Star Formation Newsletter
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17 A Model for Protostellar Cluster Luminosities and the Impact on the CO-H_2 Conversion Factor

Brandt A.L. Gaches[1] and Stella S.R. Offner[1,2]

Cluster の光度のモデル構築、

$X_{\rm CO}$のcluster のパラメータに対する依存性を調べた

$$X_{\rm CO} = \frac{N_{\rm H_2}}{W_{\rm CO}},$$

モデル：星への降着で3種類

Inside out (Shu 1977)

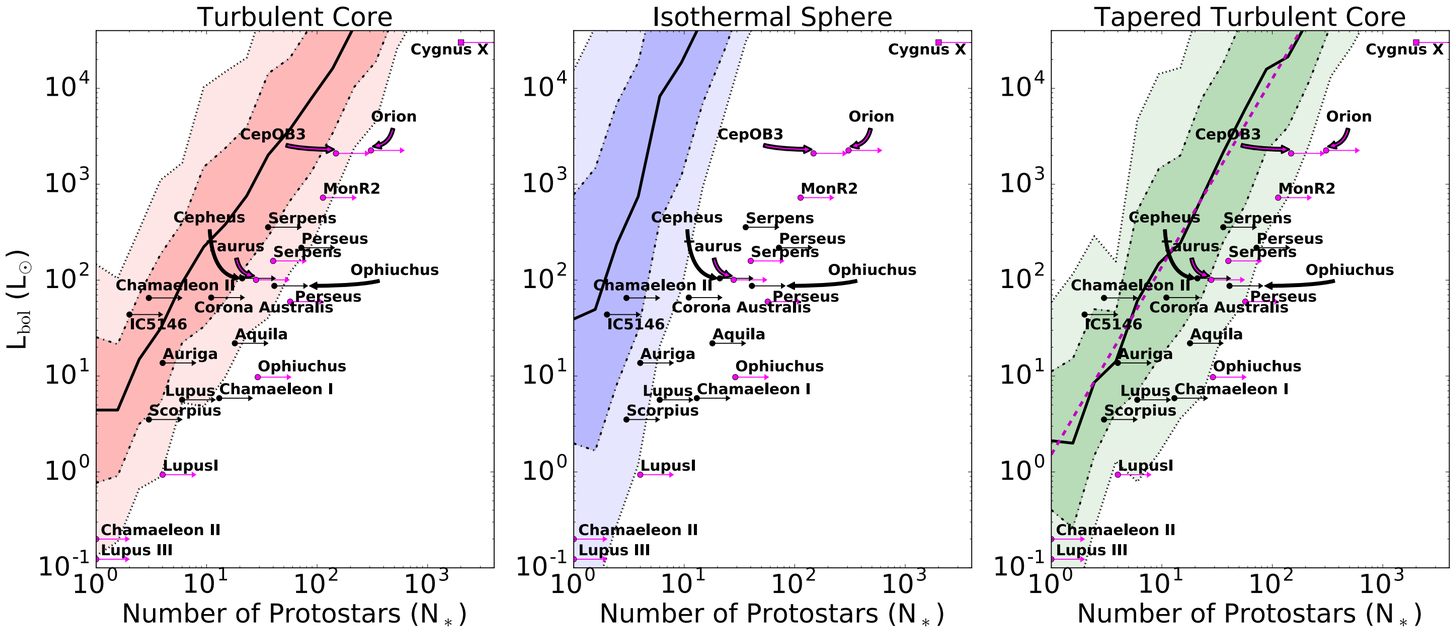
Turbulent Core (McKee & Tan 2003)

Tapered TC (Offner & McKee 2011)

