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野村英子 (国立天文台)

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11. Cometary compositions compared with protoplanetary disk midplane chemical evolution. An emerging chemical evolution taxonomy for comets

Christian Eistrup[1,2], Catherine Walsh[3] and Ewine F. van Dishoeck[1,4]

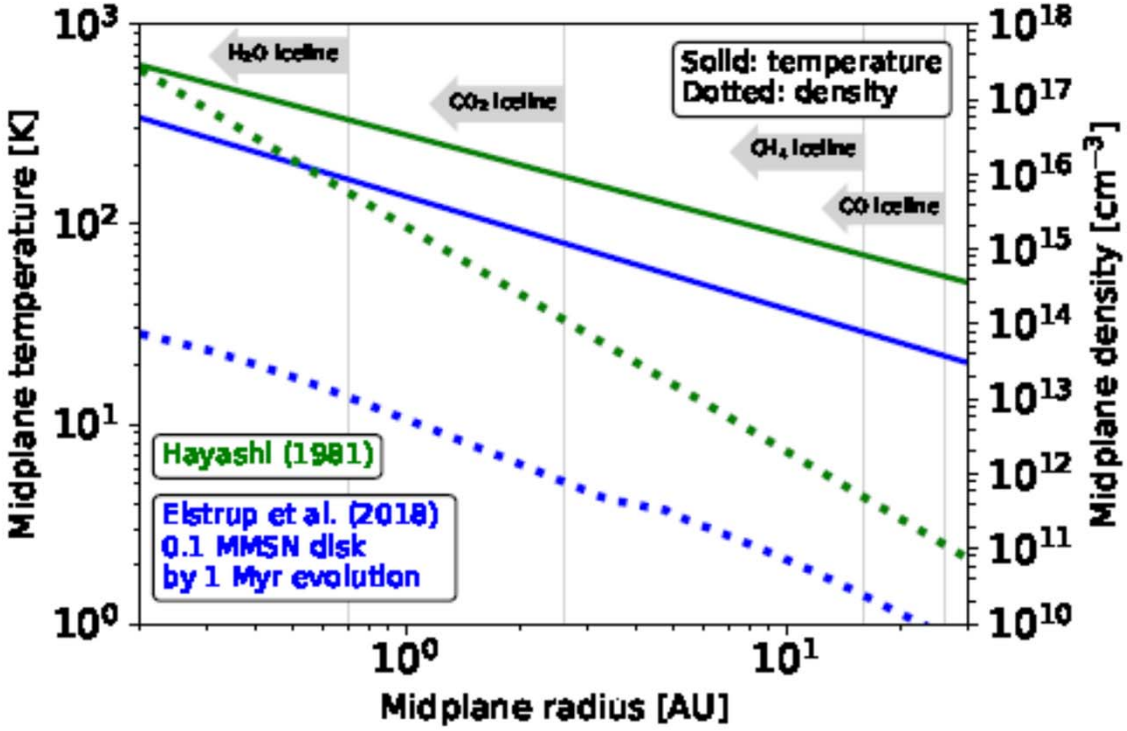
Accepted by A&A

・原始惑星系円盤の化学反応ネットワーク計算の結果と14個の彗星の組成の観測値を比較し、χ^2fittingの最も小さくなる円盤半径と年齢を求め、彗星形成領域を議論した。

・物理モデル(温度・密度)：右図青線
密度分布：粘性拡散で時間進化
温度分布：密度分布進化に伴い進化
(各スノーラインの位置も進化)

・化学反応ネットワーク
UMIST RATE12 + ダスト表面反応

・初期条件
- 分子モデル (分子雲の組成比を仮定)
- 原子モデル (円盤形成時における分子の破壊を仮定)



・化学反応計算の結果との比較に用いた彗星中の分子 (親分子)

