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First Detection of [C I] $^3P_1 - {}^3P_0$ Emission from a Protoplanetary Disk

Takashi Tsukagoshi, Munetake Momose, Masao Saito, Yoshimi Kitamura,
Yoshito Shimajiri and Ryohei Kawabe * *Astrophysical Journal Letters*

ABSTRACT

We performed single point [C I] $^3P_1$–$^3P_0$ and CO J=4–3 observations toward three T Tauri stars, DM Tau, LkCa 15, and TW Hya, using the Atacama Large Millimeter/submillimeter Array (ALMA) Band 8 qualification model receiver installed on the Atacama Submillimeter Telescope Experiment (ASTE). Two protostars in the Taurus L1551 region, L1551 IRS 5 and HL Tau, were also observed. We successfully detected [C I] emission from the protoplanetary disk around DM Tau as well as the protostellar targets. The spectral profile of the [C I] emission from the protoplanetary disk is marginally single-peaked, suggesting that atomic carbon (C) extends toward the outermost disk. The detected [C I] emission is optically thin and the column densities of C are estimated to be $\lesssim 10^{16}$ cm^{-2} and $\sim 10^{17}$ cm^{-2} for the T Tauri star targets and the protostars, respectively. We found a clear difference in the total mass ratio of C to dust, M(C)/M(dust), between the T Tauri stars and protostellar targets; the M(C)/M(dust) ratio of the T Tauri stars is one order of magnitude smaller than that of the protostars. The decrease of the estimated M(C)/M(dust) ratios for the disk sources is consistent with a theoretical prediction that the atomic C can survive only in the near surface layer of the disk and C^+/C/CO transition occurs deeper into the disk midplane.

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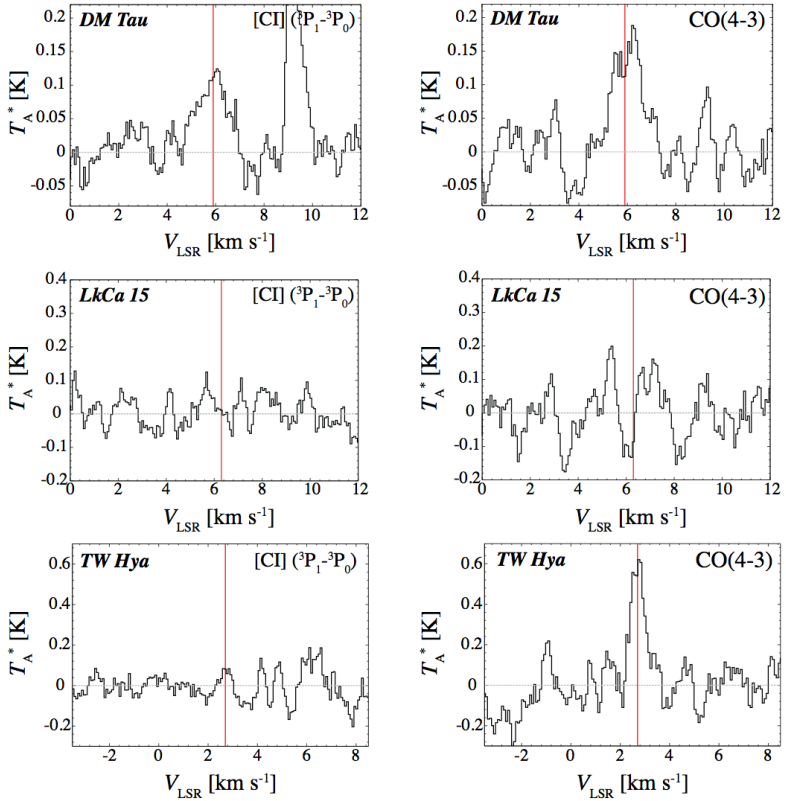
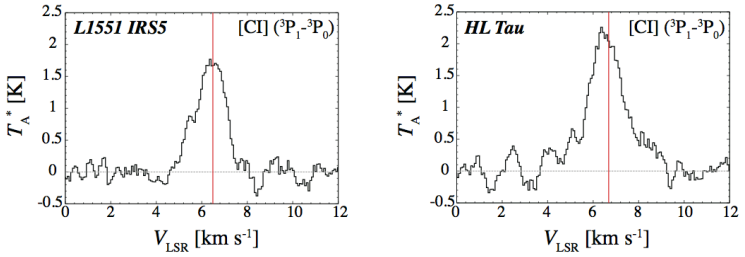
- C の観測は以下の理解に重要
  - disk dissipation
  - dust evolution in the disk

