Star Formation Newsletter #329 36-42

Yusuke Aso (KASI)

Planet formation by pebble accretion in ringed disks

A. Morbidelli

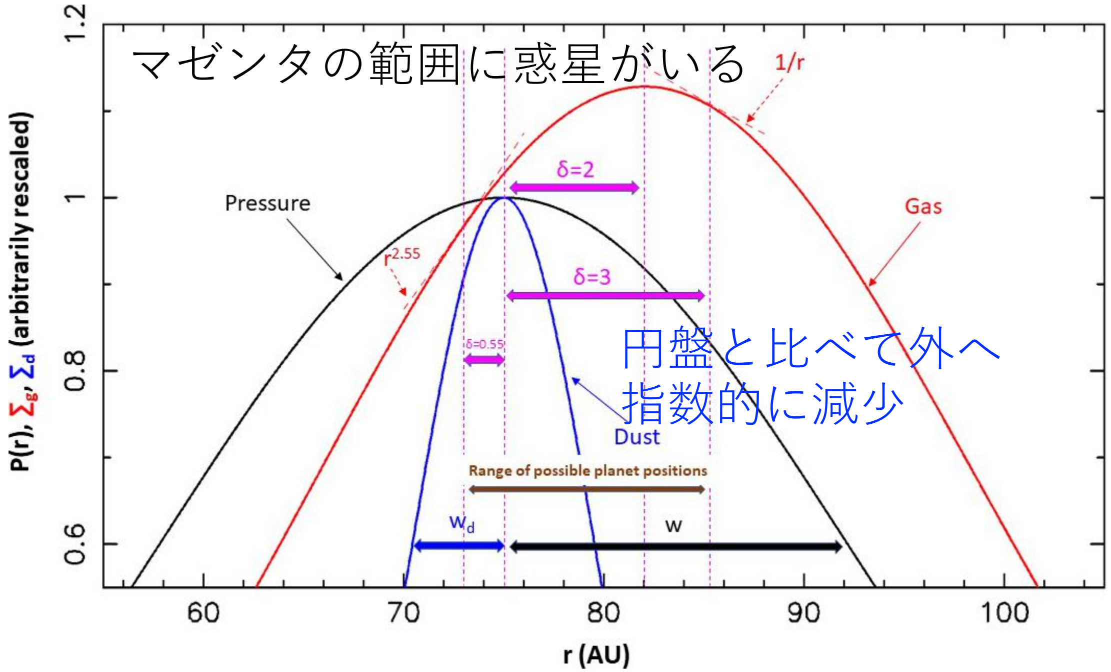
- 寡占成長では100 kmから成長しないのでドリフトでペブルを集めて成長。
- 数auでガスに対してダストがなくなっていない。降着しないペブルが内側で巨大惑星になっていない。
- 圧力バンプで止まるとうい解。リング分布のペブルを検証。

- ガウシアンリング圧力 $$p(r) = p_0 \exp\left(-\frac{(r-r_0)^2}{2w^2}\right),$$
- ガスドラッグと粘性拡散のバランスでダスト面密度。

$$v_r(r) = -\frac{H^2\Omega\tau}{w^2(1+\tau^2)}(r-r_0) \qquad D_\mathrm{d} = \frac{D}{1+\tau^2},$$

$$\Gamma = \frac{\Gamma_0}{\gamma}\left[(-2.5-1.7b+0.1a)+1.1 f_\mathrm{v}(\nu, M)\left(\frac{3}{2}-a\right) + f_\mathrm{E}(\nu,\chi,M)\left(7.9\frac{\xi}{\gamma}\right)\right],$$

（a, bはΣ, Tの指数）



- トルク：f_V渦、f_Eエントロピー起源。
- 粘性が小さいとf_Vも小さいが磁場や惑星がリングを維持するのでf_V~1とする。
- f_Eは断熱で0、等温で定値。トルク０のところに惑星が留まる。