降着率は温度のみに依存

Mstar 大ほど降着率大

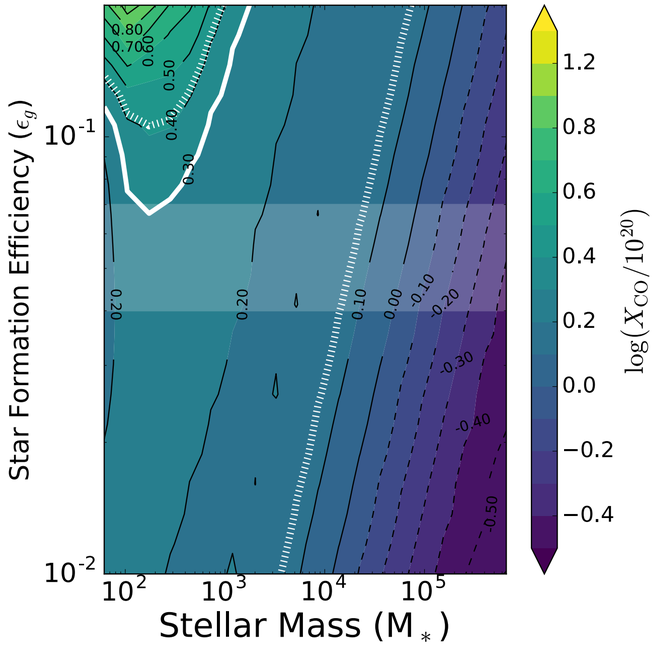
星形成が終了に近づくと降着率低下

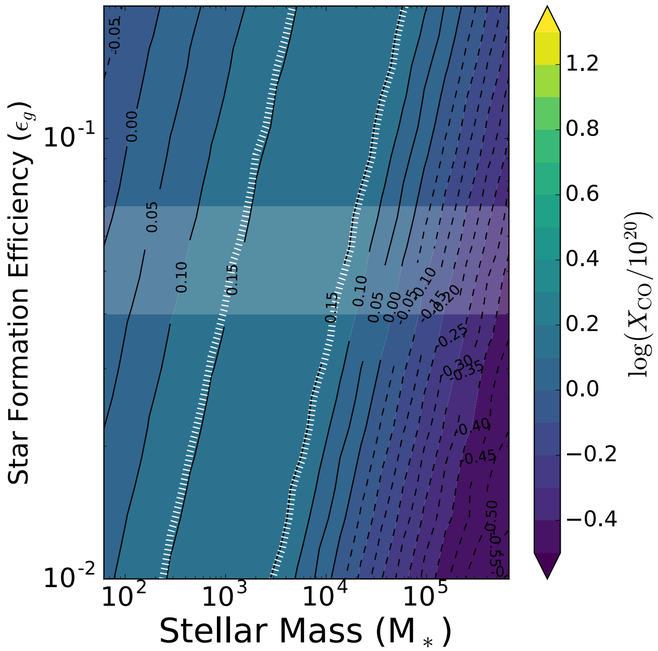


観測とモデルを比較

TTCが観測をもっとも良く再現

TCだとN~10-100で過大評価





星質量、星形成効率に対するXcoの依存性

白線：典型的なXco, 点線が30%error

白帯が典型的な星形成効率

X_{CO}：大きなClusterではMstar大で微減

Mstar大でFUV大

COのdissociation と温度の上昇がcancel してXcoの変化は小さい

efficiency 一定、Mstar大ならビリアル速度大

→線幅が広がりCOの積分強度が増加、Xcoが減少

上がCluster 内からのFUVを考慮、下では無視

典型的な値までXcoを上げるには中からのFUVの寄与が必要

星からの寄与が最大で10倍程度Xcoを増加させる

An ALMA study of the Orion Integral Filament: I. Evidence for narrow fibers in a massive cloud