Fig. 1



・しかし、
原始惑星系円盤でsubmm の
C の微細構造線の観測例はなし

Fig. 2



・ASTEで[C I] $^3P_1 - {}^3P_0$ と CO(4-3) を観測
  ・HPBW = 17”

・DM Tau, protostar で[C I] を検出
・single-peaked profile near the systemic velo.
  ⇨ C extends toward the outermost disk

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- 光学的厚みを求め、C の質量や、M(C)/M(dust)(≡ R) を導出
- T Tauri star よりprotostar の方が一桁 R が大きい
- 進化によりRの値を下げるには
  - R ∝ g/d × X(C)
    - X (C) を減らす
    - g/d (= gas to dust ratio) を減らす
- ありえそうなのは前者
  - C の寿命はガス密度が上がると短くなるため

Table 3. Physical parameters derived from [C I] line.

Source	$\tau_{[C\ I]}$	$N(C)$ (10^{16} cm^{-2})	$M(C)$ (10^{-7} $M_\odot$)	$\frac{M(C)}{M(dust)}$ (10^{-4})
DM Tau	0.02	1.6±0.5	0.75±0.22	3.1
LkCa 15	<0.03	<4.1	<1.48	<3.1
TW Hya	<0.09	<3.6	<0.12	<0.4
L1551 IRS5	0.47	10.7±0.8	15.3±1.2	31
HL Tau	0.65	19.0±0.8	27.4±1.1	46

Note. — Column (1) gives the source name. Column (2) gives the optical depth of the [C I] line. Column (3) gives the column density of C after correction for the beam filling factor of the disk. Column (4) gives the total mass of C. Column (5) gives the ratio of the total mass of C to the dust mass listed in Table 1.

Tracing the Conversion of Gas into Stars in Young Massive Cluster Progenitors

D.L. Walker, S.N. Longmore, N. Bastian, J.M.D. Kruijssen, J.M. Rathborne,
J.M. Jackson, J.B. Foster and Y. Contreras * *MNRAS*

contain > 10^5 $M_\odot$ within only a few pc

ABSTRACT

Whilst young massive clusters (YMCs; $M \gtrsim 10^4$ $M_\odot$, age $\lesssim 100$ Myr) have been identified in significant numbers, their progenitor gas clouds have eluded detection. Recently, four extreme molecular clouds residing within 200 pc of the Galactic centre have been identified as having the properties thought necessary to form YMCs. Here we utilise far-IR continuum data from the Herschel Infrared Galactic Plane Survey (HiGAL) and millimetre spectral line data from the Millimetre Astronomy Legacy Team 90 GHz Survey (MALT90) to determine their global physical and kinematic structure. We derive their masses, dust temperatures and radii and use virial analysis to conclude that they are all likely gravitationally bound – confirming that they are likely YMC progenitors. We then compare the density profiles of these clouds to those of the gas and stellar components of the Sagittarius B2 Main and North proto-clusters and the stellar distribution of the Arches YMC. We find that even in these clouds – *the most massive and dense quiescent clouds in the Galaxy* – the gas is not compact enough to form an Arches-like ($M = 2\text{x}10^4$ $M_\odot$, $R_{eff} = 0.4$ pc) stellar distribution. Further dynamical processes would be required to condense the resultant population, indicating that the mass becomes more centrally concentrated as the (proto)-cluster evolves. These results suggest that YMC formation may proceed hierarchically rather than through monolithic collapse.