Planet formation by pebble accretion in ringed disks の続き

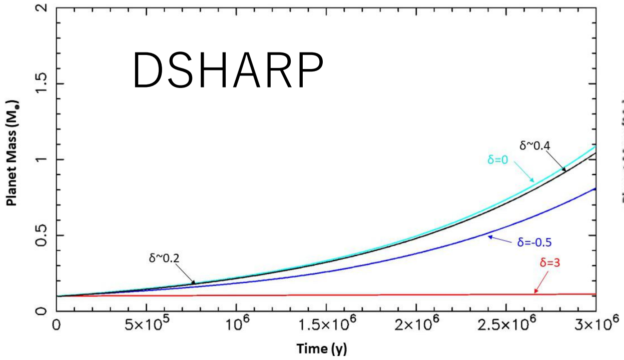
A. Morbidelli

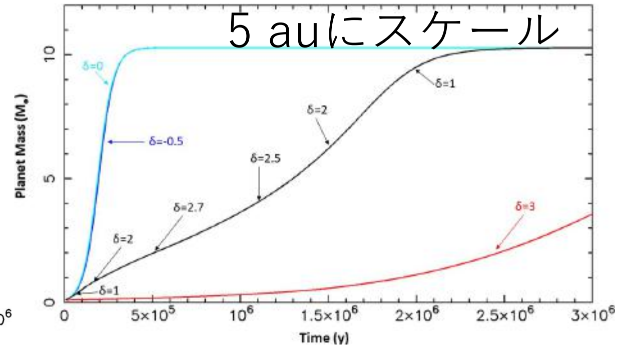
- 惑星が得られる質量の最大値を計算。 $\dot{M}_{\rm Max} = 2\times 2\pi r_p \Sigma_d(r_p) v_r(r_p) = A\tau\delta\Sigma_{d,0}\exp\left(-\frac{\delta^2 w^2 \tau}{2\alpha r_0^2}\right),$
- 円盤と違って前後からダストが来るが総量は少ない。
- 常に最大値を取って進化すると $\dot{M} = \frac{A}{(2\pi)^{3/2} r_0 w}\sqrt{\frac{\tau^3}{\alpha}}(M_{\rm ring}^{\rm init} - M)\delta\exp\left(-\frac{\delta^2 w^2\tau}{2\alpha r_0^2}\right)$
- 解は $M(t) = M_{\rm ring}^{\rm init}[1-\exp(Bt)], \quad B = \frac{A}{(2\pi)^{3/2} r_0 w}\sqrt{\frac{\tau^3}{\alpha}}\delta\exp\left(-\frac{\delta^2 w^2\tau}{2\alpha r_0^2}\right).$

- 0.1 M_Eを種にしてDSHARPのメディアンリング。 $r_0 = 75$ AU, $T = 22$ K, $w_d = 4.5$ AU, $M_{\rm dust} = 40\,M_\oplus$.
- →3 Myrでは大きくならない。大きくなっていればリングを食べ尽くすので観測とは合う。
- $\Sigma \propto r^{-1.5}$でr_0=5 auまでスケールすると3 Myrで10 M_Eになる。

- トルクはオパシティや磁場に敏感に依る。

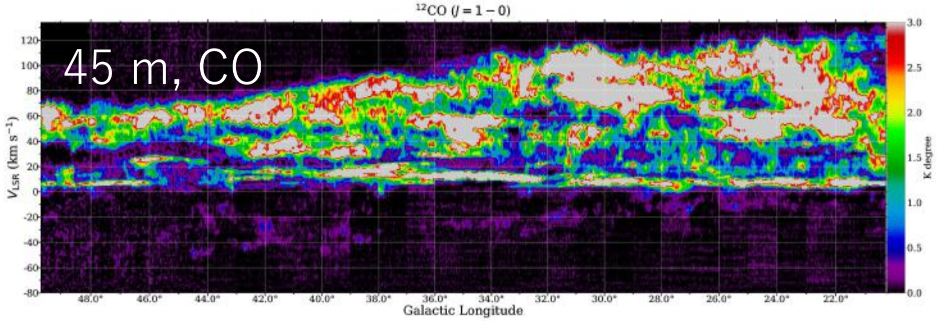
- バンプがないとpebble-isolation質量に達する。
  これは>20 M_Eで木星コアより３倍は小さい。
  リングによって小さいコアを実現可能。

