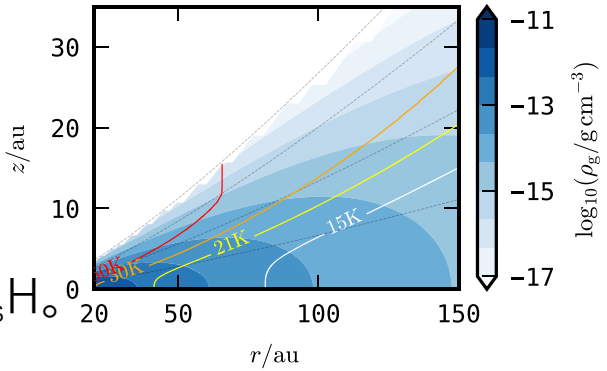
Star Formation Newsletter #332 33-40

Yusuke Aso (KASI)

CO Depletion in Protoplanetary Disks: A Unified Picture Combining Physical Sequestration and Chemical Processing

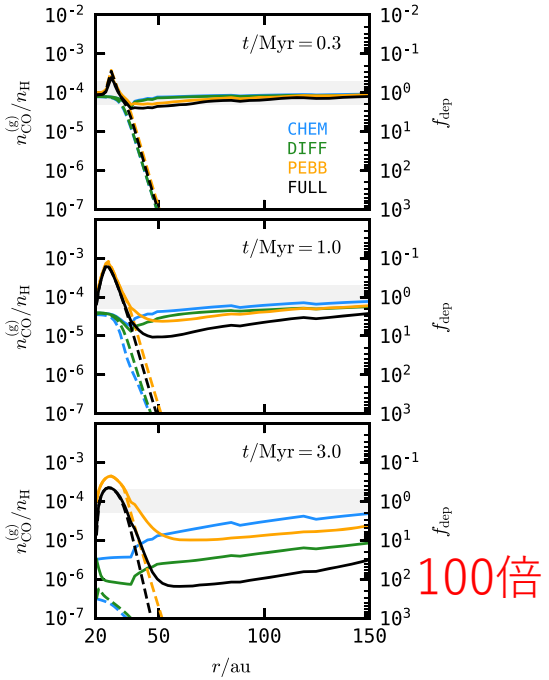
Sebastiaan Krijt[1,5,7], Arthur D. Bosman[2], Ke Zhang[2,5], Kamber R. Schwarz[3,6], Fred J. Ciesla[4,7], and Edwin A. Bergin[2]

- 最近の観測からCOは1-3 Myrで10-100倍消失。惑星組成にも影響。
- 化学反応、z+r方向の輸送、宇宙線によるイオン化を調べる。

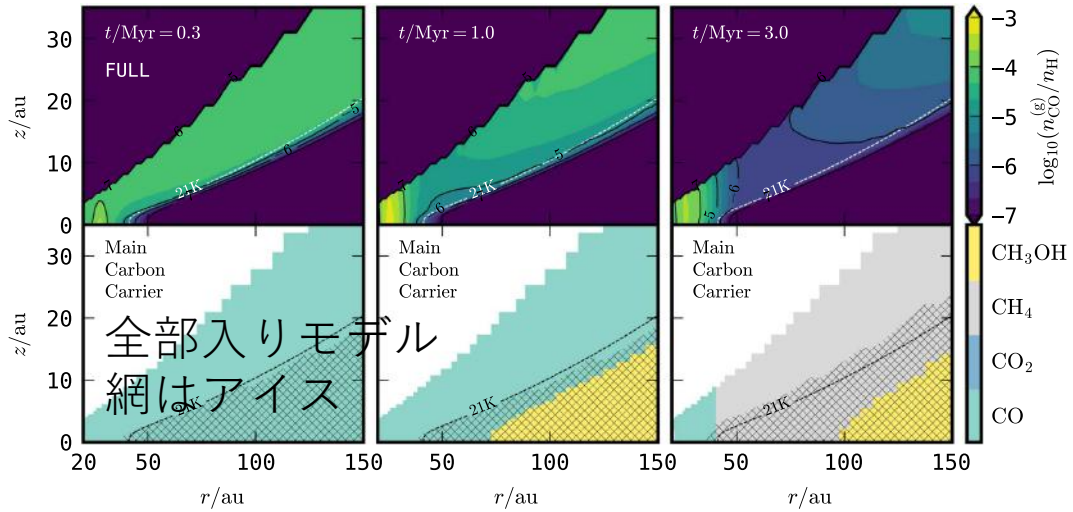


- 円盤モデル：r_c=80 au, M_{disk}/M_*=0.1, T_{1au}=135 K, g/d=100, a=0.1 μm。
- 化学：CO iceからCH_3OH, 表面でCO + OH → CO_2, ガスCO + He+ → CH_4
- 温度でガス相へ。初期雪線は34 au, 23 K。 $\alpha=10^{-4}$の乱流で拡散係数$D_g=\alpha c_s H$。
- $\tau_{d\to p}$でダストから1 mmのペブルへ（a_1=10）。
- ペブルが動いてCOを放出。ペブル上化学反応なし。衝突破壊なし。3 Myrまで。

$$\tau_{\mathrm{d}\to\mathrm{p}} = \frac{a_1}{\Omega}\left(\frac{\rho_\mathrm{d}}{\rho_\mathrm{g}}\right)^{-1},$$