Comet	H_2O	CO	CH_4	CO_2	C_2H_6	CH_3OH	H_2CO	O_2	SO_2	H_2S	OCS
1P/Halley	✓	✓	✓	✓	✓	✓	✓	✓		✓	
C/1995 O1 (Hale-Bopp)	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
C/1996 B2 (Hyakutake)	✓	✓	✓		✓	✓	✓			✓	✓
C/2001 A2 (LINEAR)	✓	✓	✓		✓	✓	✓			✓	
C/2012 F6 (Lemmon)	✓	✓	✓			✓	✓				
C/2013 R1 (Lovejoy)	✓	✓				✓	✓				
103P/Hartley 2	✓	✓		✓	✓	✓	✓				
73P/Schwassmann-Wachmann 3	✓				✓	✓	✓			✓	
2P/Encke	✓		✓		✓	✓	✓				
9P/Tempel 1	✓	✓	✓		✓	✓	✓			✓	
6P/d'Arrest	✓				✓	✓	✓				
17P/Holmes	✓	✓			✓	✓					
21P/Giacobini-Zinner	✓	✓			✓	✓					
67P summer hemisphere	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
67P winter hemisphere	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

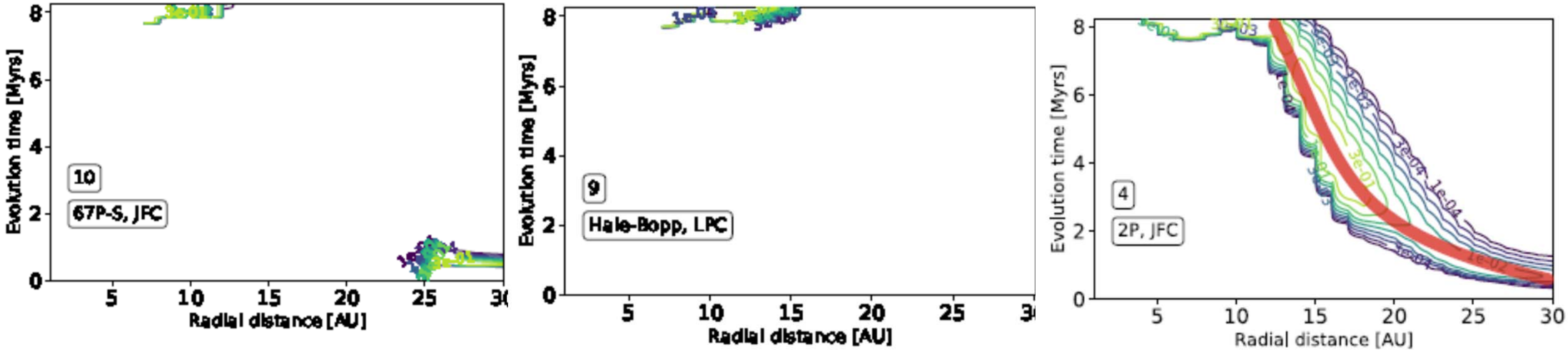
・化学反応計算の結果と彗星中の分子の組成の比較

$$\chi^2(r,t) = \sum_{i=1}^{n} \frac{\left(\log(n_{i,\mathrm{obs}}(r,t)) - \log(n_{i,\mathrm{mod}}(r,t))\right)^2}{\left(\sigma'_{i,\mathrm{obs}}(r,t)\right)^2}$$