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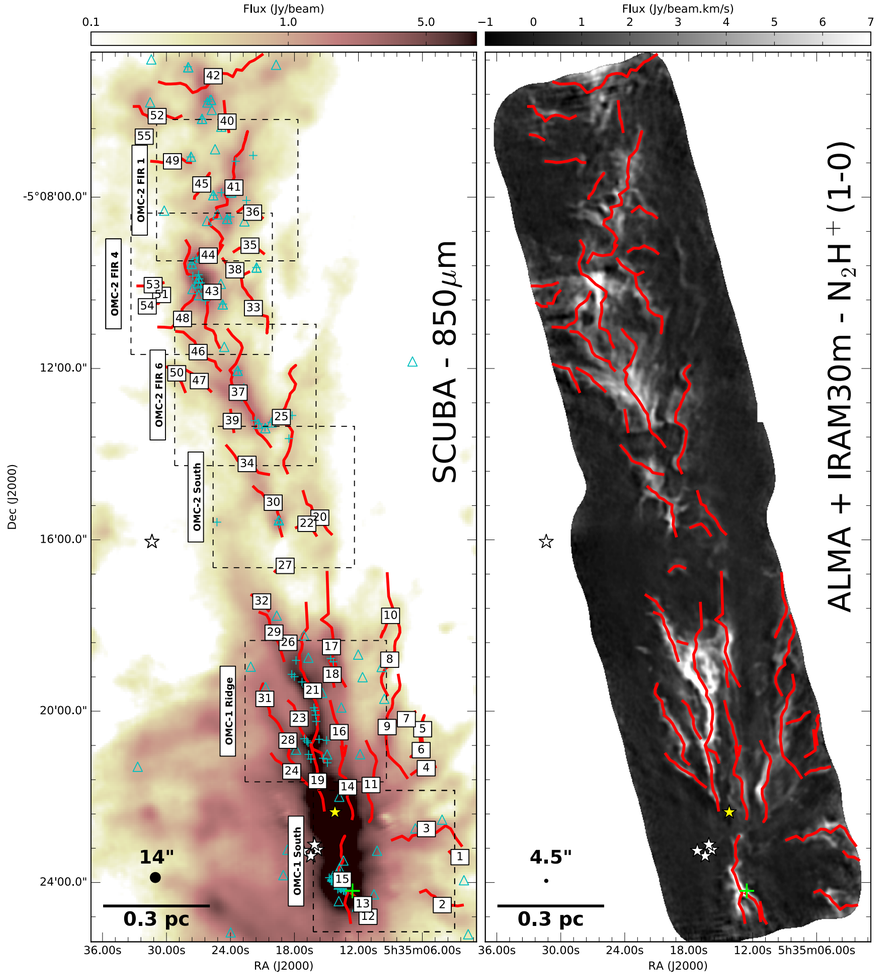
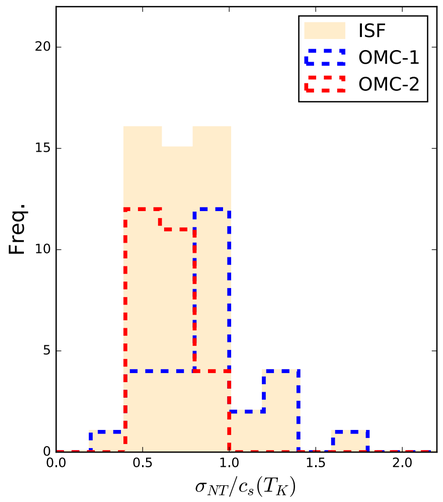
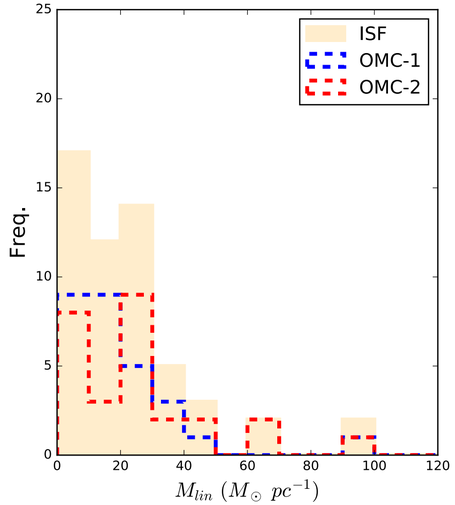
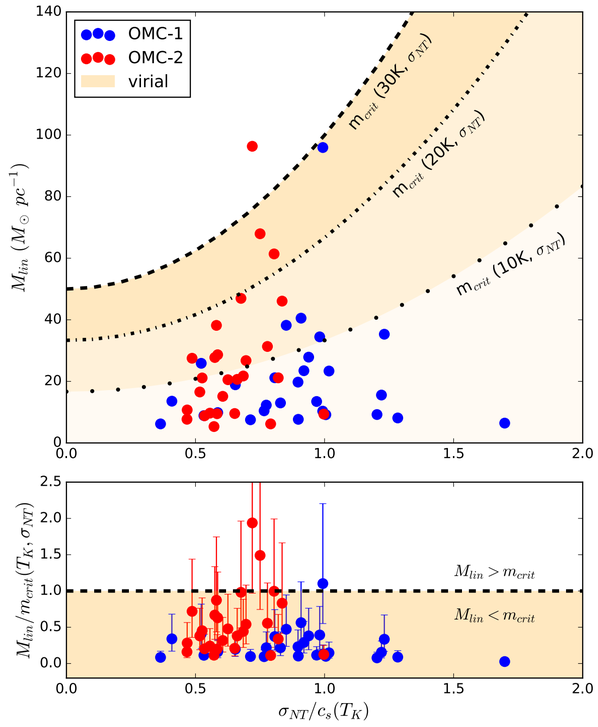
重い Filament (Integral Shape Filament (ISF), M_line~500Msun/pc)の substructure (fiber)の観測→55本同定







