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32 JCMT BISTRO Survey observations of the Ophiuchus Molecular Cloud: Dust grain alignment properties inferred using a Ricean noise model

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33 Vortex instabilities triggered by low-mass planets in pebble-rich, inviscid protoplanetary discs

A. Pierens[1], M.-K. Lin[2], S.N. Raymond[1]

34 The Duration of Star Formation in Galactic Giant Molecular Clouds. I. The Great Nebula in Carina

Matthew S. Povich[1], Jessica T. Maldonado[1], Evan Haze Nuez[1] and Thomas P. Robitaille[2]

35 Gas accretion within the dust cavity in AB Aur

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36 Pebble-driven planet formation for TRAPPIST-1 and other compact systems

Djoeke Schoonenberg[1], Beibei Liu[2], Chris W. Ormel[1], and Caroline Dorn[3]

37 The Physical and chemical structure of Sagittarius B2 – IV. Converging filaments in the high-mass cluster forming region Sgr B2(N)

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JCMT BISTRO Survey observations of the Ophiuchus Molecular Cloud: Dust grain alignment properties inferred using a Ricean noise model

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The dependence of polarization fraction p on total intensity I in polarized submillimeter emission measurements is typically parameterized as $p \propto I^{-\alpha}$ ($\alpha \leq 1$), and used to infer dust grain alignment efficiency in star-forming regions, with an index $\alpha = 1$ indicating near-total lack of alignment of grains with the magnetic field. In this work we demonstrate that the non-Gaussian noise characteristics of polarization fraction may produce apparent measurements of $\alpha \sim 1$ even in data with significant signal-to-noise in Stokes Q, U and I emission, and so with robust measurements of polarization angle. We present a simple model demonstrating this behavior, and propose a criterion by which well-characterized measurements of polarization fraction may be identified. We demonstrate that where our model is applicable, α can be recovered by fitting the $p-I$ relationship with the mean of the Rice distribution, without statistical debiasing of polarization fraction. We apply our model to JCMT BISTRO Survey POL-2 850μm observations of three clumps in the Ophiuchus Molecular Cloud, finding that in the externally-illuminated Oph A region, $\alpha \approx 0.34$, while in the more isolated Oph B and C, despite their differing star formation histories, $\alpha \sim 0.6 - 0.7$. Our results thus suggest that dust grain alignment in dense gas is more strongly influenced by incident interstellar radiation field than by star formation history. We further find that grains may remain aligned with the magnetic field at significantly higher gas densities than has previously been believed, thus allowing investigation of magnetic field properties within star-forming clumps and cores.

パラメータαに注目, α~0:各optical depth で同程度ダストが磁場にalign, α~1:表面のみ整列し変更に寄与
BISTROの結果からOpniuchus のαを見る

・dense gas での整列は、internal irradiation よりexternal irradiation の影響の方が大きい
・これまで想定していたより、より高密度領域でも磁場に整列している→星形成コアにも使える

33

Vortex instabilities triggered by low-mass planets in pebble-rich, inviscid protoplanetary discs

A. Pierens[1], M.-K. Lin[2], S.N. Raymond[1]

In the innermost regions of protoplanerary discs, the solid-to-gas ratio can be increased considerably by a number of processes, including photoevaporative and particle drift. MHD disc models also suggest the existence of a dead-zone at $R \lesssim 10$ AU, where the regions close to the midplane remain laminar. In this context, we use two-fluid hydrodynamical simulations to study the interaction between a low-mass planet ($\sim 1.7\ M_\oplus$) on a fixed orbit and an inviscid pebble-rich disc with solid-to-gas ratio $\epsilon \geq 0.5$. For pebbles with Stokes numbers $St = 0.1,\ 0.5$, multiple dusty vortices are formed through the Rossby Wave Instability at the planet separatrix. Effects due to gas drag then lead to a strong enhancement in the solid-to-gas ratio, which can increase by a factor of $\sim 10^3$ for marginally coupled particles with $St = 0.5$. As in streaming instabilities, pebble clumps reorganize into filaments that may plausibly collapse to form planetesimals. When the planet is allowed to migrate in a MMSN disc, the vortex instability is delayed due to migration but sets in once inward migration stops due a strong positive pebble torque. Again, particle filaments evolving in a gap are formed in the disc while the planet undergoes an episode of outward migration. Our results suggest that vortex instabilities triggered by low-mass planets could play an important role in forming planetesimals in pebble-rich, inviscid discs, and may significantly modify the migration of low-mass planets. They also imply that planetary dust gaps may not necessarily contain planets if these migrated away.

低質量惑星（~1.7Me）とペブルリッチ円盤(solid/gas>0.5)の相互作用 (inviscid)

St=0.1, 0.5 : 複数のdusty vortices がRWIで形成　solid/gasが10^3 大きくなる(St=0.5)

期待されること

　フィラメント状→微惑星形成

　ペブルからの正のトルクでmigration が止まる→惑星が外へ移動

The Duration of Star Formation in Galactic Giant Molecular Clouds. I. The Great Nebula in Carina

Matthew S. Povich[1], Jessica T. Maldonado[1], Evan Haze Nuez[1] and Thomas P. Robitaille[2]

We present a novel infrared spectral energy distribution (SED) modeling methodology that uses likelihood-based weighting of the model fitting results to construct probabilistic H–R diagrams (pHRD) for X-ray identified, intermediate-mass (2–8 $M_\odot$), pre-main sequence young stellar populations. This methodology is designed specifically for application to young stellar populations suffering strong, differential extinction ($\Delta A_V > 10$ mag), typical of Galactic massive star-forming regions. We pilot this technique in the Carina Nebula Complex (CNC) by modeling the 1–8 μm SEDs of 2269 likely stellar members that exhibit no excess emission from circumstellar dust disks at 4.5 μm or shorter wavelengths. A subset of ~100 intermediate-mass stars in the lightly-obscured Trumpler 14 and 16 clusters have available spectroscopic $T_{\rm eff}$, measured from the Gaia-ESO survey. We correctly identify the stellar temperature in 70% of cases, and the aggregate pHRD for all sources returns the same peak in the stellar age distribution as obtained using the spectroscopic $T_{\rm eff,S}$. The SED model parameter distributions of stellar mass and evolutionary age reveal significant variation in the duration of star formation among four large-scale stellar overdensities within the CNC and a large distributed stellar population. Star formation began ~10 Myr ago and continues to the present day, with the star formation rate peaking <3 Myr ago when the massive Trumpler 14 and 16 clusters formed. We make public the set of 100,000 SED models generated from standard pre-main sequence evolutionary tracks and our custom software package for generating pHRDs and mass-age distributions from the SED fitting results.