n_i: H2Oに対する各分子の組成比

σ_i: 観測のエラー

・結果

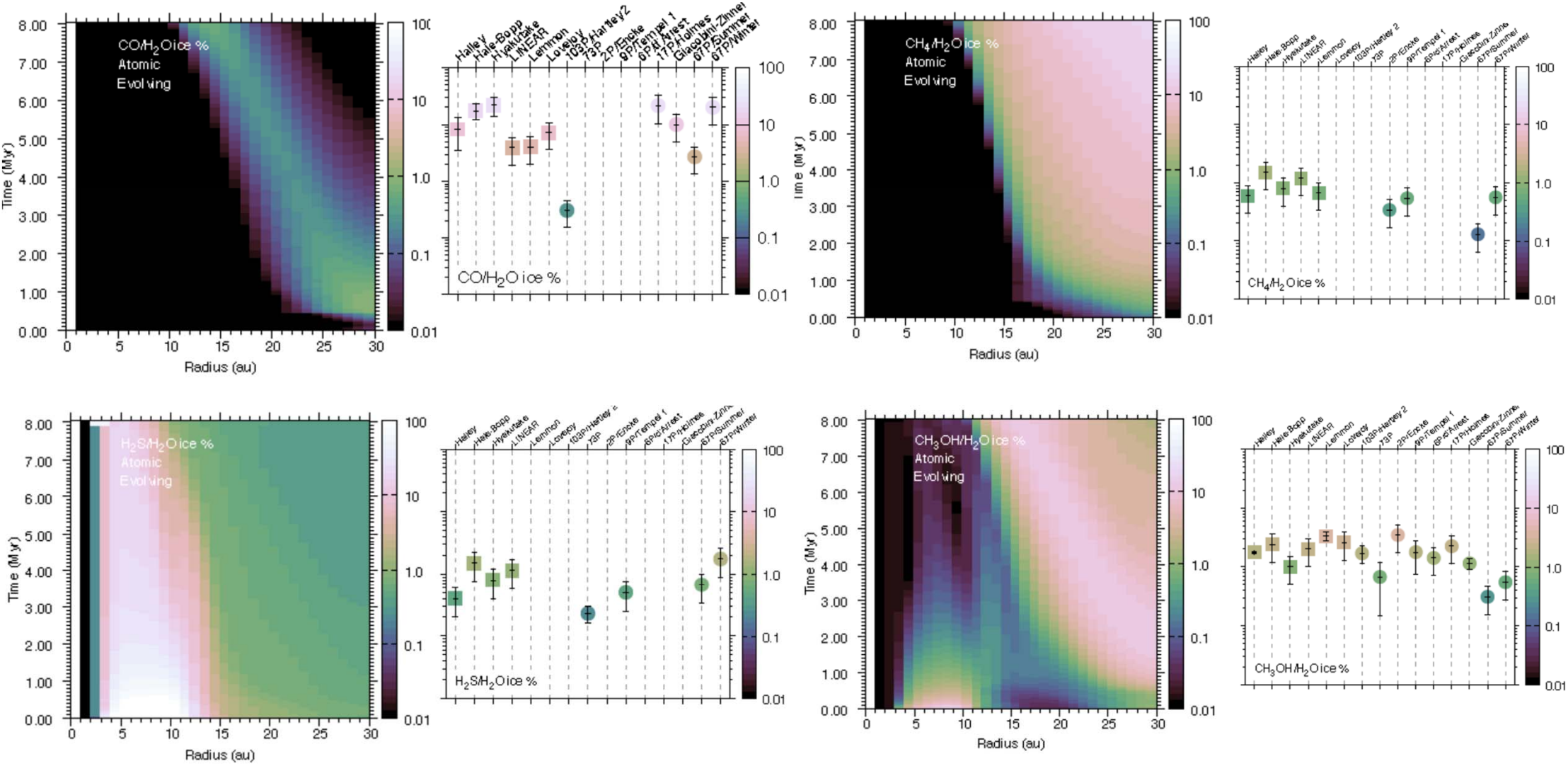


・多くの彗星に対して進化の初期段階では30AU付近、進化の後期段階では12AU付近(各時間におけるCOスノーライン付近)でモデルと彗星の観測値がよい一致

→ 彗星がCOスノーライン付近で形成されたことを示唆

・原子モデルの初期条件の方がより良い一致

・化学反応計算の結果と彗星中の分子の組成の比較



7. **High-Resolution Near Infrared Spectroscopy of HD 100546: IV. Orbiting Companion Disappears on Schedule**