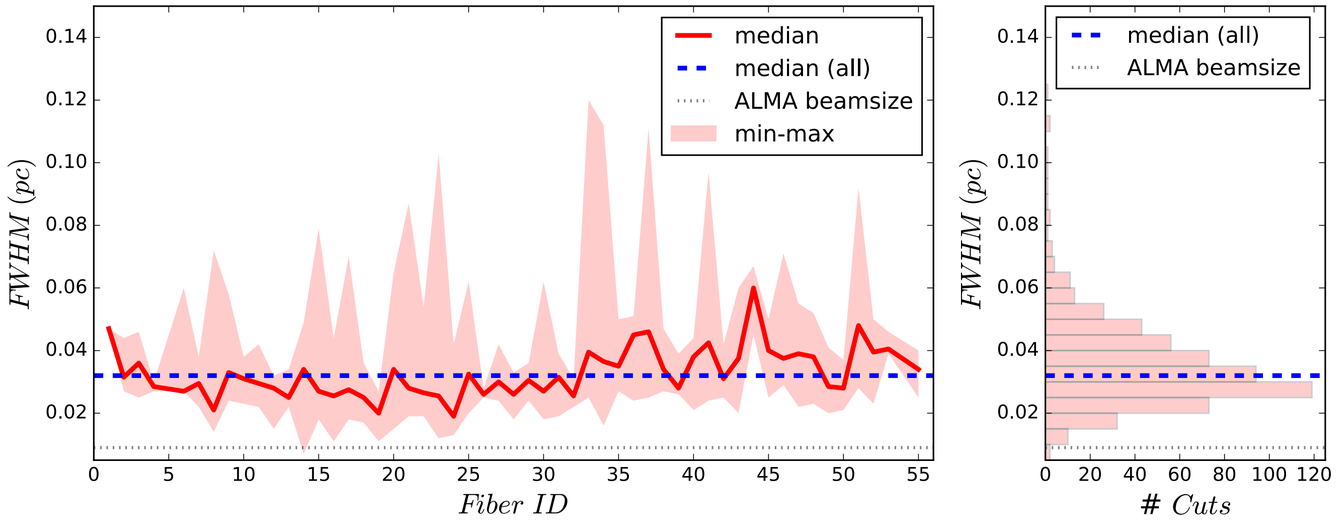
左：乱流の速度分散/音速，右line mass

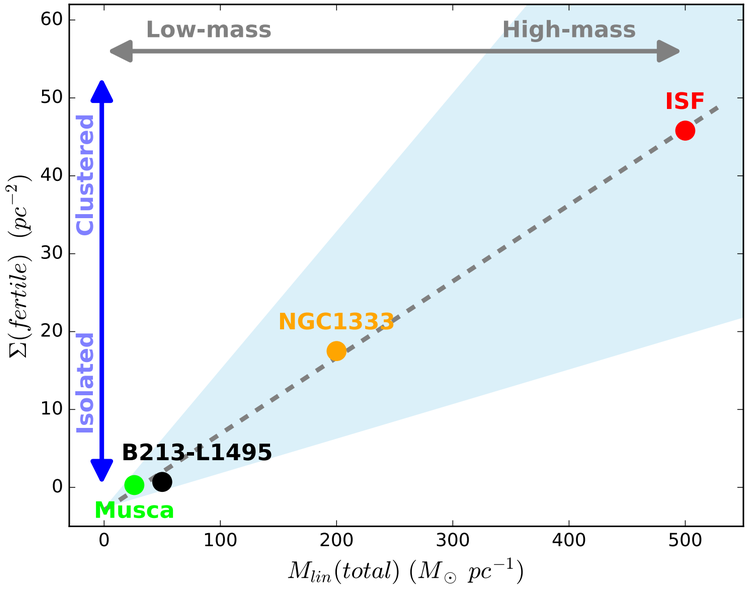


Critical line massとの比較

- 亜音速乱流が効いている。
- 約半分が重力で束縛されている。

fiber の幅～0.035pc<0.1pc





fiber の密度とtotal massが2桁の範囲で比例？

fiber の密度が星・コアの面密度と正の相関 (Hacar+2017)