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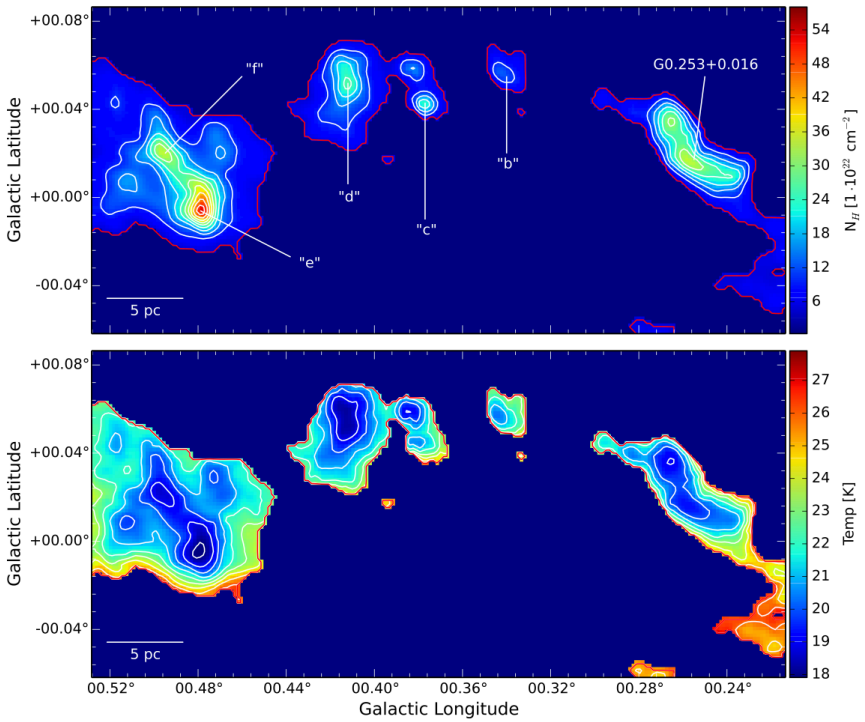
- G0.253+0.016, ‘d’, ‘e’ and ‘f’, are all ⇒ YMC progenitor candidates
  - high mass (M ~ 10^5 $M_\odot$),
  - cold (T_{dust} ~ 20 K)
  - dense (ρ ~ 10^4 cm^{-3})



- Comparison of the mass surface density distributions with other YMC
  Sagittarius B2 proto-YMC , Arches YMC

- not compact or centrally concentrated
  enough to form an Arches-like YMC in their current state

Are the majority of Sun-like stars single?

A. P. Whitworth and O. Lomax * *MNRAS*

ABSTRACT

It has recently been suggested that, in the field, $\sim$ 56% of Sun-like stars ($0.8\,\mathrm{M}_\odot \lesssim M_\star \lesssim 1.2\,\mathrm{M}_\odot$) are single. We argue here that this suggestion may be incorrect, since it appears to be based on the multiplicity frequency of systems with Sun-like primaries, and therefore takes no account of Sun-like stars that are secondary (or higher-order) components in multiple systems. When these components are included in the reckoning, it seems likely that only $\sim 46\%$ of Sun-like stars are single. This estimate is based on a model in which the system mass function has the form proposed by Chabrier, with a power-law Salpeter extension to high masses; there is a flat distribution of mass ratios; and the probability that a system of mass M is a binary is $0.50 + 0.46 \log_{10}(M/\mathrm{M}_\odot)$ for $0.08\,\mathrm{M}_\odot \leq M \leq 12.5\,\mathrm{M}_\odot$, 0 for $M < 0.08\,\mathrm{M}_\odot$, and 1 for $M > 12.5\,\mathrm{M}_\odot$. The constants in this last relation are chosen so that the model also reproduces the observed variation of multiplicity frequency with primary mass. However, the more qualitative conclusion, that a minority of Sun-like stars are single, holds up for virtually all reasonable values of the model parameters. Parenthetically, it is still likely that the majority of *all* stars in the field are single, but that is because most M Dwarfs probably are single.

The Massive Star Population of Cygnus OB2

Nicholas J. Wright, Janet E. Drew and Michael Mohr-Smith * *MNRAS*

ABSTRACT

We have compiled a significantly updated and comprehensive census of massive stars in the nearby Cygnus OB2 association by gathering and homogenising data from across the literature. The census contains 169 primary OB stars, including 52 O-type stars and 3 Wolf-Rayet stars. Spectral types and photometry are used to place the stars in a Hertzprung-Russell diagram, which is compared to both non-rotating and rotating stellar evolution models, from which stellar masses and ages are calculated. The star formation history and mass function of the association are assessed, and both are found to be heavily influenced by the evolution of the most massive stars to their end states. We find that the mass function of the most massive stars is consistent with a 'universal' power-law slope of $\Gamma = 1.3$. The age distribution inferred from stellar evolutionary models with rotation and the mass function suggest the majority of star formation occurred more or less continuously between 1 and 7 Myr ago, in agreement with studies of low- and intermediate mass stars in the association. We identify a nearby young pulsar and runaway O-type star that may have originated in Cyg OB2 and suggest that the association has already seen its first supernova. Finally we use the census and mass function to calculate the total mass of the association of 16500^{+3800}_{-2800} $M_{\odot}$, at the low end, but consistent with, previous estimates of the total mass of Cyg OB2. Despite this Cyg OB2 is still one of the most massive groups of young stars known in our Galaxy making it a prime target for studies of star formation on the largest scales.