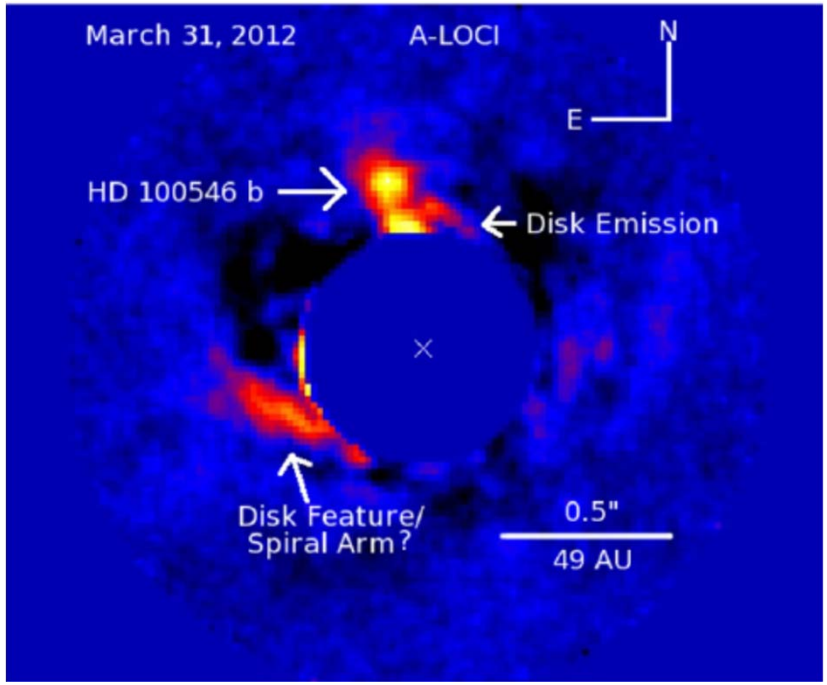
Sean D. Brittain[1], Joan R. Najita[2] and John S. Carr[3] Accepted by ApJ

・Herbig Ae星HD100546からの赤外線5μm帯COバンドの2003年から2017年までの時間進化を調べ、原始惑星系円盤のinner hole中の周惑星円盤からの放射の可能性について議論した。