Low-mass とHigh-massの星形成メカニズムについての
unified theory がありそう

21 On the Rotation of Supermassive Stars

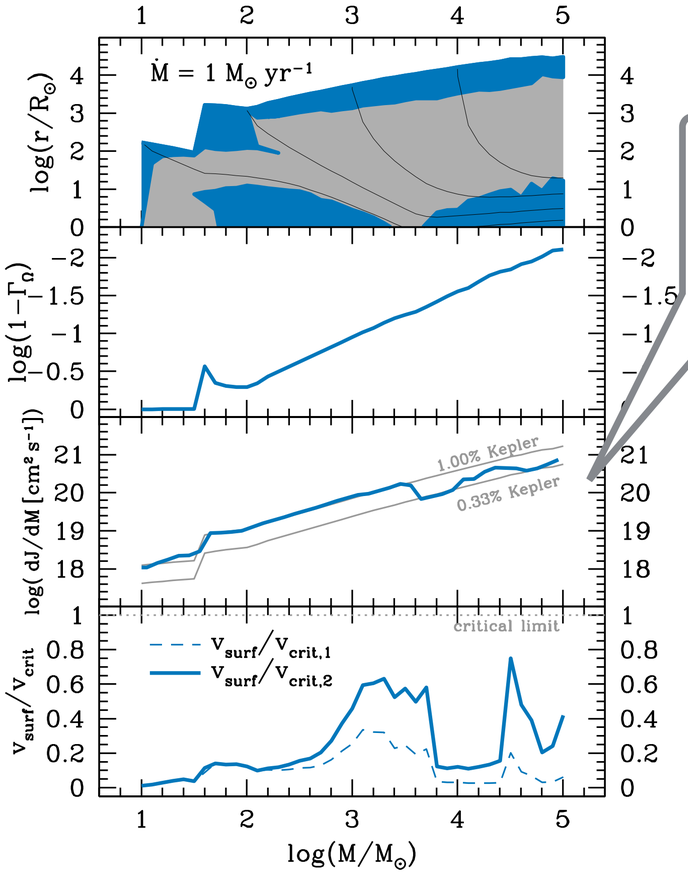
Lionel Haemmerlé[1], Tyrone E. Woods[2], Ralf S. Klessen[3,4], Alexander Heger[2] and Daniel J. Whalen[5]