SEDモデリングの新しい手法をCarina Nebula complexに適用

Gaia-ESO survey からTeff が分かっているものについて、この手法から70%の天体で星のパラメータを正しく推定できた。

星形成は~10Myr 前から始まり、<3Myr 前で星形成率が最大となる。

35

Gas accretion within the dust cavity in AB Aur

Pablo Riviére-Marichalar[1], Asunción Fuente[1], Clément Baruteau[2], Roberto Neri[3], Sandra P. Treviño-Morales[4], Andrés Carmona[2], Marcelino Agúndez[5] and Rafael Bachiller[1]

AB Aur is a Herbig Ae star hosting a well-known transitional disk. Because of its proximity and low inclination angle, it is an excellent object to study planet formation. Our goal is to investigate the chemistry and dynamics of the molecular gas component in the AB Aur disk, and its relation with the prominent horseshoe shape observed in continuum mm emission. We used the NOEMA interferometer to map with high angular resolution the $J = 3$–2 lines of HCO^+ and HCN. By combining both, we can gain insight into the AB Aur disk structure. Chemical segregation is observed in the AB Aur disk: HCO^+ shows intense emission toward the star position, at least one bright molecular bridge within the dust cavity, and ring-like emission at larger radii, while HCN is only detected in an annular ring that is coincident with the dust ring and presents an intense peak close to the dust trap. We use HCO^+ to investigate the gas dynamics inside the cavity. The observed bright HCO^+ bridge connects the compact central source with the outer dusty ring. This bridge can be interpreted as an accretion flow from the outer ring to the inner disk/jet system proving gas accretion through the cavity.

NOEMAによるAB Aurの観測。HCO+ と HCN (J=3-2)
HCO+ : ダストギャップ中にbridge、半径の大きなリング
HCN: ダストリングと一致するリング構造

HCO+のbridge:outer dusty ring とinner disk/jet をつなぐ降着流

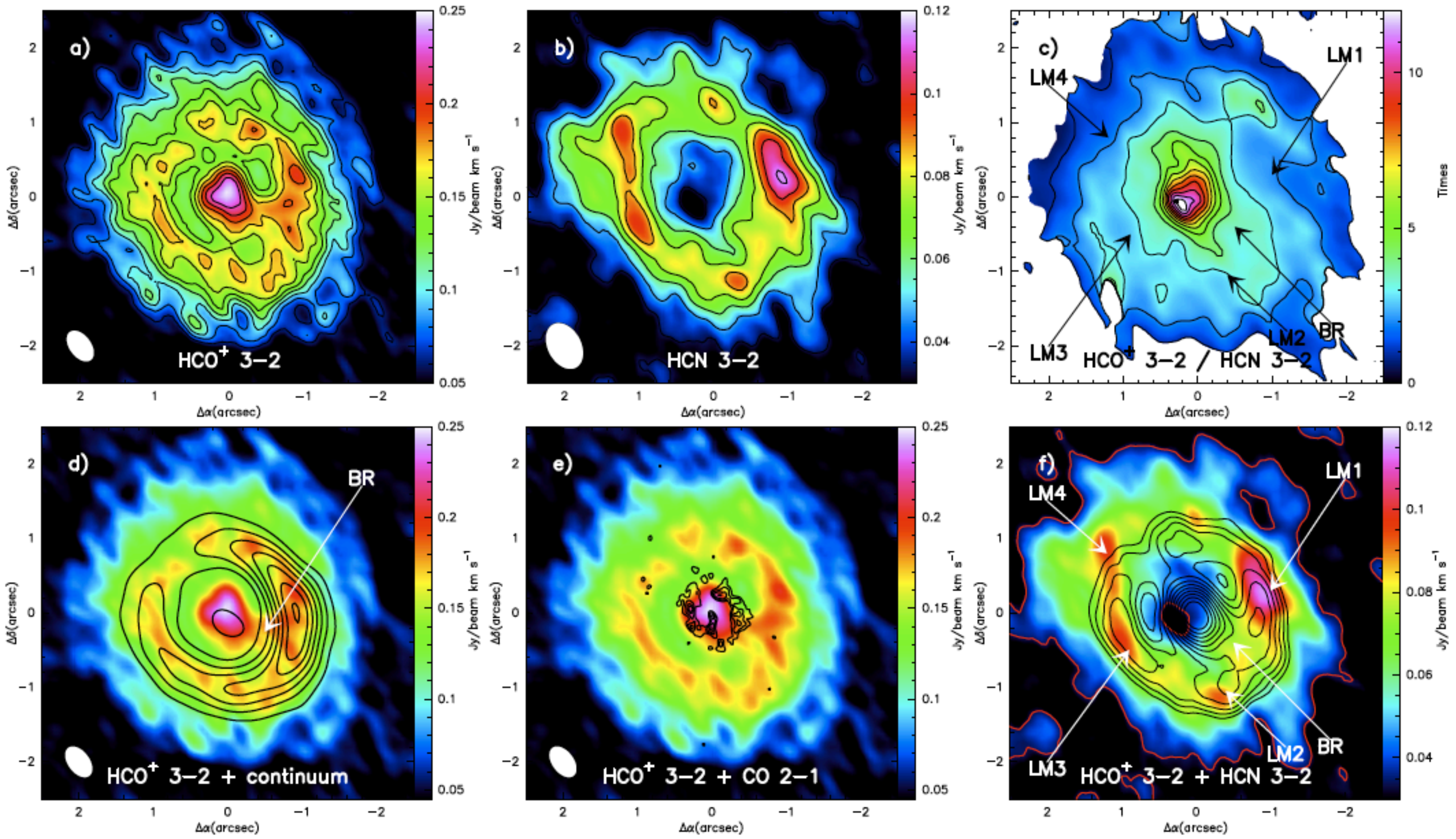
AB Aur

Herbig Ae 型星（~163pc）遷移円盤をもつ

渦状腕構造、ダストギャップなどが観測されている。

HCO+とHCNでダイナミクスを探る。

NOEMA 分解能 0.”4, ~60 au



HCN

・リング構造のみ観測(>5σ)