Radio Continuum Observations of the Galactic Center: Photoevaporative Proplyd-like Objects near Sgr A*

F. Yusef-Zadeh, D. A. Roberts, M. Wardle, W. Cotton, R. Sch¨odel and M. J. Royster　* *ApJL*

ABSTRACT

We present radio images within 30″ of Sgr A* based on recent VLA observations at 34 GHz with 7.8 μJy sensitivity and resolution $\sim 88 \times 46$ milliarcseconds (mas). We report 44 partially resolved compact sources clustered in two regions in the E arm of ionized gas that orbits Sgr A*. These sources have size scales ranging between $\sim$ 50 and 200 mas (400 to 1600 AUs), and a bow-shock appearance facing the direction of Sgr A*. Unlike the bow-shock sources previously identified in the near-IR but associated with massive stars, these 34 GHz sources do not appear to have near-IR counterparts at 3.8 μm. We interpret these sources as a candidate population of photoevaporative protoplanetary disks (proplyds) that are associated with newly formed low mass stars with mass loss rates $\sim 10^{-7} - 10^{-6}\ M_{\odot}\ \mathrm{yr}^{-1}$ and are located at the edge of a molecular cloud outlined by ionized gas. The disks are externally illuminated by strong Lyman continuum radiation from the ∼100 OB and WR massive stars distributed within 10″ of Sgr A*. The presence of proplyds implies current in-situ star formation activity near Sgr A* and opens a window for the first time to study low mass star, planetary and brown dwarf formations near a supermassive black hole.

使用データ

VLA　: 34GHz continuum
VLT　: L’-band(3.8 μm)
ALMA: Si0 (5-4)

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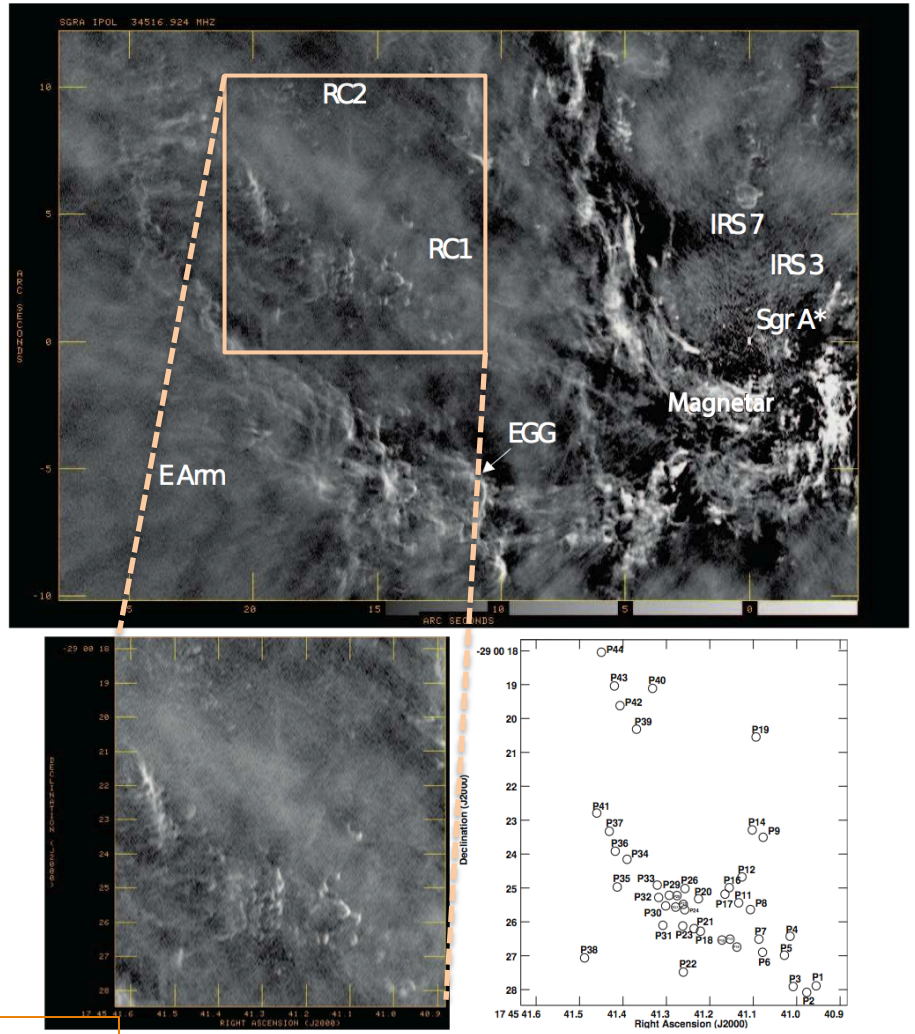
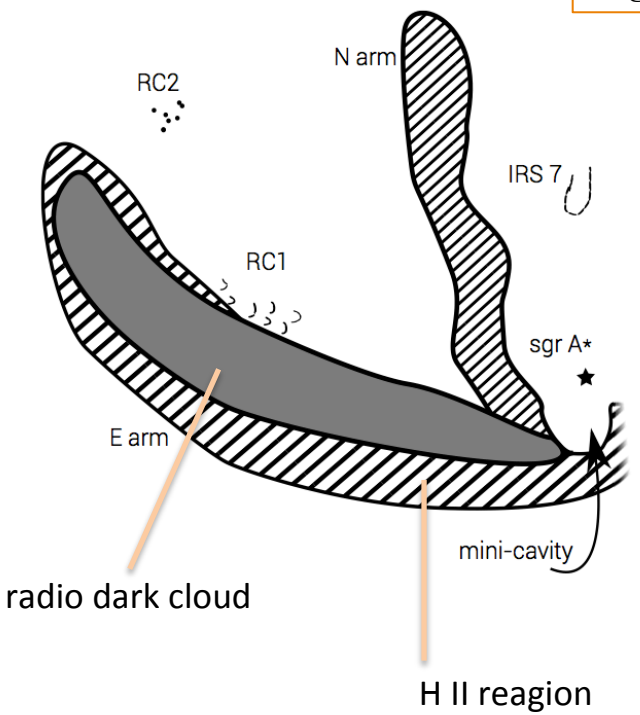