大質量初代星形成での自転の進化を調べた

輻射＋遠心力＜重力が必要(ΩΓ-limit)、大質量星は輻射力大→回転が小さい必要がある。

回転を考慮した星の進化計算

convective region では剛体回転、radiative region ではシアと子午面環流による角運動量輸送を考慮



M<500Msun dJ/dM~1% of Kepler

M>500Msun dJ/dM~0.3% of Kepler

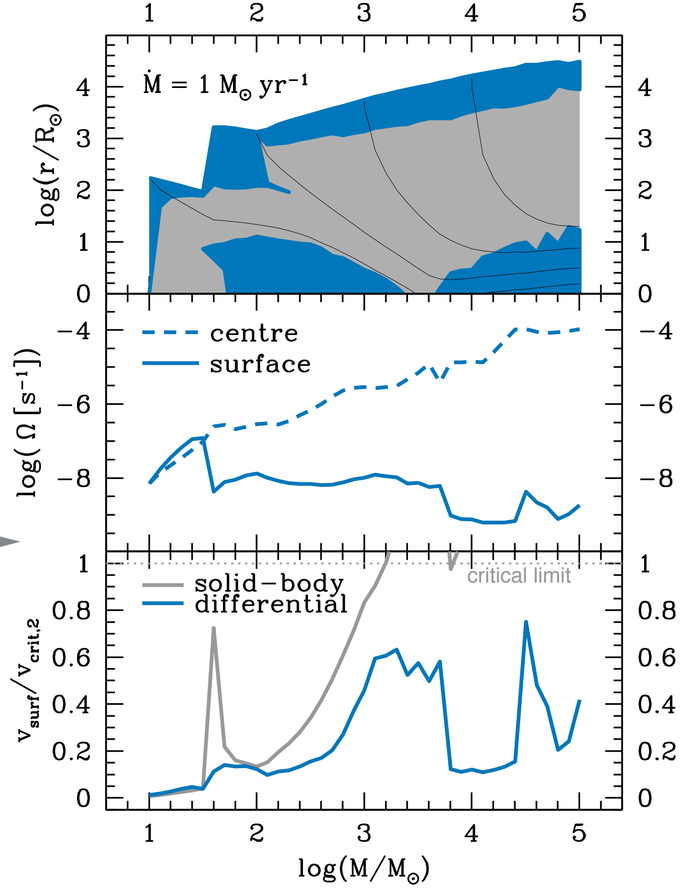
であれば>10^5Msun まで進化可能

収縮とともに中心の回転速度増加

表面より4桁以上速い回転速度

剛体回転を仮定するよりも

ΩΓ-limitの条件が緩和される



14 The structure and spectrum of the accretion shock in the atmospheres of young stars

Alexandr Dodin[1]

The structure and spectrum of the accretion shock have been self-consistently simulated for a wide range of parameters typical for Classical T Tauri Stars (CTTS). Radiative cooling of the shocked gas was calculated, taking into account the self-absorption and non-equilibrium (time-dependent) effects in the level populations. These effects modify the standard cooling curve for an optically thin plasma in coronal equilibrium, however the shape of high-temperature ($T > 3 \times 10^5\,\mathrm{K}$) part of the curve remains unchanged. The applied methods allow us to smoothly describe the transition from the cooling flow to the hydrostatic stellar atmosphere. Thanks to this approach, it has been found that the narrow component of He II lines is formed predominantly in the irradiated stationary atmosphere (hotspot), i.e. at velocities of the settling gas $< 2\,\mathrm{km\,s^{-1}}$. The structure of the pre-shock region is calculated simultaneously with the heated atmosphere. The simulation shows that the pre-shock gas produces a noticeable emission component in He II lines and practically does not manifest itself in He I lines ($\lambda\lambda$ 5876, 10830 Å). The UV spectrum of the hotspot is distorted by the pre-shock gas, namely numerous red-shifted emission and absorption lines overlap each other forming a pseudo-continuum. The spectrum of the accretion region at high pre-shock densities $\sim 10^{14}\,\mathrm{cm^{-3}}$ is fully formed in the in-falling gas and can be qualitatively described as a spectrum of a star with an effective temperature derived from the Stefan-Boltzmann law via the full energy flux.