・ダストとよく合う

HCO+

・リングだけでなく、中心星付近に明るい成分

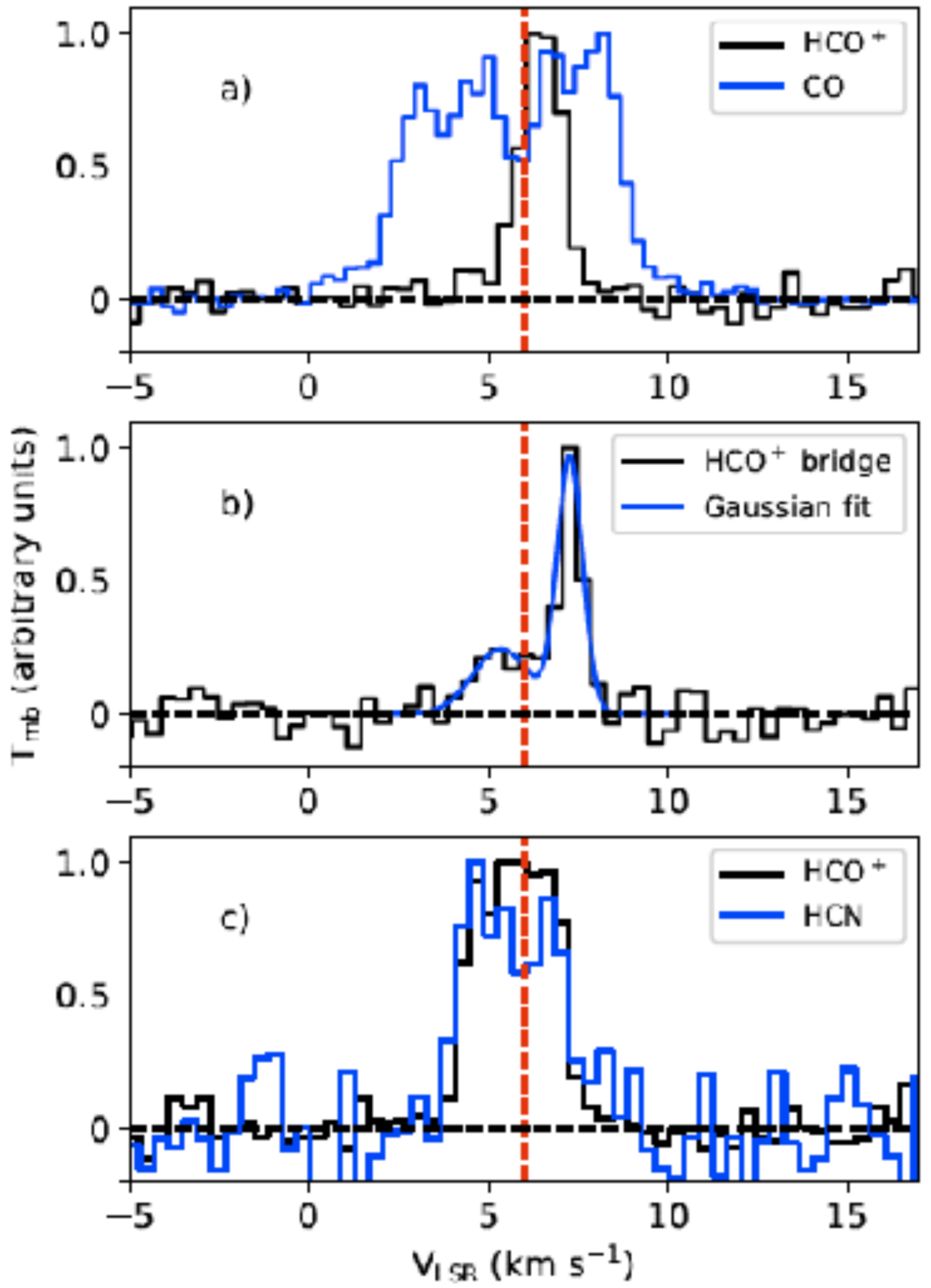
・リングと中心をつなぐbridge 構造も存在

・大ダストの分布をトレース

LM1がダストピークとの位置と一致

LM2-4 はノイズの可能性あり

領域ごとに積分したline profile

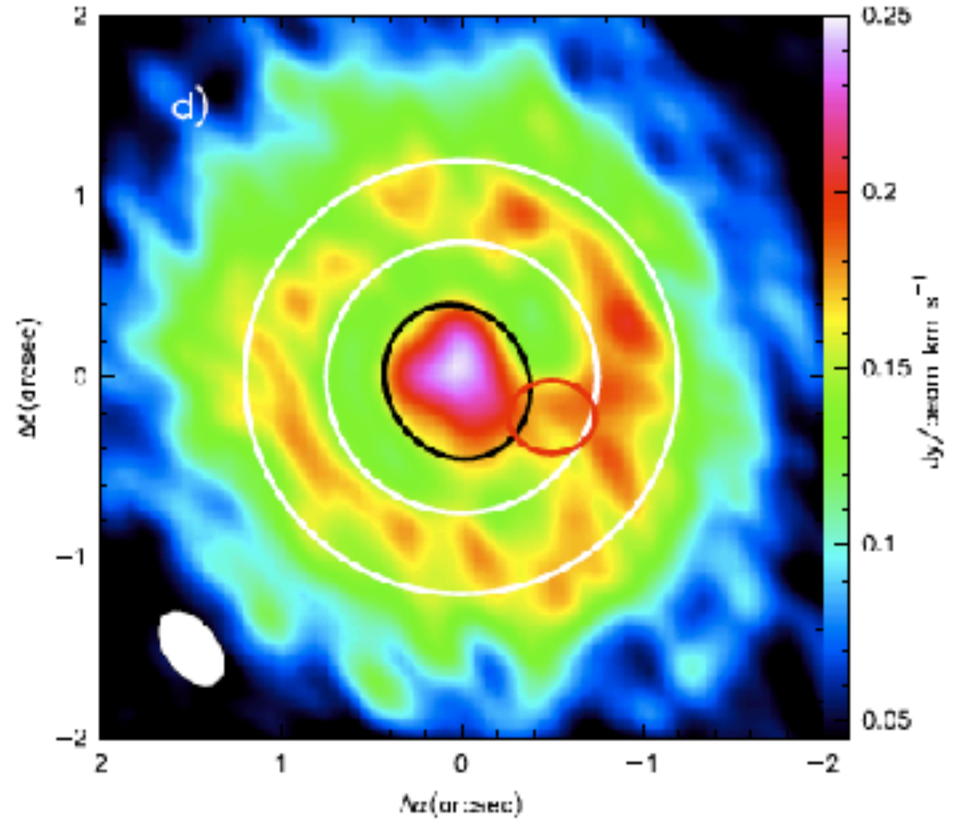


積分領域

中心（黒）

bridge（赤）

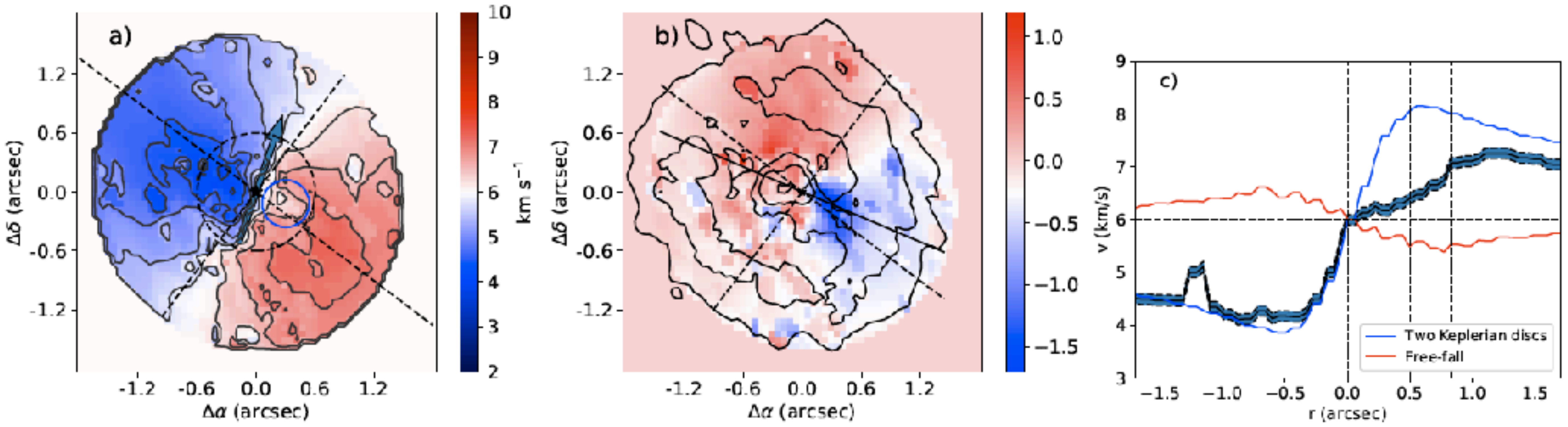
リング（白）



bridge の profile は中心と異なる

中心の成分のビームによるelongation ではない

HCO+ のmoment 1 map



(a) 内側0.”6でねじれ。二つのケプラー回転円盤でよく近似できる

(b)残差を見ると、ブリッジ構造付近で大きなズレが残る。

(c)ブリッジの位置でfreefall を仮定するとズレを説明できる。

　ブリッジでの降着率は $3x10^{-8\sim-7}$ Msun/yr

HCO+/HCN がギャップ中のdust cavity 中のdense gas の指標になる

　dust cavity 中では中心星からのUV irradiation 大

　HCO+はその環境でも観測される数少ないline の一つ

　HD142527などでも高いHCO+/HCN比が得られている。

36 Pebble-driven planet formation for TRAPPIST-1 and other compact systems

Djoeke Schoonenberg[1], Beibei Liu[2], Chris W. Ormel[1], and Caroline Dorn[3]

Recently, seven Earth-sized planets were discovered around the M-dwarf star TRAPPIST-1. Thanks to transit-timing variations, the masses and therefore the bulk densities of the planets have been constrained, suggesting that all TRAPPIST-1 planets are consistent with water mass fractions on the order of 10%. These water fractions, as well as the similar planet masses within the system, constitute strong constraints on the origins of the TRAPPIST-1 system. In a previous work, we outlined a pebble-driven formation scenario. In this paper we investigate this formation scenario in more detail. We