- Warm molecular layerは化学だけではX_{CO}変化なし。
- 拡散を入れると上層→赤道面→CH_3OHでX_{CO}が数倍減少。
- 化学反応＋雪線以内へ落下でようやくX_{CO}が100倍減少。



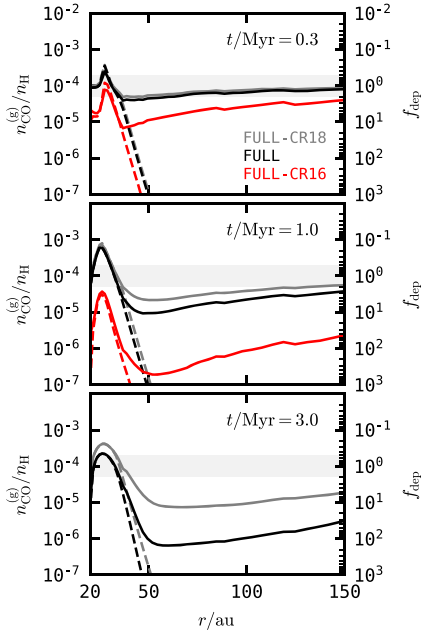
全部入りモデル
網はアイス

100倍

CO Depletion in Protoplanetary Disks: A Unified Picture Combining Physical Sequestration and Chemical Processing

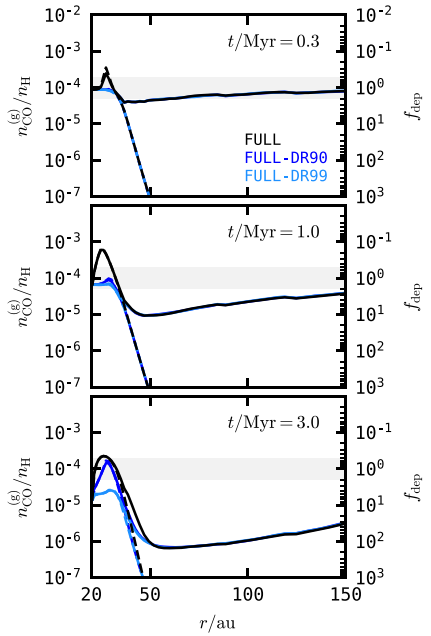
の続き

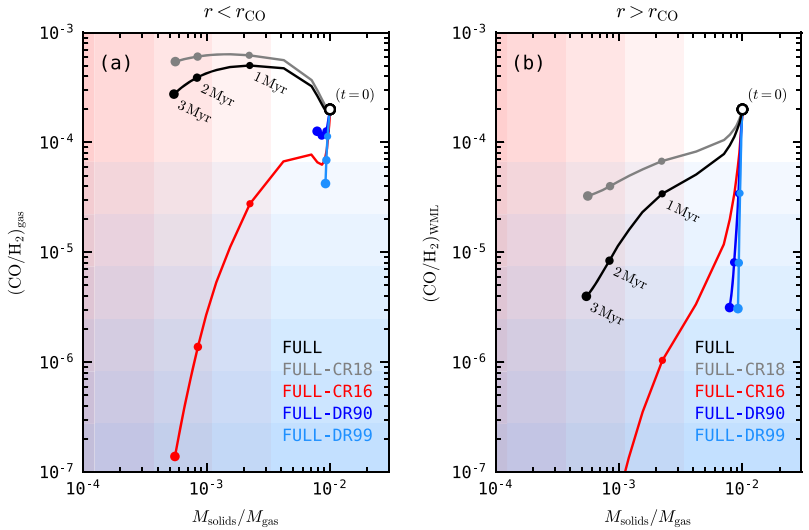
Sebastiaan Krijt[1,5,7], Arthur D. Bosman[2], Ke Zhang[2,5], Kamber R. Schwarz[3,6], Fred J. Ciesla[4,7], and Edwin A. Bergin[2]



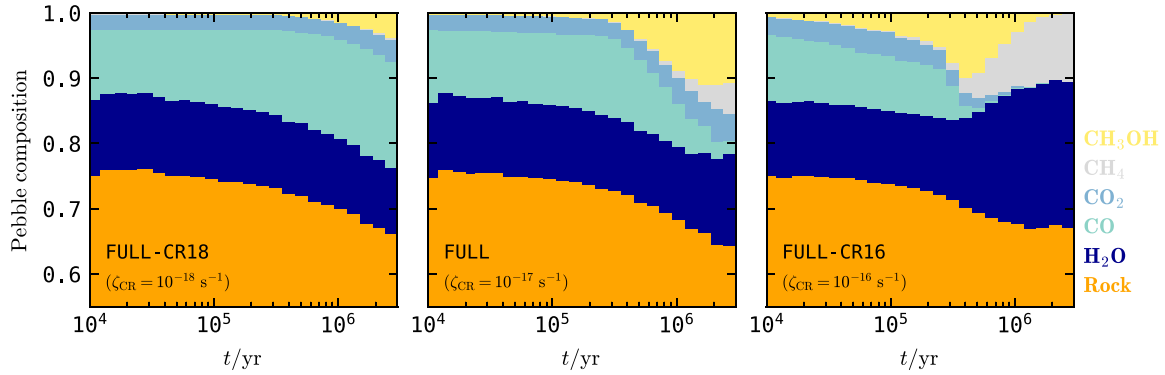
← $\zeta = 10^{-16}$だと外でCO_2になって雪線以内も減る。