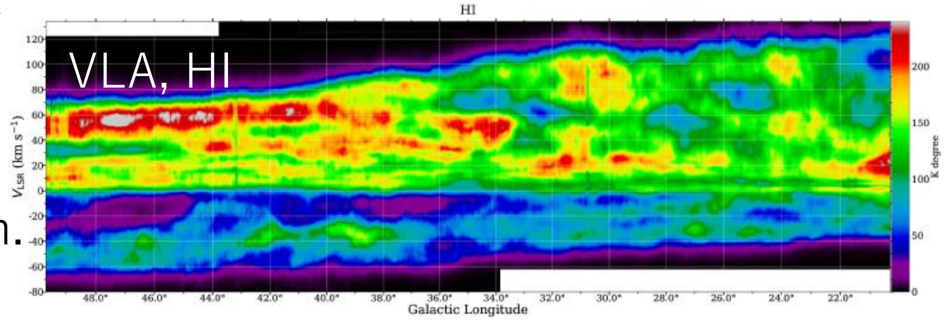




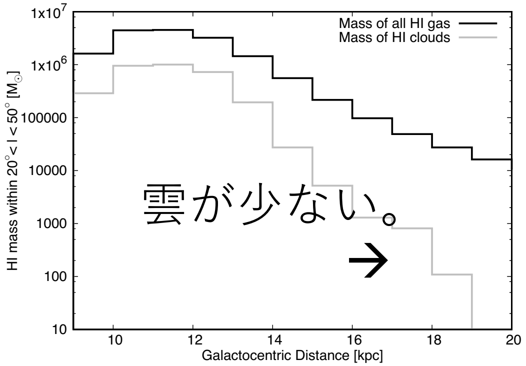
FOREST unbiased Galactic plane imaging survey with the Nobeyama 45 m telescope (FUGIN). VII. molecular fraction of HI clouds

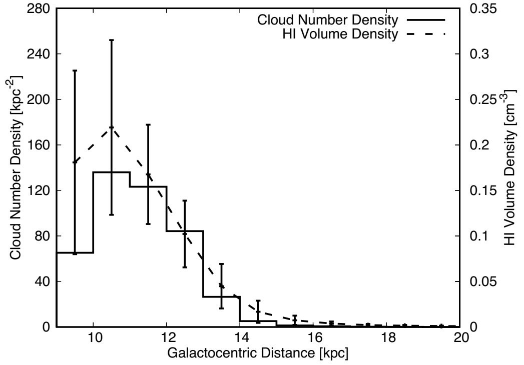
Hiroyuki NAKANISHI[1], Shinji FUJITA,[2], Kengo TACHIHARA,[2], Natsuko IZUMI[3], Mitsuhiro MATSUO[4], Tomofumi UMEMOTO[4], Yumiko OASA[5] and Tsuyoshi INOUE[2]



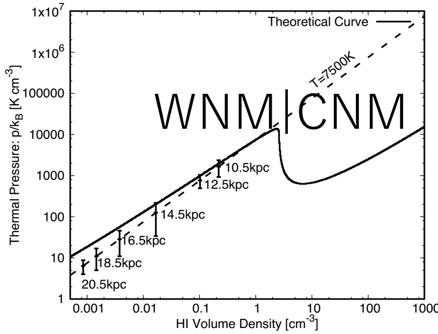


- 水素分子比は圧力、紫外線（光解離）、金属量（シールド）の情報。
- コアの外殻でHI, CI, CIIがシールドと思われていたが、CI, CIIは粒々という過去観測。一般にHI, H_2雲はどうなのか。
- Four-beam 45 mとVLAで銀河面サーベイ。
  VLA: HI, 1', 1.56 km/s, 2 K, missing fluxのためにGreen Bank 100 m.
  45 m: CO, 20", 1.3 km/s, 0.2 K@1'.
- VLAのV<–20 km/sへデンドログラムでHI雲同定。閾値：5 K, 125 voxel。全ガスの20%が分子雲。





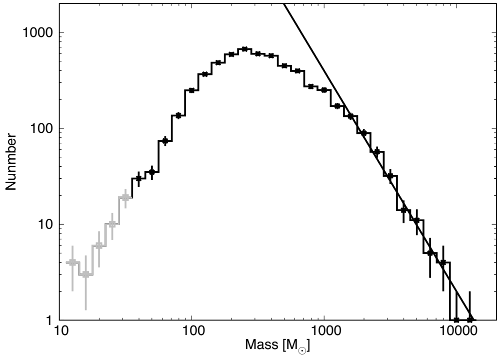
- 雲数と密度が比例。
  ←clumpy-CNM, diffuse-WNM.