used a Lagrangian smooth-particle method to model the growth and drift of pebbles and the conversion of pebbles to planetesimals through the streaming instability. We used the N-body code *MERCURY* to follow the composition of planetesimals as they grow into protoplanets by merging and accreting pebbles. This code is adapted to account for pebble accretion, type-I migration, and gas drag. In this way, we modelled the entire planet formation process (pertaining to planet masses and compositions, not dynamical configuration). We find that planetesimals form in a single, early phase of streaming instability. The initially narrow annulus of planetesimals outside the snowline quickly broadens due to scattering. Our simulation results confirm that this formation pathway indeed leads to similarly-sized planets and is highly efficient in turning pebbles into planets (~50% solids-to-planets conversion efficiency). The water content of planets resulting from our simulations is on the order of 10%, and our results predict a 'V-shaped' trend in the planet water fraction with orbital distance: from relatively high (innermost planets) to relatively low (intermediate planets) to relatively high (outermost planets).

transit-timing variation -> TRAPPIST-1planets のwater fraction ~10%

Pebble-driven formation scenario.

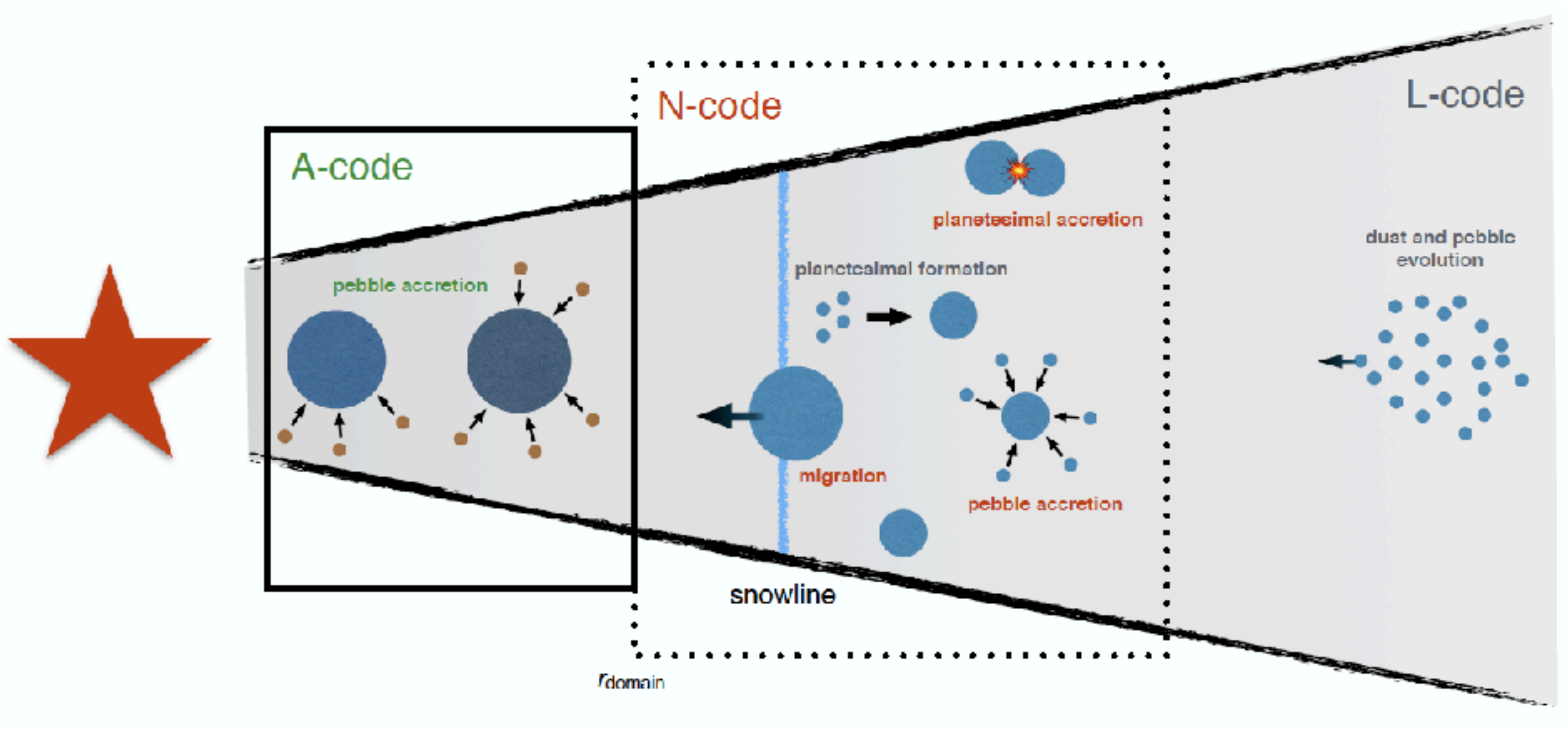
Lagrangian smooth-particle : pebble to planetesimal by SI