→ ドリフトを1%にしても雪線以内で減る。





- ドリフトが弱い（DR99）ならM_{dust}がOK。
- ζが小さい（CR16）ならM_{CO}がOK。
- 特にM_{disk}の進化の議論はg/d, X_{CO}の進化を除く必要あり。



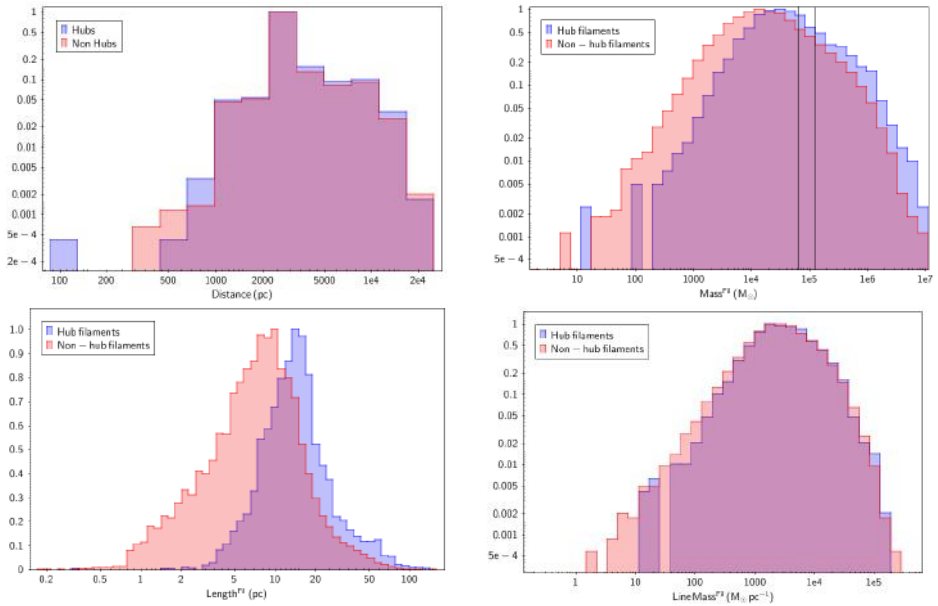
- Cold Classical Kuiper Beltの半径~45 au。
- CO rich iceの彗星の起源は雪線の外だけでなく、化学反応が進む前でも可能。

Unifying low- and high-mass star formation through density-amplified hubs of filaments

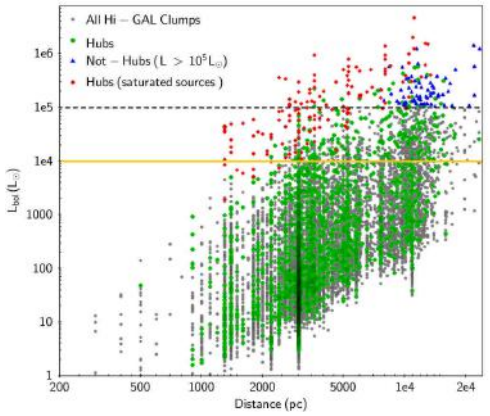
The highest mass stars (>100$M_\odot$) form only in hubs

M. S. N. Kumar[1], P. Palmeirim[1], D. Arzoumanian[1], and S. I. Inutsuka[2]

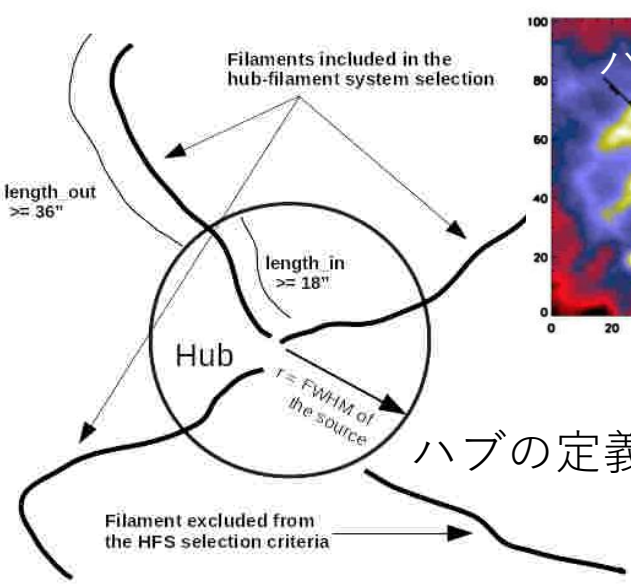
- 大質量星はGMCの中心。小質量星形成は大質量形成に止められる前。Salpeter IMF。10^5 yrで100 $M_\odot$。
- これらを統一的に理解するためにHub-filament systemを観測する。
- Herschel Infrared Galactic plane survey 250 μmでフィラメント、160, 250, 350, 500 μmで柱密度と温度。
- robustなクランプを抽出。DisPerSEでフィラメントのスケルトン。8 μmでフィラメント以外を除去。