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VLBA Determination of the Distance to Nearby Star-forming Regions. VIII. The LkHα 101 cluster

S.A. Dzib[1], G.N. Ortiz-León[1,2], Laurent Loinard[3,4], A.J. Mioduszewski[5], L.F. Rodríguez[3], S.-N.X. Medina[1], R.M. Torres[6]

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The LkHα 101 cluster takes its name from its more massive member, the LkHα 101star, which is an $\sim$15 $M_\odot$ star whose true nature is still unknown. The distance to the LkHα 101 cluster has been controversial for the last few decades, with estimated values ranging from 160 to 800 pc. We have observed members and candidate members of the LkHα 101 cluster with signs of magnetic activity, using the Very Long Baseline Array, in order to measure their trigonometric parallax and, thus, obtain a direct measurement of their distances. A young star member, LkHα 101 VLA J043001.15+351724.6, was detected at four epochs as a single radio source. The best fit to its displacement on the plane of the sky yields a distance of 535$\pm$29 pc. We argue that this is the distance to the LkHα 101 cluster.

A spectroscopic survey of the youngest field stars in the solar neighborhood. II. The optically faint sample

A. Frasca[1], P. Guillout[2], A. Klutsch[1], R. Freire Ferrero[2], E. Marilli[1], K. Biazzo[1], D. Gandolfi[3] and D. Montes[4]

Star formation in the solar neighborhood is mainly traced by young stars in open clusters, associations, and in the field, which can be identified, for example, by their X-ray emission. The determination of stellar parameters for the optical counterparts of X-ray sources is crucial for a full characterization of these stars. This work extends the spectroscopic study of the *RasTyc* sample, obtained by the cross-correlation of the TYCHO and ROSAT All-Sky Survey catalogs, to stars fainter than $V = 9.5$ mag and aims to identify sparse populations of young stars in the solar neighborhood. We acquired 625 high-resolution spectra for 443 presumably young stars with four different instruments in the northern hemisphere. The radial and rotational velocity ($v \sin i$) of our targets were measured by means of the cross-correlation technique, which is also helpful to discover single-lined (SB1), double-lined spectroscopic binaries (SB2), and multiple systems. We used the code ROTFIT to perform an MK spectral classification and to determine the atmospheric parameters ($T_{\rm eff}$, $\log g$, [Fe/H]) and $v \sin i$ of the single stars and SB1 systems. For these objects, we used the spectral subtraction of slowly rotating templates to measure the equivalent widths of the Hα and Li I 6708 Å lines, which enabled us to derive their chromospheric activity level and lithium abundance. We made use of *Gaia* DR1 parallaxes and proper motions to locate the targets in the Hertzsprung-Russell (HR) diagram and to compute the space velocity components of the youngest objects. We find a remarkable percentage (at least 35 %) of binaries and multiple systems. On the basis of the lithium abundance, the sample of single stars and SB1 systems appears to be mostly ($\sim$60 %) composed of stars younger than the members of the UMa cluster. The remaining sources are in the age range between the UMa and Hyades clusters ($\sim$20 %) or older ($\sim$20 %). In total, we identify 42 very young (PMS-like) stars, which lie above or very close to the Pleiades upper envelope of the lithium abundance. A significant percentage ($\sim$12 %) of evolved stars (giants and subgiants) is also present in our sample. Some of these stars ($\sim$36 %) are also lithium rich (A(Li)$>$ 1.4).