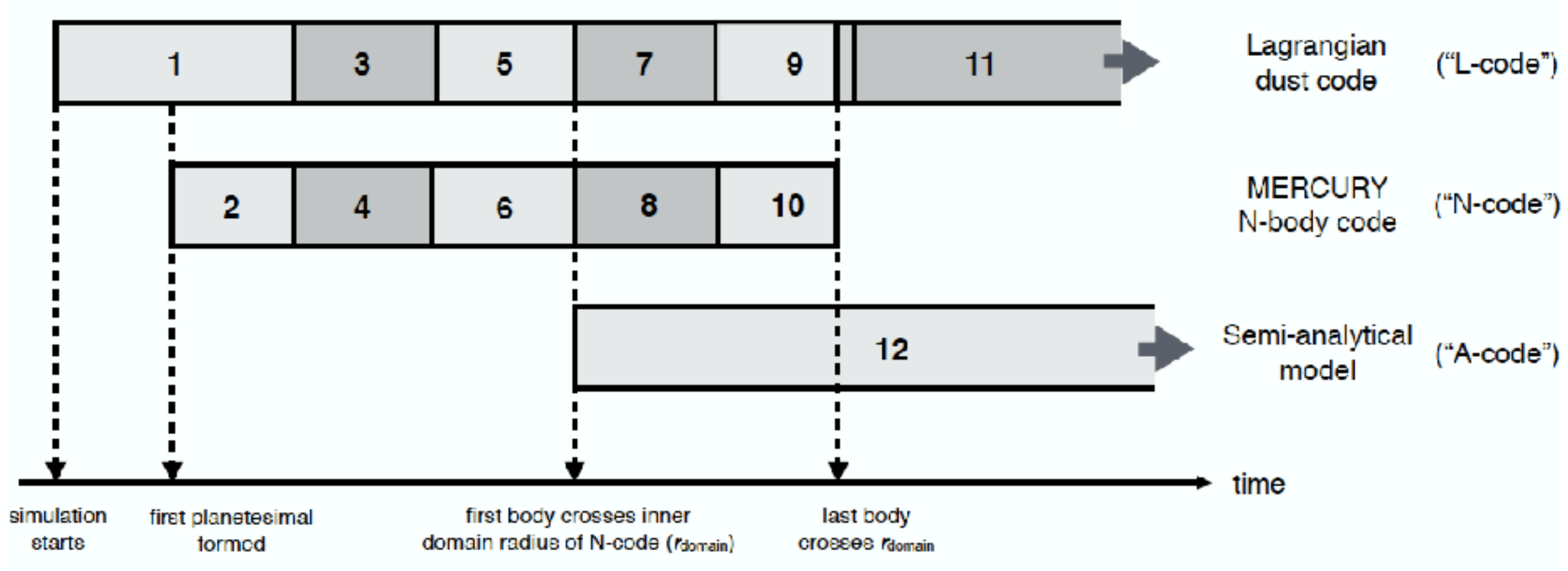
N-body code: 合体、pebble accretion での原始惑星形成、微惑星の組成の進化

微惑星は初期の一度のSIで形成(~snow line の外側)、微惑星リングが散乱で広がる

同程度サイズの惑星が形成、ペブルの~50%が惑星へ。water fraction ~10%, “V-shaped“ trend を予言

計算の概要





Lagrangian smooth-particle code でpebble の進化を計算

微惑星形成率

$$\frac{dM_{\rm pltsml}}{dt} = \max[\dot{M}_{\rm peb} - \dot{M}_{\rm peb,crit}, 0].$$