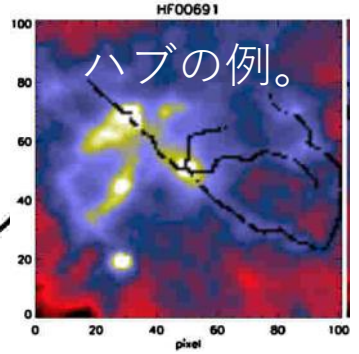
- ハブフィラメントはどこにでもあって、線密度は同じだが長くて重い。



- エディントン限界以上は全てハブ（not-hubsは>5 kpc）。
→ ハブで大質量星形成。



ハブの定義。



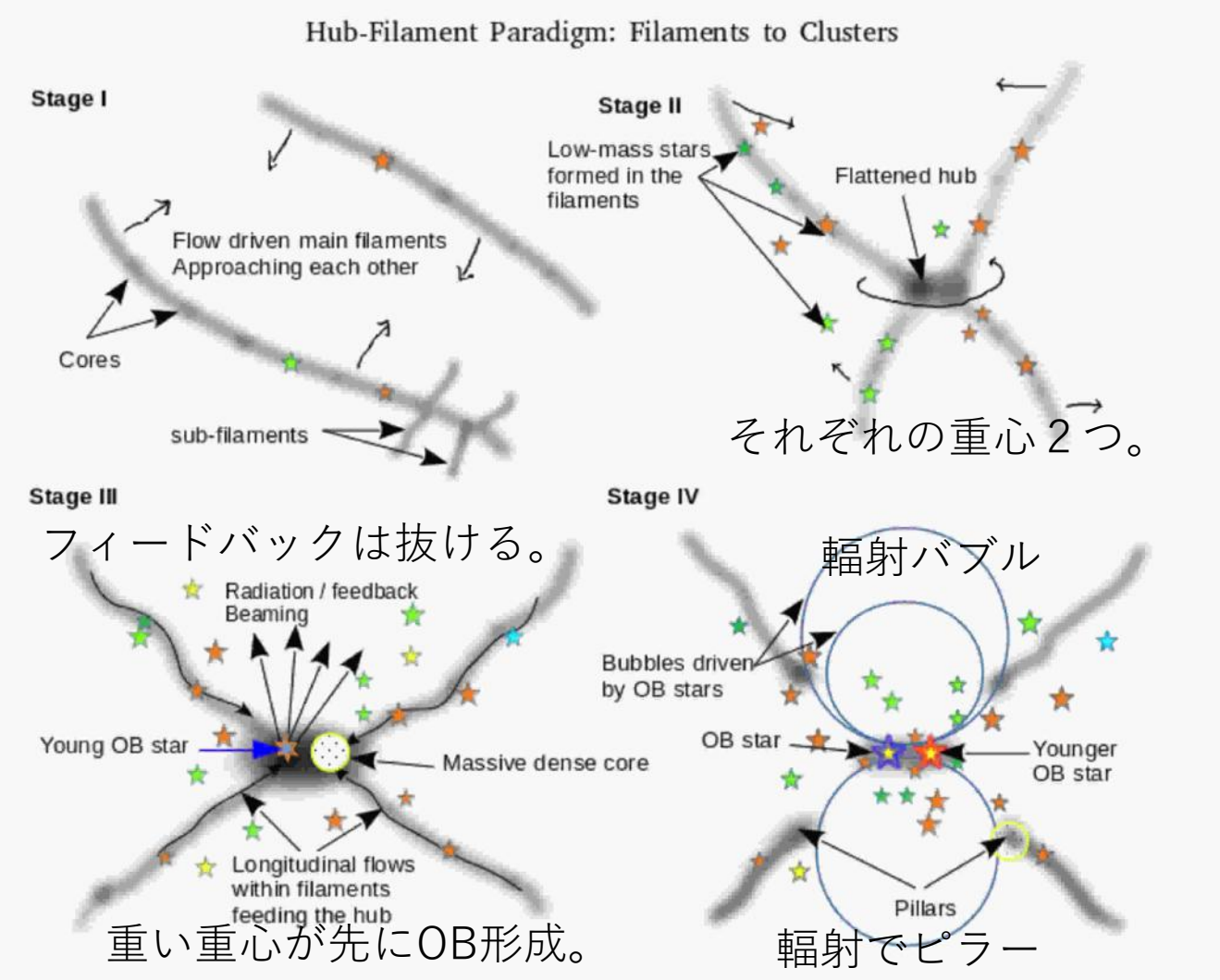
ハブの例。

Unifying low- and high-mass star formation through density-amplified hubs of filaments

The highest mass stars (>100$M_\odot$) form only in hubs

の続き

M. S. N. Kumar[1], P. Palmeirim[1], D. Arzoumanian[1], and S. I. Inutsuka[2]



それぞれの重心２つ。

フィードバックは抜ける。

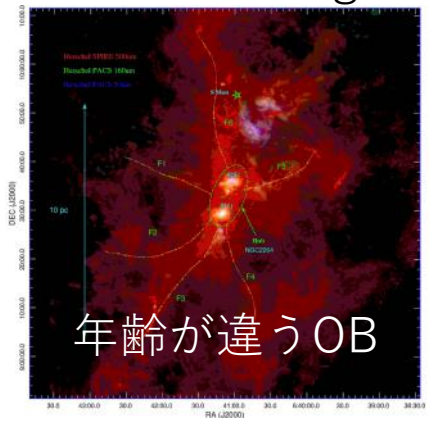
輻射バブル

重い重心が先にOB形成。

輻射でピラー

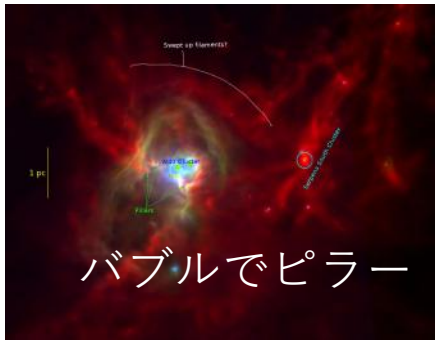
- 中心で大質量。
- 小質量はハブ形成前から。
- 全部合わせるとSalpeter IMF。
- フィラメントごとの形成時期が年齢の幅に。
- 個々のフィラメントが肥えていないとハブでOB associationに。