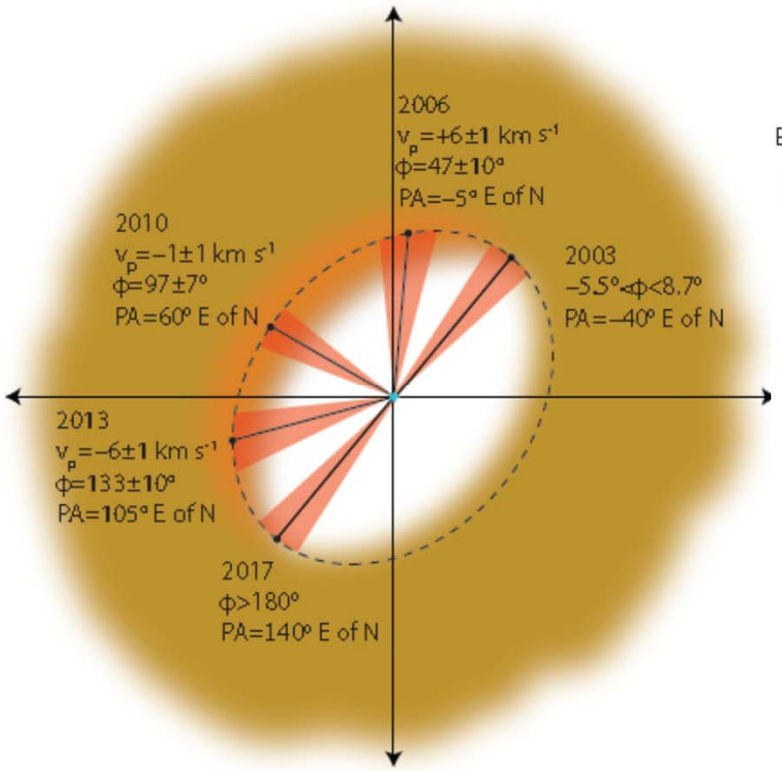
・観測装置：

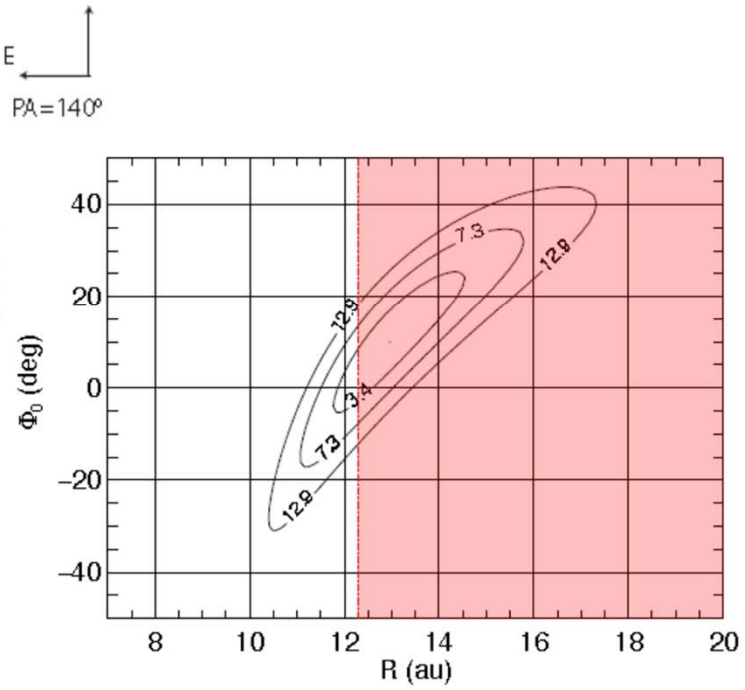
PHOENIX/Gemini, CRIRES/VLT
(R=50,000)

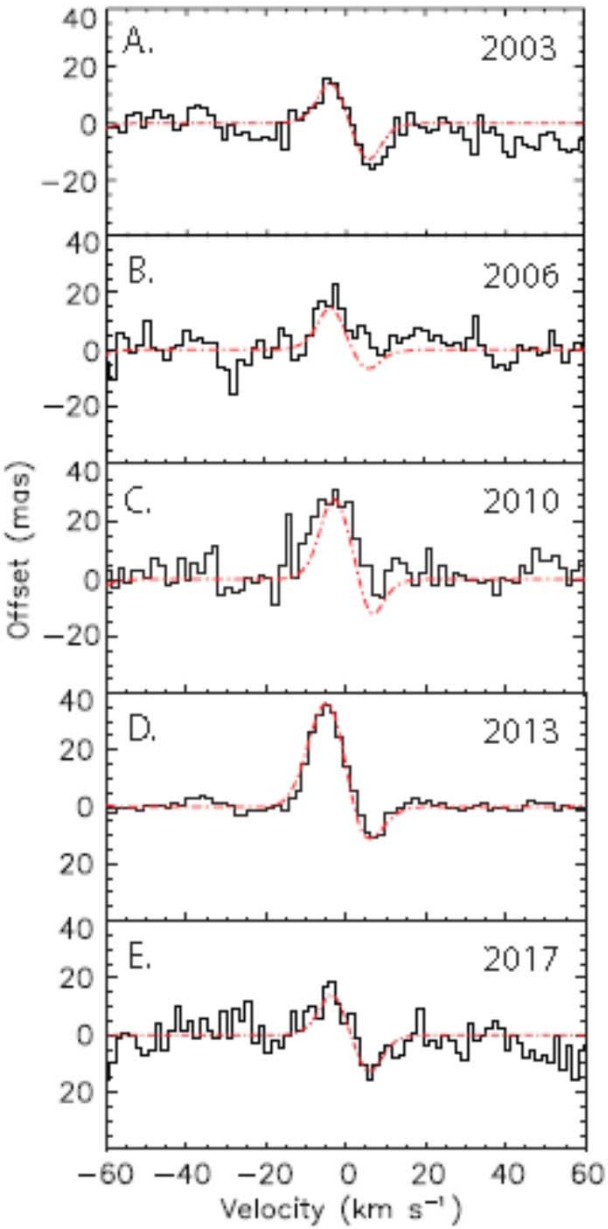
HD100546 (Currie+2014, Quanz+2013)