を与える

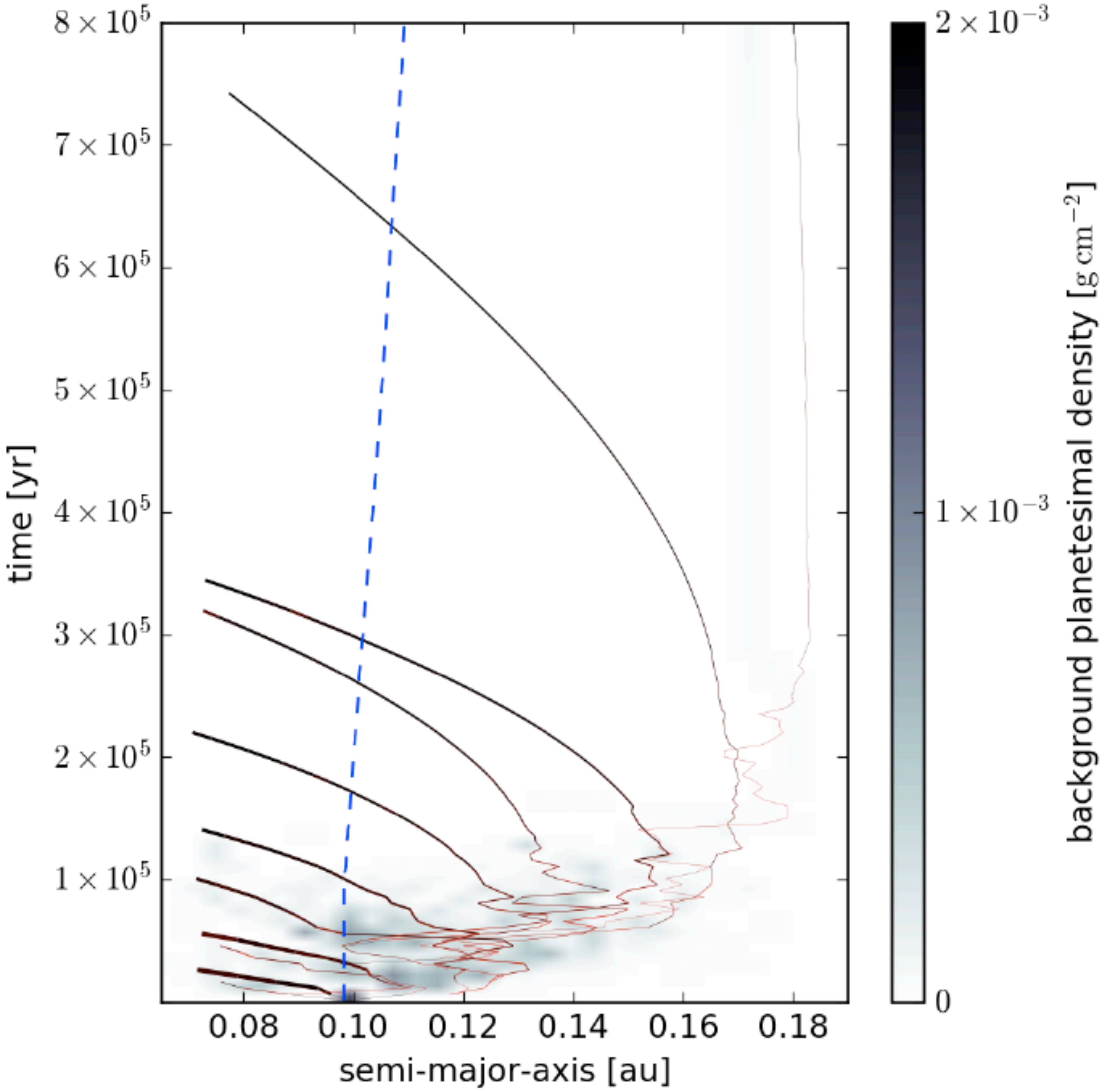
（Mpeb,crit はsnow line でSIを起こすのに必要な
ペブルフラックス）

微惑星の進化はN体計算　微惑星へのペブル降着も計算

微惑星の位置　r < r_domain=0.7r_snow の時、
semi-analytic code で計算（計算コスト削減のため）

結果の紹介

原始惑星の軌道進化

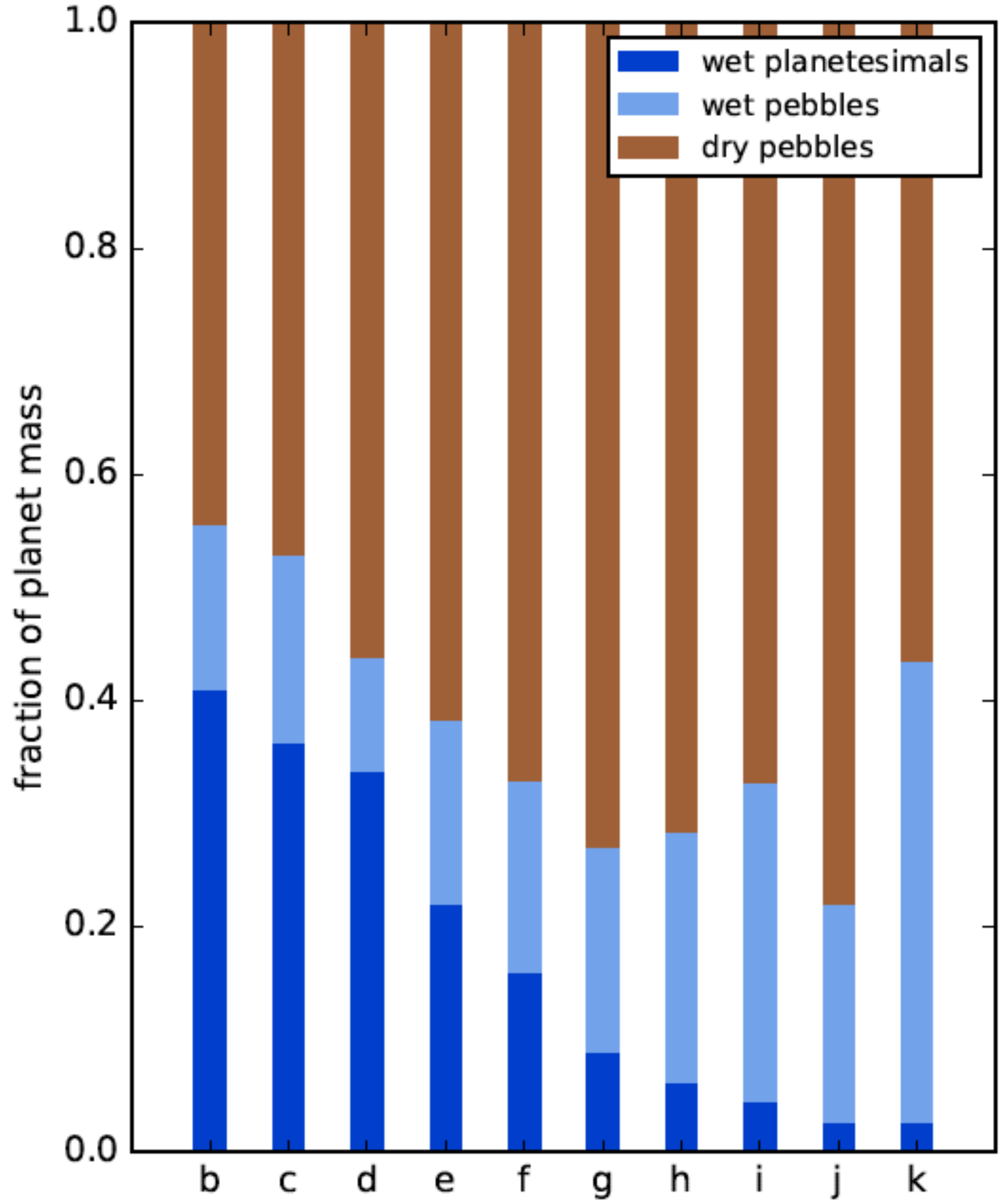


線の色：赤 eccentric , 黒 circular

太さ　：質量

グレー：planetesimal density

各惑星の組成



wet : 50% water

37 The Physical and chemical structure of Sagittarius B2 – IV. Converging filaments in the high-mass cluster forming region Sgr B2(N)