NGC2264 Stage III



年齢が違うOB

W40 Stage IV



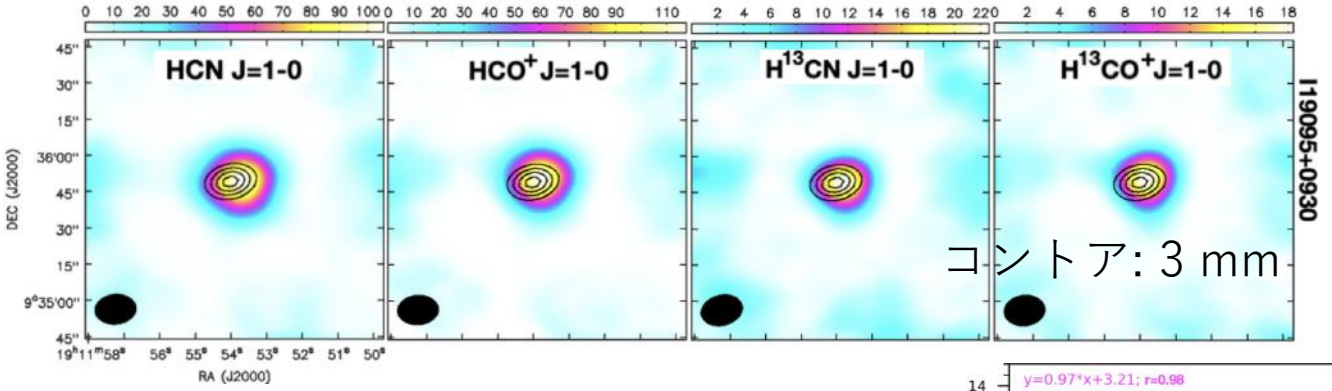
バブルでピラー

- ハブは円盤より低密度なので磁場で安定化。小質量星に分裂せずトーラス状に。

ATOMS: ALMA three-millimeter observations of massive star-forming regions – II. Compact objects in ACA observations and star formation scaling relations

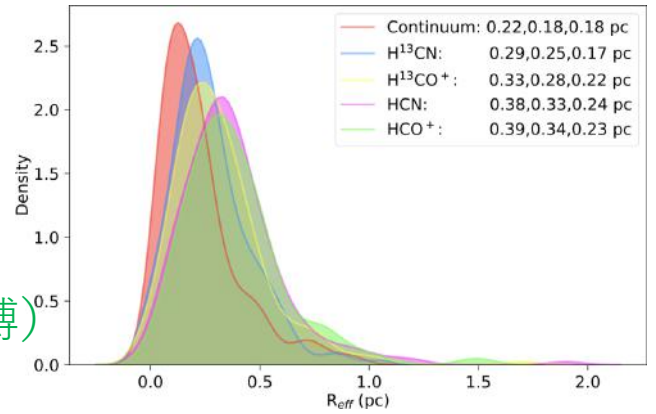
Tie Liu,[1,2,3★] Neal J. Evans,[2,4] Kee-Tae Kim,[2,5] Paul F. Goldsmith,[6]
Sheng-Yuan Liu,[7] Qizhou Zhang,[8] Ken'ichi Tatematsu,[9] Ke Wang,[10] Mika Juvela,[11]

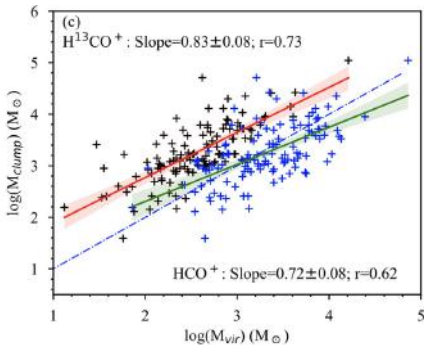
- 赤外SFRと、ガスの総量ではなく、高密度ガスの量に相関 → dense gas star formation law。
- HCN, HCO^+ J=1-0が使われるが低密度でも厚くなる → 同位体で確認したい。
- ALMA large, ATOMSのACA（銀河面クランプ>0.2 pc）、13"-60", dv=0.2-0.4 km/s, 50-90 mJy/beam。



コントア: 3 mm

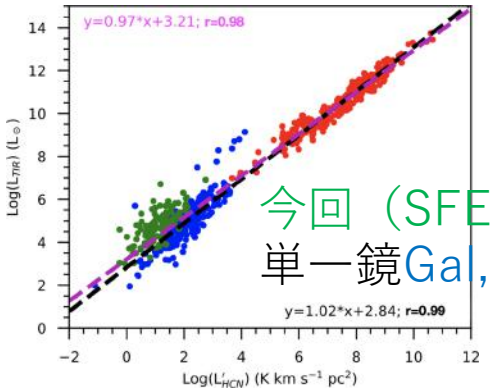
- free-freeを避けるためR_{eff}, M_{clump}は単一鏡（0.87, 1.2 mm）。
- 高密度トレーサーほど小さい。