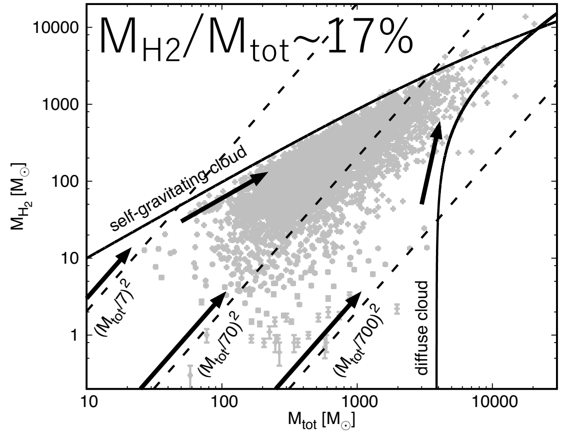
- 内側の>~1000 K cm^{-3}は外的擾乱でCNMになって雲を作れる。
- 最小雲質量14 M_{sun}はCNMではなくWNMの熱不安定（$c_s t_l$内の質量）。

FOREST unbiased Galactic plane imaging survey with the Nobeyama 45 m telescope (FUGIN). VII. molecular fraction of HI clouds の続き

Hiroyuki NAKANISHI[1], Shinji FUJITA,[2], Kengo TACHIHARA,[2], Natsuko IZUMI[3], Mitsuhiro MATSUO[4], Tomofumi UMEMOTO[4], Yumiko OASA[5] and Tsuyoshi INOUE[2]

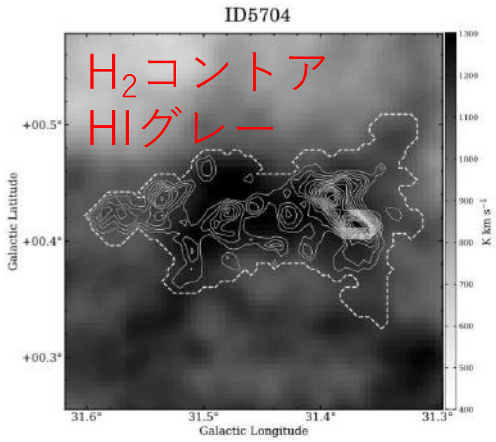


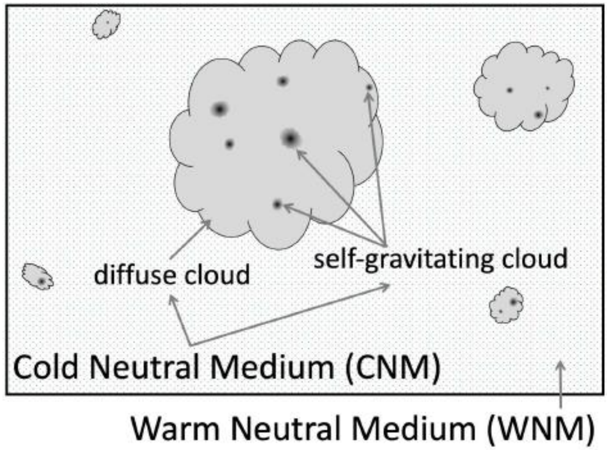
- 指数 –2.3
- GMCの–0.5より軽い側に集中。



- Diffuseとself-gravitatingが提唱されているが、今回はその間。→混合物。
- 3D MHD計算で$M_{tot} \propto t^{0.9}$, $M_{H2} \propto t^{1.8}$→$M_{H2} \propto M_{tot}^2$. 全体として右の矢印のような進化。

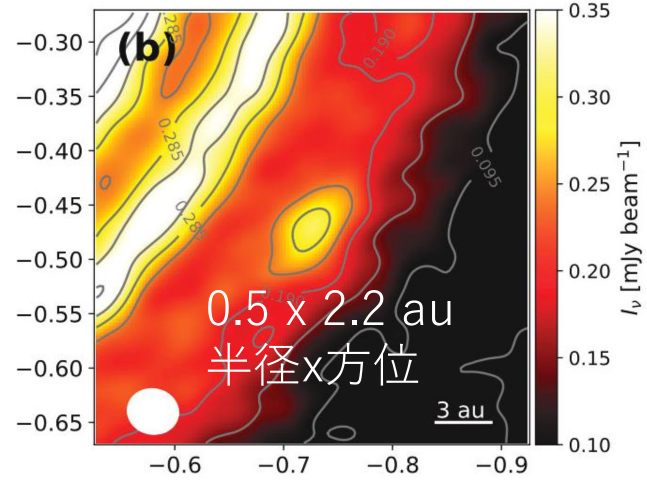
- HIガスは球状ではなく、分子ガスも点在。特に端は分子雲衝突など外的ラム圧。
- ジャムドーナッツではなくチョコチップスコーン。