A. Schwörer[1], Á. Sánchez-Monge[1], P. Schilke[1], T. Möller[1], A. Ginsburg[2], F. Meng[1], A. Schmiedeke[3], H. S. P. Müller[1], D. Lis[4] and S. -L. Qin[5]

We have used an unbiased, spectral line-survey that covers the frequency range from 211 to 275 GHz and was obtained with ALMA (angular resolution of 0.4 arcsec) to study the small-scale structure of the dense gas in Sagittarius B2 (north). Eight filaments are found converging to the central hub and extending for about 0.1 pc. The spatial structure, together with the presence of the massive central region, suggest that these filaments may be associated with accretion processes. In order to derive the kinematic properties of the gas in a chemically line-rich source like SgrB2(N), we have developed a new tool that stacks all the detected transition lines of any molecular species. This permits to increase the signal-to-noise ratio of our observations and average out line blending effects, which are a common problem in line-rich regions. We derive velocity gradients along the filaments of about 20-100 km/s/pc, which are 10-100 times larger than those typically found on larger scales (1 pc) in other star-forming regions. The mass accretion rates of individual filaments are about 0.05 Msun/yr, which result in a total accretion rate of 0.16 Msun/yr. Some filaments harbor dense cores that are likely forming stars and stellar clusters. The stellar content of these dense cores is on the order of 50% of the total mass. We conclude that the cores may merge in the center when already forming stellar clusters but still containing a significant amount of gas, resulting in a ”damp” merger. The high density and mass of the central region, combined with the presence of converging filaments with high mass, high accretion rates and embedded dense cores already forming stars, suggest that SgrB2(N) may have the potential to evolve into a super stellar cluster.

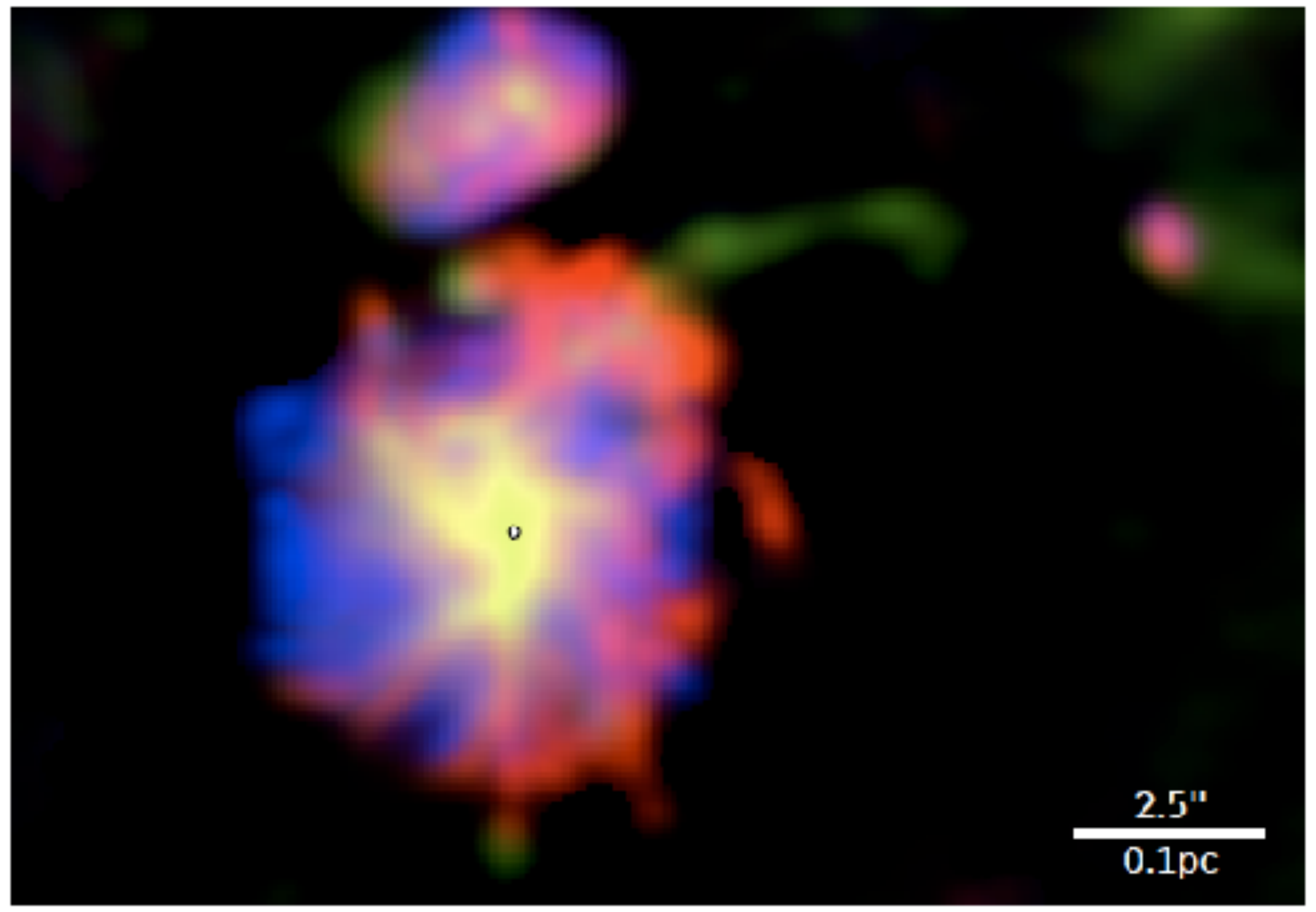
Sagittarius B2 (north)のALMA観測（分解能0.4 arcsec）