- HCO^+は単一鏡と同じものを見ていて、$H^{13}CO^+$は小さい。

H13CO+
HCO+

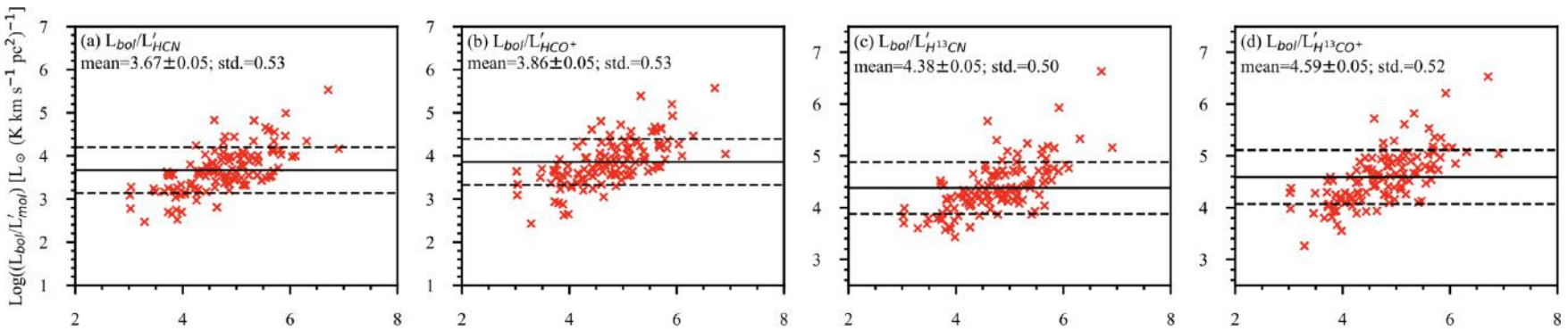


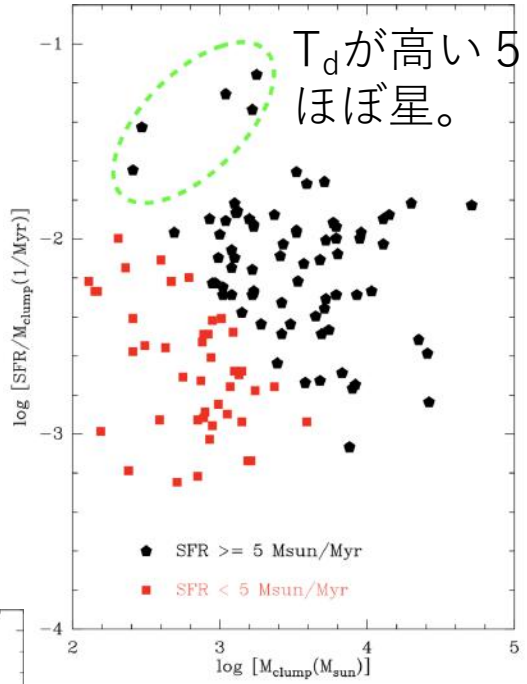
今回（SFEが高い、束縛）
単一鏡Gal, ex-gal

ATOMS: ALMA three-millimeter observations of massive star-forming regions – II. Compact objects in ACA observations and star formation scaling relations

の続き

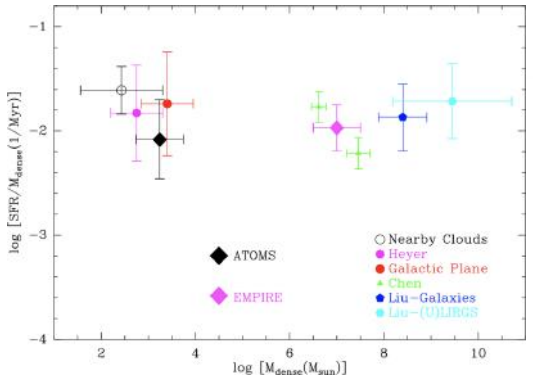
Tie Liu,[1,2,3★] Neal J. Evans,[2,4] Kee-Tae Kim,[2,5] Paul F. Goldsmith,[6]
Sheng-Yuan Liu,[7] Qizhou Zhang,[8] Ken'ichi Tatematsu,[9] Ke Wang,[10] Mika Juvela,[11]





T_dが高い５個ほぼ星。

- L_{bol}/L_{mol}が４つの分子で似ている
  → dg-sf lawは光学的厚さの影響を受けない。
- HCN/H^{13}CNとHCO^+/$H^{13}CO^+$が似ている → τが同じ（~12, 11）。
- L_{bol}に対する増加は進化（← T_dに対しても増加）。
- FUVを反映するHCN/HCO^+はATOMSサンプルでは銀河中心からの距離（環境）には依らない。



- L_{bol}, L_{TIR}からSFRを求めてMで割る → SFE。
- SFEに傾向はないが、暗い（軽い）ものはSFRが小さい。
- SFEの値は近傍の雲や遠方銀河と同じ。

The dependence of episodic accretion on eccentricity during the formation of binary stars

Rajika L. Kuruwita[1], Christoph Federrath[2], and Troels Haugbølle[1]