18 BANYAN. XI. The BANYAN Σ multivariate Bayesian algorithm to identify members of young associations within 150 pc

Jonathan Gagné[1,2], Eric E. Mamajek[3,4], Lison Malo[5], Adric Riedel[6], David Rodriguez[6], David Lafrenière[5], Jacqueline K. Faherty[7], Olivier Roy-Loubier[5], Laurent Pueyo[6], Annie C. Robin[8], and René Doyon[5]

BANYAN Σ is a new Bayesian algorithm to identify members of young stellar associations within 150 pc of the Sun. It includes 27 young associations with ages in the range ∼1–800 Myr, modelled with multivariate Gaussians in 6-dimensional XYZUVW space. It is the first such multi-association classification tool to include the nearest sub-groups of the Sco-Cen OB star-forming region, the IC 2602, IC 2391, Pleiades and Platais 8 clusters, and the ρ Ophiuchi, Corona Australis, and Taurus star-formation regions. A model of field stars is built from a mixture of multivariate Gaussians based on the Besançon Galactic model. The algorithm can derive membership probabilities for objects with only sky coordinates and proper motion, but can also include parallax and radial velocity measurements, as well as spectrophotometric distance constraints from sequences in color-magnitude or spectral type-magnitude diagrams. BANYAN Σ benefits from an analytical solution to the Bayesian marginalization integrals that makes it more accurate and significantly faster than its predecessor BANYAN II. A contamination versus hit rate analysis is presented and demonstrates that BANYAN Σ achieves a better classification performance than other moving group classification tools, especially in terms of cross-contamination between young associations. An updated list of bona fide members in the 27 young associations, augmented by the Gaia-DR1 release, are presented. This new tool will make it possible to analyze large data sets such as the upcoming Gaia-DR2 to identify new young stars. IDL and Python versions of BANYAN Σ are made available with this publication.

Distributed star formation throughout the Galactic Center cloud Sgr B2

Adam Ginsburg[1,2], John Bally[3], Ashley Barnes[4], Nate Bastian[4], Cara Battersby[5,6], Henrik Beuther[7], Crystal Brogan[8], Yanett Contreras[9], Joanna Corby[8,10], Jeremy Darling[3], Chris De Pree[11], Roberto Galván-Madrid[12], Guido Garay[13], Jonathan Henshaw[7], Todd Hunter[8], J.M. Diederik Kruijssen[14], Steven Longmore[4], Xing Lu[15], Fanyi Meng[16], Elisabeth A.C. Mills[17,18], Juergen Ott[19], Jaime E. Pineda[20], Álvaro Sánchez-Monge[16], Peter Schilke[16], Anika Schmiedeke[16,20], Daniel Walker[4,21,22], and David Wilner[5]

We report ALMA observations with resolution $\sim 0\farcs5$ at 3 mm of the extended Sgr B2 cloud in the Central Molecular Zone (CMZ). We detect 271 compact sources, most of which are smaller than 5000 AU. By ruling out alternative possibilities, we conclude that these sources consist of a mix of hypercompact HII regions and young stellar objects (YSOs). Most of the newly-detected sources are YSOs with gas envelopes which, based on their luminosities, must contain objects with stellar masses $M_* \gtrsim 8\ M_\odot$. Their spatial distribution spread over a $\sim 12 \times 3$ pc region demonstrates that Sgr B2 is experiencing an extended star formation event, not just an isolated 'starburst' within the protocluster regions. Using this new sample, we examine star formation thresholds and surface density relations in Sgr B2. While all of the YSOs reside in regions of high column density ($N(\mathrm{H_2}) \gtrsim 2 \times 10^{23}$ cm^{-2}), not all regions of high column density contain YSOs. The observed column density threshold for star formation is substantially higher than that in solar vicinity clouds, implying either that high-mass star formation requires a higher column density or that any star formation threshold in the CMZ must be higher than in nearby clouds. The relation between the surface density of gas and stars is incompatible with extrapolations from local clouds, and instead stellar densities in Sgr B2 follow a linear Σ_*–$\Sigma_{\rm gas}$ relation, shallower than that observed in local clouds. Together, these points suggest that a higher volume density threshold is required to explain star formation in CMZ clouds.