8本のfilament がひとつのhubにつながった構造~0.1pc, filament から降着か

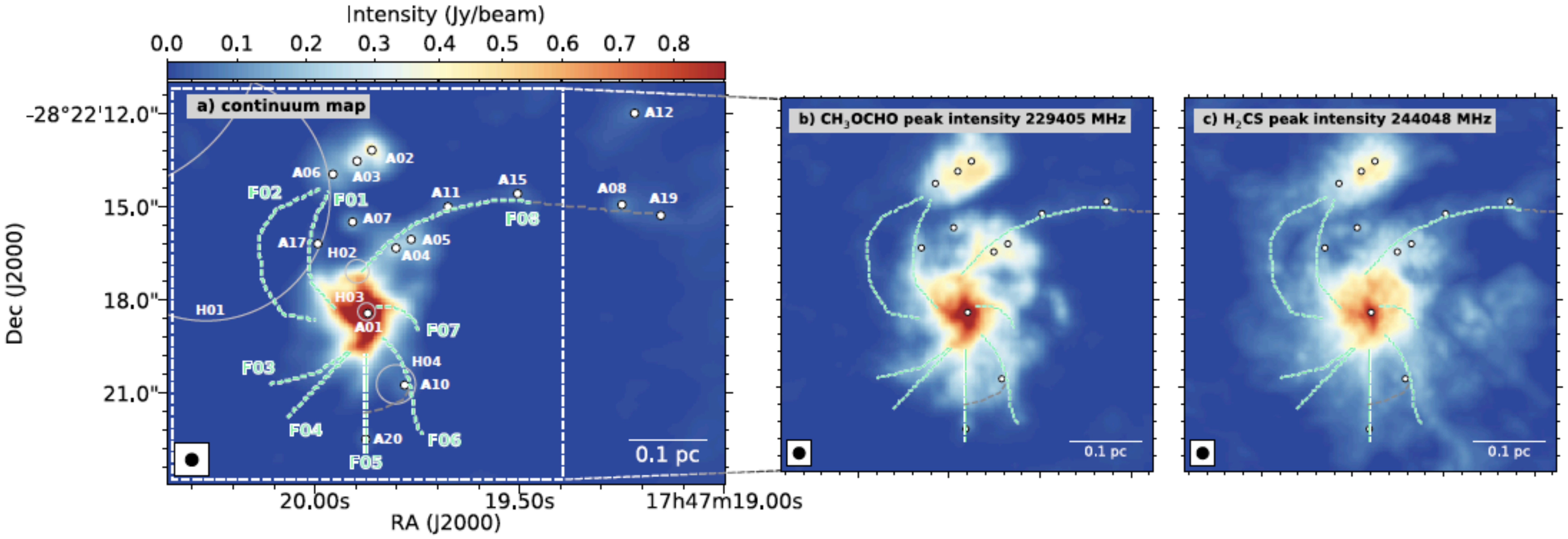
多数のラインをstacking して解析、mass accretion rate 0.05Msun/yr per filament, total 0.16Msun/yr

filament 中にstar forming core, mass ~50%

SgrB2(N)はsuper stellar cluster に進化する可能性

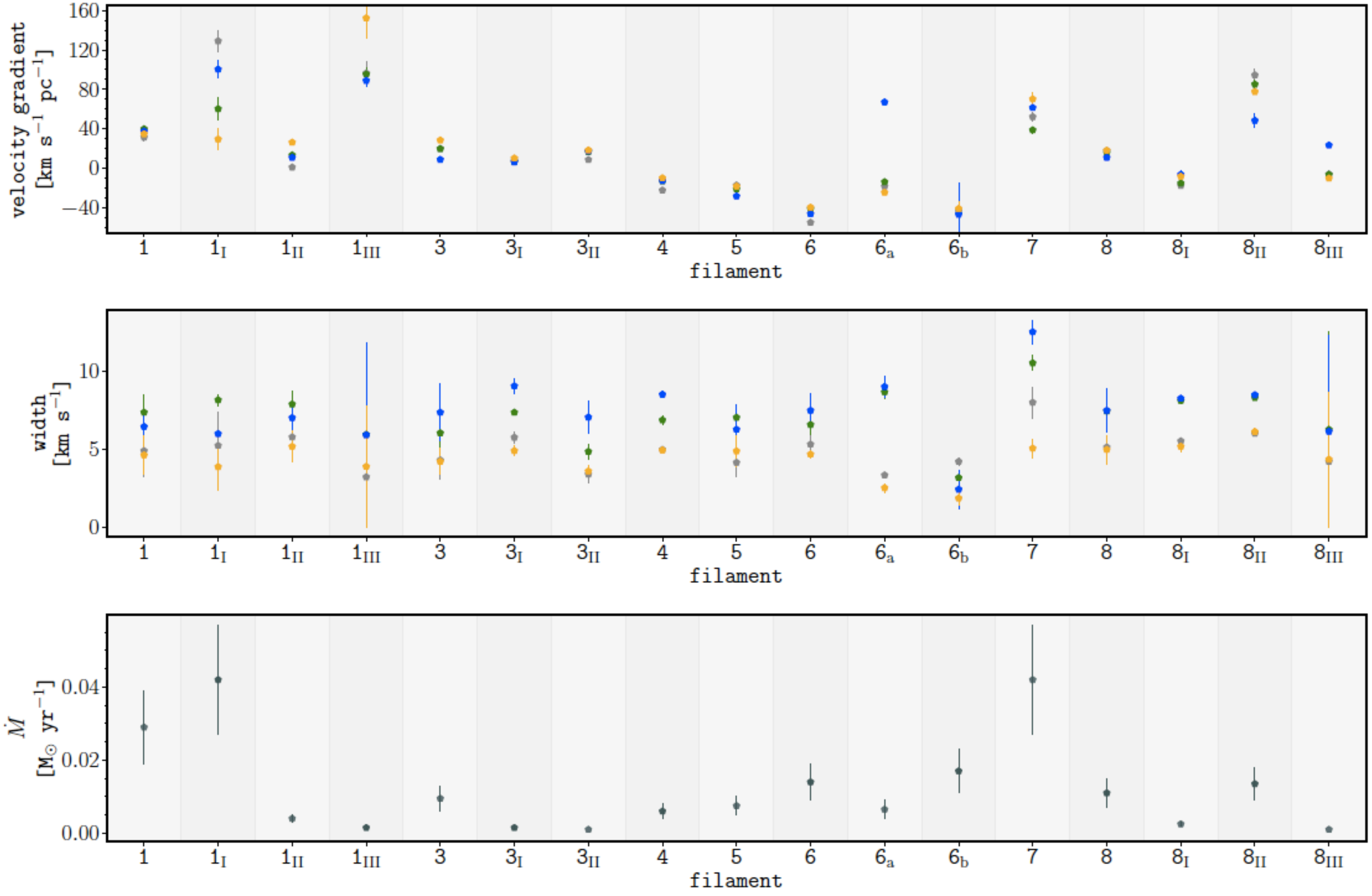


緑：242GHz continuum
赤：CH3OCHO
青：C2H5CN
continuum と CH3OCHO がfilamentary
C2H5CNはspherical or bubble-like



Filament :F01-F08
A01-20: 先行研究のcontinuum source

各フィラメントの速度勾配、line width、質量降着率



質量はダストから見積もる。
質量降着率は

$$\dot{M} = v_{\parallel} \cdot \frac{M_{\rm fil}}{L_{\rm fil}} = \nabla v_{\parallel} \cdot M_{\rm fil},$$