ABSTRACT

Context. Episodic accretion has been observed in short-period binaries, where bursts of accretion occur at periastron. The binary trigger hypothesis has also been suggested as a driver for accretion during protostellar stages.
Aims. Our goal is to investigate how the strength of episodic accretion bursts depends on eccentricity.
Methods. We investigate the binary trigger hypothesis in longer-period (>20 yr) binaries by carrying out three-dimensional magneto-hydrodynamical simulations of the formation of low-mass binary stars down to final separations of ∼10 AU, including the effects of gas turbulence and magnetic fields. We ran two simulations with an initial turbulent gas core of one solar mass each and two different initial turbulent Mach numbers, $\mathcal{M} = \sigma_v/c_s = 0.1$ and $\mathcal{M} = 0.2$, for 6500 yr after protostar formation.
Results. We observe bursts of accretion at periastron during the early stages when the eccentricity of the binary system is still high. We find that this correlation between bursts of accretion and passing periastron breaks down at later stages because of the gradual circularisation of the orbits. For eccentricities greater than $e = 0.2$, we observe episodic accretion triggered near periastron. However, we do not find any strong correlation between the strength of episodic accretion and eccentricity. The strength of accretion is defined as the ratio of the burst accretion rate to the quiescent accretion rate. We determine that accretion events are likely triggered by torques between the rotation of the circumstellar disc and the approaching binary stars. We compare our results with observational data of episodic accretion in short-period binaries and find good agreement between our simulations and the observations.
Conclusions. We conclude that episodic accretion is a universal mechanism operating in eccentric young binary-star systems, independent of separation, and it should be observable in long-period binaries as well as in short-period binaries. Nevertheless, the strength depends on the torques and hence the separation at periastron.

連星で起きるaccretion burstの強さは離心率とは関係なく、近星点の距離で決まる。

The large-scale magnetic field of the eccentric pre-main-sequence binary system V1878 Ori

A. Lavail [1]★ O. Kochukhov,[1] G. A. J. Hussain,[2] C. Argiroffi,[3,4] E. Alecian,[5] J. Morin[6] and the BinaMIcS collaboration

ABSTRACT

We report time-resolved, high-resolution optical spectropolarimetric observations of the young double-lined spectroscopic binary V1878 Ori. Our observations were collected with the ESPaDOnS spectropolarimeter at the Canada–France–Hawaii Telescope through the BinaMIcS large programme. V1878 Ori A and B are partially convective intermediate mass weak-line T Tauri stars on an eccentric and asynchronous orbit. We also acquired X-ray observations at periastron and outside periastron. Using the least-squares deconvolution technique (LSD) to combine information from many spectral lines, we clearly detected circular polarization signals in both components throughout the orbit. We refined the orbital solution for the system and obtained disentangled spectra for the primary and secondary components. The disentangled spectra were then employed to determine atmospheric parameters of the two components using spectrum synthesis. Applying our Zeeman Doppler imaging code to composite Stokes *IV* LSD profiles, we reconstructed brightness maps and the global magnetic field topologies of the two components. We find that V1878 Ori A and B have strikingly different global magnetic field topologies and mean field strengths. The global magnetic field of the primary is predominantly poloidal and non-axisymmetric (with a mean field strength of 180 G). While the secondary has a mostly toroidal and axisymmetric global field (mean strength of 310 G). These findings confirm that stars with very similar parameters can exhibit radically different global magnetic field characteristics. The analysis of the X-ray data shows no sign of enhanced activity at periastron, suggesting the lack of strong magnetospheric interaction at this epoch.

離心率の高いWTTSの連星の円偏光。主星はポロイダル。伴星はトロイダル。相互作用なし。

Protostellar collapse: the conditions to form dust rich protoplanetary disks.

U. Lebreuilly[1], B. Commerçon[1], and G. Laibe[1]

ABSTRACT

Context. Dust plays a key role during star, disk and planet formation. Yet, its dynamics during the protostellar collapse remains a poorly investigated field. Recent studies seem to indicate that dust may decouple efficiently from the gas during these early stages.
Aims. We aim to understand how much and in which regions dust grains concentrate during the early phases of the protostellar collapse, and see how it depends on the properties of the initial cloud and of the solid particles.
Methods. We use the multiple species dust dynamics solver MULTIGRAIN of the grid-based code RAMSES to perform various simulations of dusty collapses. We perform hydrodynamical and magnetohydrodynamical simulations where we vary the maximum size of the dust distribution, the thermal-to-gravitational energy ratio and the magnetic properties of the cloud. We simulate the simultaneous evolution of ten neutral dust grains species with grain sizes varying from a few nanometers to a few hundredth of microns.
Results. We obtain a significant decoupling between the gas and the dust for grains of typical sizes a few ~ 10 μm. This decoupling strongly depends on the thermal-to-gravitational energy ratio, the grain sizes or the inclusion of a magnetic field. With a semi-analytic model calibrated on our results, we show that the dust ratio mostly varies exponentially with the initial Stokes number at a rate that depends on the local cloud properties.
Conclusions. We find that larger grains tend to settle and drift efficiently in the first-core and in the newly formed disk. This can produce dust-to-gas ratios of several times the initial value. Dust concentrates in high density regions (cores, disk and pseudo-disk) and is depleted in low density regions (envelope and outflows). The size at which grains decouple from the gas depends on the initial properties of the clouds. Since dust can not necessarily be used as a proxy for gas during the collapse, we emphasize on the necessity of including the treatment of its dynamics in protostellar collapse simulations.