・赤外線撮像観測により、円盤のinner hole内に点源の存在が示唆されている

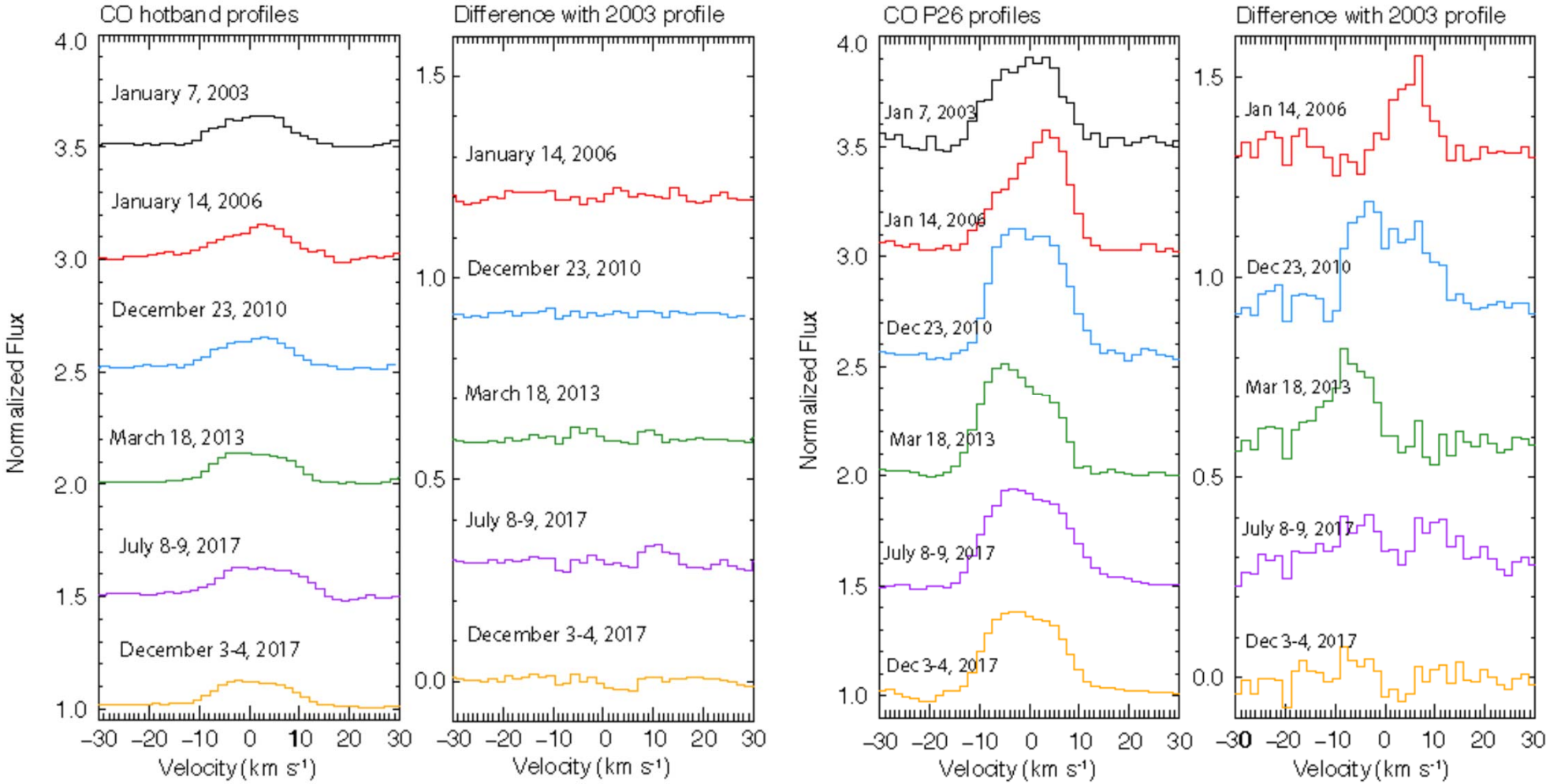






・スペクトロアストロメトリの手法により、
輝線放射領域の位置を調べた。
→inner holeの縁からの放射と考えてconsistent

・輝線プロファイルの時間進化



・CO Hotband全体では2003年からの差分に有意な差はなかったが、P26輝線のみでは、差が表れた。→inner holeの淵で放射が隠されている？

6

Fragmentation, rotation, and outflows in the high-mass star-forming region IRAS 23033+5951. A case study of the IRAM NOEMA large program CORE

Felix Bosco[1,2], Henrik Beuther[1], Aida Ahmadi[1,2], Joseph C. Mottram[1], Rolf Kuiper[3,1], Hendrik Linz[1], Luke Maud[4], Jan M. Winters[5], Thomas Henning[1], Siyi Feng[6,7], Thomas Peters[8], Dmitry Semonov[1,9], Pamela D. Klaassen[10], Peter Schilke[11], James S. Urquhart[12], Maria T. Beltrán[13], Stuart L. Lumsden[14], Silvia Leurini[15], Luca Moscadelli[13], Riccardo Cesaroni[13], Álvaro Sánchez-Monge[16], Aina Palau[17], Ralph Pudritz[18], Friedrich Wyrowski[11] and Steven Longmore[19]

The formation process of high-mass stars ($> 8\,M_\odot$) is poorly constrained, particularly the effects of clump fragmentation creating multiple systems and the mechanism of mass accretion onto the cores. We study the fragmentation of dense gas clumps, and trace the circumstellar rotation and outflows by analyzing observations of the high-mass ($\sim 500\,M_\odot$) star-forming region IRAS 23033+5951. Using the Northern Extended Millimeter Array (NOEMA) in three configurations and the IRAM 30m single-dish telescope at 220 GHz, we probe the gas and dust emission at an angular resolution of ~0.45 arcsec, corresponding to 1900 au. In the millimeter (mm) continuum emission, we identify a protostellar cluster with at least four mm-sources, where three of them show a significantly higher peak intensity well above a signal-to-noise ratio of 100. Hierarchical fragmentation from large to small spatial scales is discussed. Two fragments are embedded in rotating structures and drive molecular outflows, traced by ^{13}CO (2–1) emission. The velocity profiles across two of the cores are similar to Keplerian but are missing the highest-velocity components close to the center of rotation, which is a common phenomena from observations like these, and other rotation scenarios are not excluded entirely. Position–velocity diagrams suggest protostellar masses of ~ 6 and $19\,M_\odot$. Rotational temperatures from fitting CH_3CN $(12_K - 11_K)$ spectra are used for estimating the gas temperature and thereby also the disk stability against gravitational fragmentation, utilizing Toomre's Q parameter. Assuming that the candidate disk is in Keplerian rotation about the central stellar object and considering different disk inclination angles, we identify only one candidate disk as being unstable against gravitational instability caused by axisymmetric perturbations. The dominant sources cover different evolutionary stages within the same maternal gas clump. The appearance of rotation and outflows of the cores are similar to those found in low-mass star-forming regions.