TW Hya: an old protoplanetary disc revived by its planet

Sergei Nayakshin,[1★] Takashi Tsukagoshi,[2] Cassandra Hall,[1] Allona Vazan,[3,4] Ravit Helled,[4] Jack Humphries,[1] Farzana Meru,[5,6] Patrick Neunteufel[1,7] and Olja Panic[8]



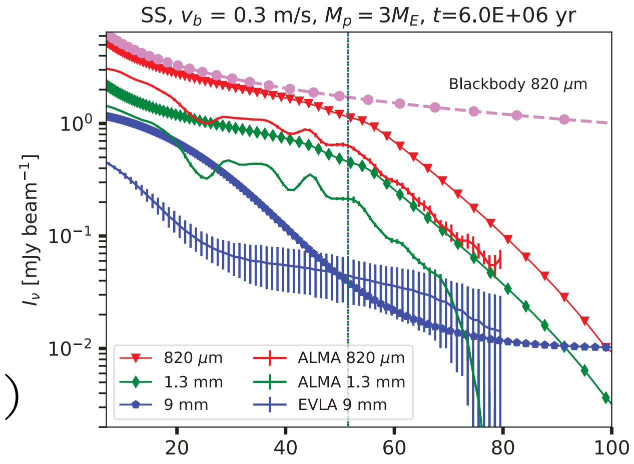
- 若い円盤のサブ構造があって、そんな円盤の質量は惑星形成には不十分→<1 Myrでの惑星形成。
- a few Myrの円盤にmmダストを観測　vs.　ドリフト。 $M_d \sim 1\ M_J$ならば速く移動しない。
- TW Hya, 60 pc, 10 Myr, $1.8\times10^{-9}\ M_{sun}/yr$。1, 24, 41 auにギャップ、しかし惑星候補は外側の崖にある。M_{dust}がClass II平均の100倍。

- 結論：Steady-stateではなく惑星から質量放出。

- SS. 冪乗、α粘性、50 auで10 Myrのドリフト。
  → M_d~0.2 M_{sun}, M_{cpd} > $10M_E$ << M_p（✖）。
  外の方がドリフト時間が短いので元はもっと急（✖）。
  タイプI移動時間は0.04 Myr。惑星100個（✖）。

- M_pなどパラメーターを調整してもダメ。→

３倍のズレ。
崖で光学的に厚い。
（TW Hya; ∝ ν 2.6）



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の続き

- リング状放出。$\dot{M}_Z$=6x10^{-6} M_E/yr。
- 成長すると内側へ落下→自然に崖。光学的にも薄い。

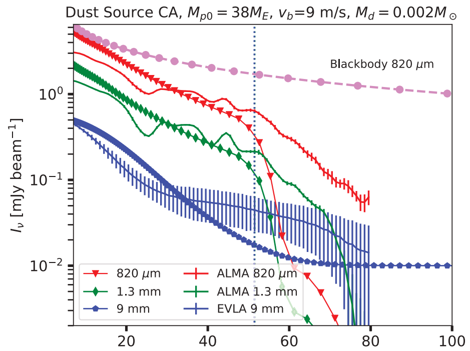
- 惑星は質量も軌道も一定なので物理を追加。

- CA: 崩壊前M_p~20 M_Eはケプラー速度程度で壊れる。
  落ちないようにM_dを下げて$\dot{M}$ を変えないようにα を上げた。

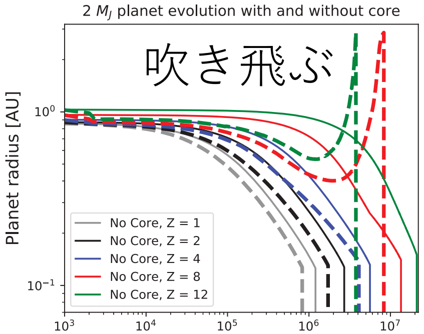
- GI: 早く惑星ができるので円盤が> M_Jだと落ちてしまう。
  最近のオパシティを使うと崩壊まで5-10 Myrかかる。
  崩壊前のコアが>10 M_Eだとエンベロープが吹き飛ぶ。

