5.71	4.24-4.24	4.07-4.16	7.6-7.7
J1	5.75	4.90-4.95	4.05-4.08	3.53-3.58	7.0-7.1
J2	5.75	5.30-5.34	4.23-4.23	4.06-4.10	7.6-7.7
J1	5.80	4.60-4.66	3.99-4.02	3.43-3.50	6.8-6.9
J2	5.80	5.05-5.08	4.22-4.22	4.04-4.08	7.6

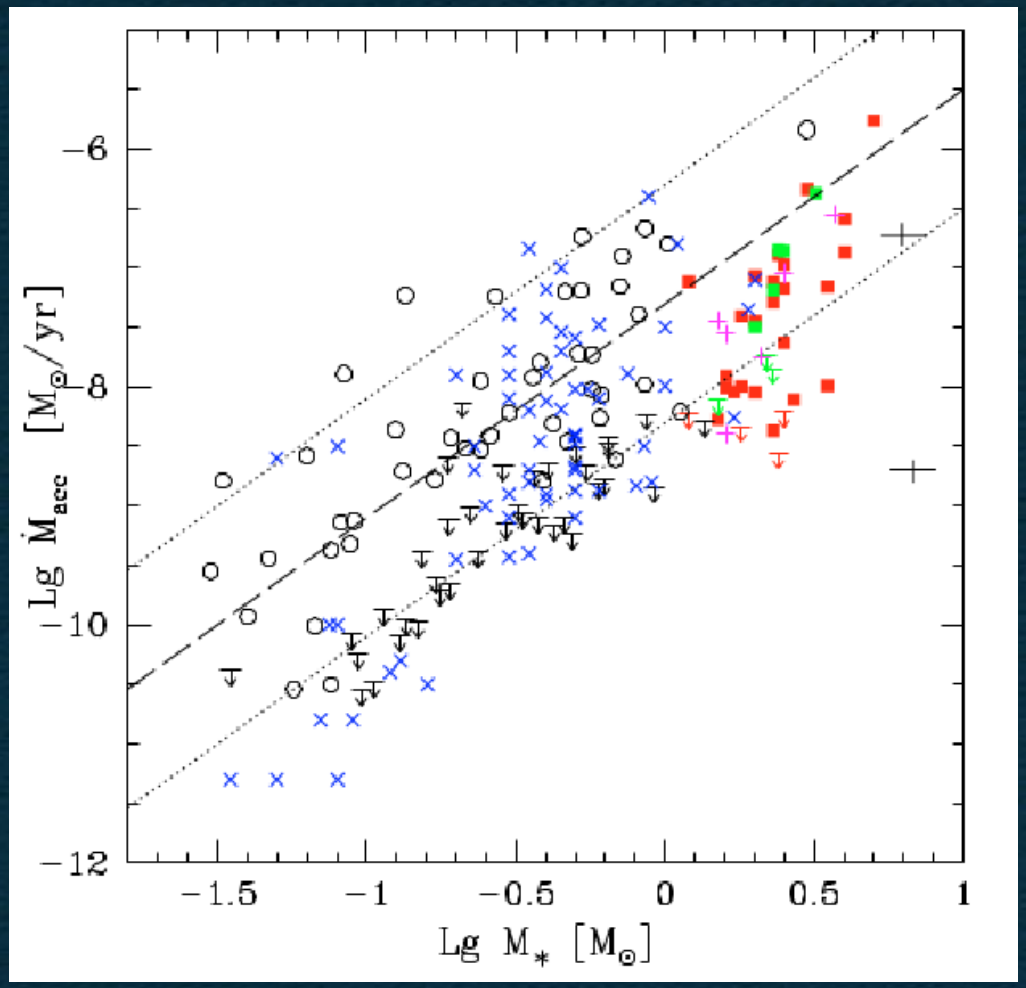
Accretion Properties



Accretion Properties

Stars	Log(Age) (yr)	Mass ($M_\odot$)	Log(T_{eff}) (K)	Log(g) (in cgs)	log($M_\odot$ yr^{-1})
J1	5.55	5.90	4.14	3.61	-7.2
J2	5.55	6.40	4.27	4.13	-8.9
J1	5.60	5.59	4.11	3.56	-7.3
J2	5.60	6.09	4.26	4.10	-8.8
J1	5.65	5.35	4.09	3.55	-7.1
J2	5.65	5.79	4.25	4.08	-8.8
J1	5.70	5.09	4.06	3.52	-7.3
J2	5.70	5.54	4.24	4.07	-8.8
J1	5.75	4.90	4.05	3.53	-7.1
J2	5.75	5.30	4.23	4.06	-8.8
J1	5.80	4.60	3.99	3.43	-7.0
J2	5.80	5.05	4.22	4.04	-8.7

Accretion Properties



Adapted from, Garcia-Lopez+, 2004

Conclusions

- We have found two YSOs in interaction with SNR CTB 109
- The YSOs are massive 5-7 Msun.
- J1 is active (-7.1 Msun /yr) but accretion in J2 ceases.
- Difference in “g” explains the accretion difference.
- No star with disks found from the progenitor generation.
- Spectra of the YSOs are needed.
- Sample will grow with three other SNRs.

CTB 109

- Shell Type SNR
- MC Interaction
- Dist: 3.2+/-0.2 kpc
- Tau: 15 kyr
- NS: Magnetar
- Bright in X-ray & Radio
- No Optical Shell