ダストサイズ、圧力β、磁場などを変えてダストとガスの乖離度合いを調べた。
エンベロープ、分子流よりコア、円盤に集中。つまりガス分布と違う。

THE MOLECULAR CLOUDS ASSOCIATED WITH THE H II REGIONS/CANDIDATES BETWEEN $L = 207.7°$ AND $L = 211.7°$

Chong Li,[1,2] Hongchi Wang,[1,3] Miaomiao Zhang,[1] Yuehui Ma,[1,2] and Lianghao Lin[1,3]

ABSTRACT

Using the PMO-13.7 m millimeter telescope at Delingha in China, we have conducted a large-scale simultaneous survey of ^{12}CO, ^{13}CO, and C^{18}O $J = 1 - 0$ emission toward the sky region centered at l=209.7°, b=−2.25° with a coverage of 4.0° × 4.5°. The majority of the emission in the region comes from the clouds with velocities lying in the range from −3 km s^{-1} to 55 km s^{-1}, at kinematic distances from 0.5 kpc to 7.0 kpc. The molecular clouds in the region are concentrated into three velocity ranges. The molecular clouds associated with the ten H II regions/candidates are identified and their physical properties are presented. Massive stars are found within Sh2-280, Sh2-282, Sh2-283, and BFS54, and we suggest them to be the candidate excitation sources of the H II regions. The distributions of excitation temperature and line width with the projected distance from the center of H II region/candidate suggest that the majority of the ten H II regions/candidates and their associated molecular gas are three-dimensional structures, rather than two-dimensional structures.

COサーベイ。分子雲は３個の速度に集中。HII領域に付随する分子雲と大質量星。
励起温度、線幅はHII領域と分子雲の３次元構造を示唆。

Steady Wind-blown Cavities within Infalling Rotating Envelopes: Application to the Broad Velocity Component in Young Protostars

Lịchen Liang[1], Doug Johnstone[2,3], Sylvie Cabrit[4], and Lars E. Kristensen[5]

Abstract

Wind-driven outflows are observed around a broad range of accreting objects throughout the universe, ranging from forming low-mass stars to supermassive black holes. We study the interaction between a central isotropic wind and an infalling, rotating envelope, which determines the steady-state cavity shape formed at their interface under the assumption of weak mixing. The shape of the resulting wind-blown cavity is elongated and self-similar, with a physical size determined by the ratio between wind ram pressure and envelope thermal pressure. We compute the growth of a warm turbulent mixing layer between the shocked wind and the deflected envelope, and calculate the resultant broad-line profile, under the assumption of a linear (Couette-type) velocity profile across the layer. We then test our model against the warm broad velocity component observed in CO $J = 16$–15 by Herschel/HIFI in the protostar Serpens-Main SMM1. Given independent observational constraints on the temperature and density of the dust envelope around SMM1, we find an excellent match to all its observed properties (line profile, momentum, temperature) and to the SMM1 outflow cavity width for a physically reasonable set of parameters: a ratio of wind to infall mass flux of $\simeq$4%, a wind speed of $v_{\rm w} \simeq 30$ km s^{-1}, an interstellar abundance of CO and H_2, and a turbulent entrainment efficiency consistent with laboratory experiments. The inferred ratio of ejection to disk accretion rate, $\simeq$6%–20%, is in agreement with current disk wind theories. Thus, the model provides a new framework to reconcile the modest outflow cavity widths in protostars with large observed flow velocities. Being self-similar, it is applicable over a broader range of astrophysical contexts as well.

等方風と回転落下エンベロープの相互作用から自己相似なキャビティを導出。

ALMA observations of envelopes around first hydrostatic core candidates

María José Maureira,[1,2⋆] Héctor G. Arce,[1] Michael M. Dunham,[3,4] Diego Mardones,[5,2] Andrés E. Guzmán,[6], Jaime E. Pineda,[2] and Tyler L. Bourke, [7,3]

ABSTRACT

We present ALMA 3 mm molecular line and continuum observations with a resolution of ~3.5" towards five first hydrostatic core (FHSC) candidates (L1451-mm, Per-bolo 58, Per-bolo 45, L1448-IRS2E and Cha-MMS1). Our goal is to characterize their envelopes and identify the most promising sources that could be bona fide FHSCs. We identify two candidates which are consistent with an extremely young evolutionary state (L1451-mm and Cha-MMS1), with L1451-mm being the most promising FHSC candidate. Although our envelope observations cannot rule out Cha-MMS1 as a FHSC yet, the properties of its CO outflow and SED published in recent studies are in better agreement with the predictions for a young protostar. For the remaining three sources, our observations favor a prestellar nature for Per-bolo 45 and rule out the rest as FHSC candidates. Per-bolo 58 is fully consistent with being a Class 0, while L1448 IRS2E shows no emission of high-density tracers (NH_2D and N_2H^+) at the location of the previously identified compact continuum source, which is also undetected in our observations. Thus we argue that there is no embedded source at the presumptive location of the FHSC candidate L1448 IRS2E. We propose instead, that what was thought to be emission from the presumed L1448 IRS2E outflow corresponds to outflow emission from a nearby Class 0 system, deflected by the dense ambient material. We compare the properties of the FHSC candidates studied in this work and the literature, which shows that L1451-mm appears as possibly the youngest source with a confirmed outflow.

５個のファーストコア候補のALMA 3 mm。
エンベロープからL1451-mmが最有力。Cha-MMS1とPer-bolo 58は原始星。Per-bolo 45とL1448 IRS2Eはprestellar。