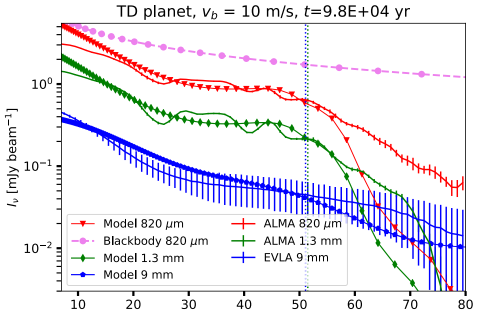
- 惑星からの質量放出によって方位角方向の伸びも説明。
  ←放出されたダストがガスの速度になって離れる。

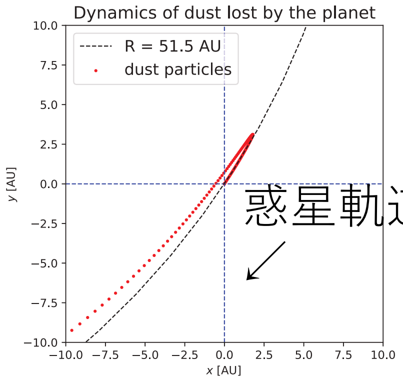
CA

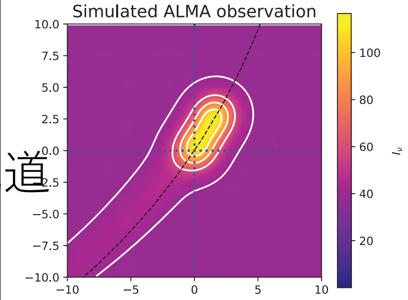


GI









2MASS J04435686+3723033 B:
A Young Companion at the Substellar Boundary with Potential Membership in the β Pictoris Moving Group

Caprice L. Phillips,[1,2] Brendan P. Bowler,[3] Gregory Mace,[4] Michael C. Liu,[5] and Kimberly Sokal[4]

ABSTRACT

We present a detailed characterization of 2MASS J04435750+3723031, a low-mass companion orbiting the young M2 star " 2MASS J04435686+3723033 at 7$''$.6 (550 AU) with potential membership in the 23 Myr β Pictoris moving group (βPMG). Using near-infrared spectroscopy of the companion from IRTF/SpeX we have found a spectral type of M6 $\pm$ 1 and indications of youth through age-sensitive absorption lines and a low surface gravity index (VL-G). A young age is supported by Hα emission and lithium absorption in the host. We re-evaluate the membership of this system and find that it is a marginally consistent kinematic match to the βPMG using *Gaia* parallaxes and new radial velocities for the host and companion. If this system does belong to the βPMG, it would be a kinematic outlier and the companion would be over-luminous compared to other similar ultracool objects like PZ Tel B; this would suggest 2M0443+3723 B could be a close brown dwarf binary ($\approx$52+52 M_{Jup} if equal-flux, compared with 99 $\pm$ 5 M_{Jup} if single), and would make it the sixth substellar companion in this group. To test this hypothesis, we acquired NIR AO images with Keck II/NIRC2, but they do not resolve the companion to be a binary down to the diffraction limit of $\sim$3 AU. If 2M0443+3723 AB does not belong to any moving group then its age is more uncertain. In this case it is still young ($\lesssim$30 Myr), and the implied mass of the companion would be between $\sim$30–110 M_{Jup}.

β Pic. Moving Groupの候補が明るすぎるのでBD連星かと思ったが3 auで分解できず。

Hubble Space Telescope Astrometry in the Orion Nebula Cluster: Census of Low-mass Runaways

Imants Platais[1], Massimo Robberto[2], Andrea Bellini[2], Vera Kozhurina-Platais[2], Mario Gennaro[2], Giovanni Strampelli[2], Lynne A. Hillenbrand[3], Selma E. de Mink[4,5], and David R. Soderblom[2]

Abstract

We present a catalog of high-precision proper motions in the Orion Nebula Cluster (ONC), based on Treasury Program observations with the Hubble Space Telescope's (HST) ACS/WFC camera. Our catalog contains 2454 objects in the magnitude range of $14.2 < m_{\rm F775W} < 24.7$, thus probing the stellar masses of the ONC from $\sim 0.4\,M_\odot$ down to $\sim 0.02\,M_\odot$ over an area of ~ 550 arcmin^2. We provide a number of internal velocity dispersion estimates for the ONC that indicate a weak dependence on stellar location and mass. There is good agreement with the published velocity dispersion estimates, although nearly all of them (including ours at $\sigma_{v,x} = 0.94$ and $\sigma_{v,y} = 1.25$ mas yr^{-1}) might be biased by the overlapping young stellar populations of Orion A. We identified four new ONC candidate runaways based on HST and the Gaia DR 2 data, all with masses less than $\sim 1\,M_\odot$. The total census of known candidate runaway sources is 10—one of the largest samples ever found in any Milky Way open star cluster. Surprisingly, none of them have tangential velocities exceeding 20 km s^{-1}. If most of them indeed originated in the ONC, it may compel the re-examination of dynamical processes in very young star clusters. It appears that the mass function of the ONC is not significantly affected by the lost runaways.