Fig. 1

Fig. 4



*EGG = Evaporating Gaseous Globule

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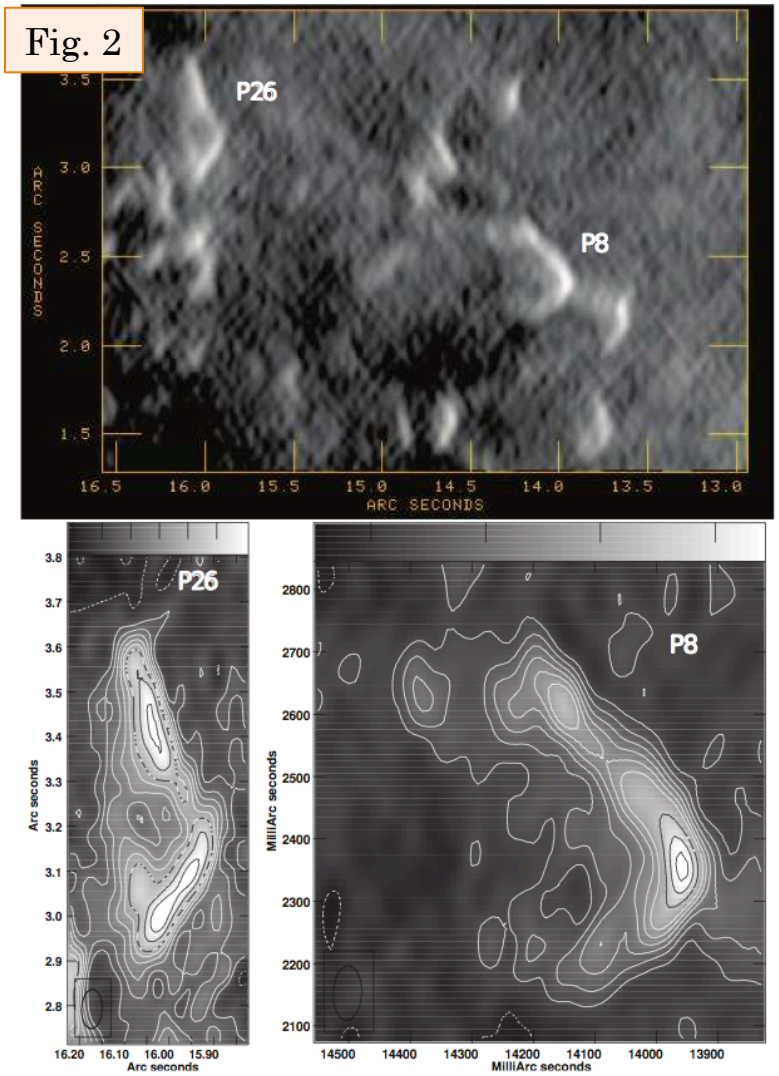
Fig. 2



- 44 sources detected
- bow-shock structures toward Sgr A*
- photoevaporative protoplanetary disk
- SiO (5-4): 12 sources detected
  => embedded protostellar outflows
- near-IR counterparts
  - massive YSO
  => almost not detected

proplyd associated with low-mass YSO