Accepted by Astronomy & Astrophysics

8

Polarization reversal of scattered thermal dust emission in protoplanetary disks at submillimetre wavelengths

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Investigation of the polarized light of protoplanetary disks is key for constraining dust properties, disk morphology, and embedded magnetic fields. However, different polarization mechanisms and the diversity of dust grain shapes and compositions lead to ambiguities in the polarization pattern. The so-called self-scattering of thermal, re-emitted radiation in the infrared and millimetre and submillimetre wavelengths is discussed as a major polarization mechanism. If the net flux of the radiation field is in the radial direction, it is commonly assumed that the polarization pattern produced by scattering in a protoplanetary disk shows concentric rings for disks seen in face-on orientation. We show that a change of 90° of the polarization vector orientation may occur and mimic the typical pattern of dichroic emission of dust grains aligned by a toroidal magnetic field in disks seen close to face-on. Furthermore, this effect of polarization reversal is a fast-changing function of wavelength and grain size, and is thus a powerful tool to constrain grain composition and size distribution present in protoplanetary disks. In addition, the effect may also provide unique constraints for the disk inclination, especially if the disk is seen close to face-on.

Accepted by A&A

9

NH_3 Observations of the S235 Star Forming Region: Dense Gas in Inter-core Bridges

Ross A. Burns[1,2,3,4], Toshihiro Handa[5], Toshihiro Omodaka[4], Andrej M. Sobolev[6], Maria S. Kirsanova[6,7,8], Takumi Nagayama[9], James O. Chibueze[10,11], Mikito Kohno[12], Makoto Nakano[13], Kazuyoshi Sunada[9] and Dmitry A. Ladeyschikov[6]

Star formation is thought to be driven by two groups of mechanisms; spontaneous collapse and triggered collapse. Triggered star formation mechanisms further diverge into cloud-cloud collision (CCC), "collect and collapse" (C&C) and shock induced collapse of pre-existing, gravitationally stable cores, or 'radiation driven implosion' (RDI). To evaluate the contributions of these mechanisms and establish whether these processes can occur together within the same star forming region we performed mapping observations of radio frequency ammonia, and water maser emission lines in the S235 massive star forming region. Via spectral analyses of main, hyperfine and multi-transitional ammonia lines we explored the distribution of temperature and column density in the dense gas in the S235 and S235AB star forming region. The most remarkable result of the mapping observations is the discovery of high density gas in inter-core bridges which physically link dense molecular cores that house young proto-stellar clusters. The presence of dense gas implies the potential for future star formation within the system of cores and gas bridges. Cluster formation implies collapse and the continuous physical links, also seen in re-imaged archival CS and ^{13}CO maps, suggests a common origin to the molecular cores housing these clusters, i.e the structure condensed from a single, larger parent cloud, brought about by the influence of a local expanding HII region. An ammonia absorption feature co-locating with the center of the extended HII region may be attributed to an older gas component left over from the period prior to formation of the HII region. Our observations also detail known and new sites of water maser emission, highlighting regions of active ongoing star formation.

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10 Forming Pop III binaries in self-gravitating discs: how to keep the orbital angular momentum

Sunmyon Chon[1] and Takashi Hosokawa[2]

The disk fragmentation is a possible process leading to the formation of Population III stellar binary systems. However, numerical simulations show diverse fates of the fragments; some evolve into stable binaries and others merge away with a central star. To clarify the physics behind such diversity, we perform a series of three dimensional hydrodynamics simulations in a controlled manner. We insert a point particle mimicking a fragment in a self-gravitating disk, where the initial mass and position are free parameters, and follow the orbital evolution for several tens of orbits. The results show great diversity even with such simple experiments. Some particles shortly merge away after migrating inward, but others survive as the migration stalls with the gap-opening in the disk. We find that our results are well interpreted postulating that the orbital angular momentum is extracted by (i) the gravitational torque from the disk spiral structure, and (ii) tidal disruption of a gravitationally-bound envelope around the particle. Our analytic evaluations show the processes (i) and (ii) are effective in an outer and inner part of the disk respectively. There is a window of the gap-opening in the middle, if the envelope mass is sufficiently large. These all agree with our numerical results. We further show that the binaries, which appear for the "survival" cases, gradually expand while accreting the disk gas. Our theoretical framework is freely scalable to be applied for the present-day star and planet formation.

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