ハッブル望遠鏡でONCの固有運動を高精度でカタログ。10個のrunawayはどれも20 km/s超えず。

Exocomets: A spectroscopic survey

I. Rebollido[1], C. Eiroa[1,2], B. Montesinos[3], J. Maldonado[4], E. Villaver[1], O. Absil[5], A. Bayo[6,7], H. Canovas[8], A. Carmona[9], Ch. Chen[10], S. Ertel[11], Th. Henning[12], D. P. Iglesias[6,7], R. Launhardt[12], R. Liseau[13], G. Meeus[1], A. Moór[14,15], A. Mora[16], J. Olofsson[6,7], G. Rauw[5], and P. Riviere-Marichalar[17]

ABSTRACT

Context. While exoplanets are now routinely detected, the detection of small bodies in extrasolar systems remains challenging. Since the discovery of sporadic events interpreted as exocomets (Falling Evaporating Bodies) around β Pic in the early 80s, only ~20 stars have been reported to host exocomet-like events.
Aims. We aim to expand the sample of known exocomet-host stars, as well as to monitor the hot-gas environment around stars with previously known exocometary activity.
Methods. We have obtained high-resolution optical spectra of a heterogeneous sample of 117 main-sequence stars in the spectral type range from B8 to G8. The data have been collected in 14 observing campaigns expanding over 2 years from both hemispheres. We have analysed the Ca II K&H and Na I D lines in order to search for non-photospheric absorptions originated in the circumstellar environment, and for variable events that could be caused by outgassing of exocomet-like bodies.
Results. We have detected non-photospheric absorptions towards 50% of the sample, attributing a circumstellar origin to half of the detections (i.e. 26% of the sample). Hot circumstellar gas is detected in the metallic lines inspected via narrow stable absorptions, and/or variable blue-/red-shifted absorption events. Such variable events were found in 18 stars in the Ca II and/or Na I lines; 6 of them are reported in the context of this work for the first time. In some cases the variations we report in the Ca II K line are similar to those observed in β Pic. While we do not find a significant trend with the age or location of the stars, we do find that the probability of finding CS gas in stars with larger $v \sin i$ is higher. We also find a weak trend with the presence of near-infrared excess, and with anomalous (λ Boo-like) abundances, but this would require confirmation by expanding the sample.

Ca II K, Ca II H, Na I D輝線で117個の主系列星で系外彗星を調査。

Rotation of Low-mass Stars in Taurus with K2

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Abstract

We present an analysis of K2 light curves (LCs) from Campaigns 4 and 13 for members of the young (∼3 Myr) Taurus association, in addition to an older (∼30 Myr) population of stars that is largely in the foreground of the Taurus molecular clouds. Out of 156 of the highest-confidence Taurus members, we find that 81% are periodic. Our sample of young foreground stars is biased and incomplete, but nearly all stars (37/38) are periodic. The overall distribution of rotation rates as a function of color (a proxy for mass) is similar to that found in other clusters: the slowest rotators are among the early M spectral types, with faster rotation toward both earlier FGK and later M types. The relationship between period and color/mass exhibited by older clusters such as the Pleiades is already in place by Taurus age. The foreground population has very few stars but is consistent with the USco and Pleiades period distributions. As found in other young clusters, stars with disks rotate on average slower, and few with disks are found rotating faster than ∼2 days. The overall amplitude of the LCs decreases with age, and higher-mass stars have generally lower amplitudes than lower-mass stars. Stars with disks have on average larger amplitudes than stars without disks, though the physical mechanisms driving the variability and the resulting LC morphologies are also different between these two classes.

Taurusの光度曲線。早期M型で遅い回転、早期FGKと後期M型で速い回転。
光度曲線の強度は年齢とともに下がり、重いほど弱い。円盤があると強い。