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今回紹介しない論文のAbstractは省略

High-resolution spectroscopic monitoring observations of FU Orionis-type object, V960 Mon

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We present the results of high-resolution ($R \geq 30,000$) optical and near-infrared spectroscopic monitoring observations of a FU Orionis-type object, V960 Mon, which underwent an outburst in 2014 November. We have monitored this object with the Bohyunsan Optical Echelle Spectrograph (BOES) and the Immersion GRating INfrared Spectrograph (IGRINS) since 2014 December. Various features produced by a wind, disk, and outflow/jet were detected. The wind features varied over time and continually weakened after the outburst. We detected double-peaked line profiles in the optical and near-infrared, and the line widths tend to decrease with increasing wavelength, indicative of Keplerian disk rotation. The disk features in the optical and near-infrared spectra fit well with G-type and K-type stellar spectra convolved with a kernel to account for the maximum projected disk rotation velocity of about 40.3±3.8 km s^{-1} and 36.3±3.9 km s^{-1}, respectively. We also report the detection of [S II] and H_2 emission lines, which are jet/outflow tracers and rarely found in FUors.

Accepted by ApJ

- FU orionis 天体 V960 Monに対する高分散分光・モニター観測
- wind, disk, outflow/jetの特徴を検出
- windの特徴は時間と共に弱まった

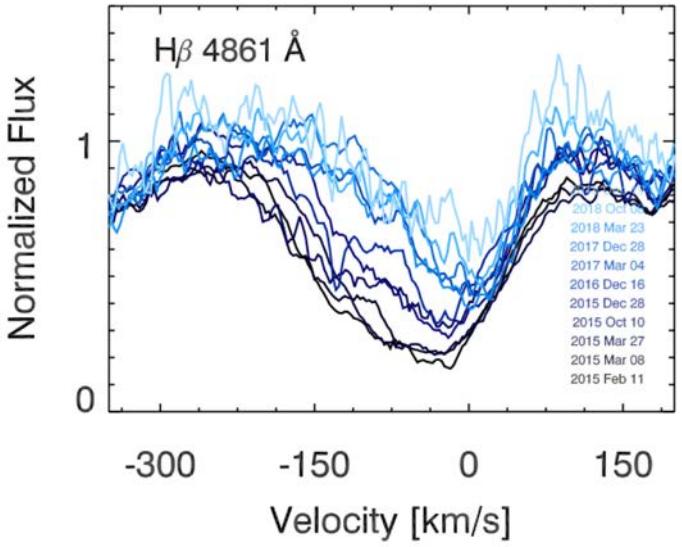
内容：1ページ

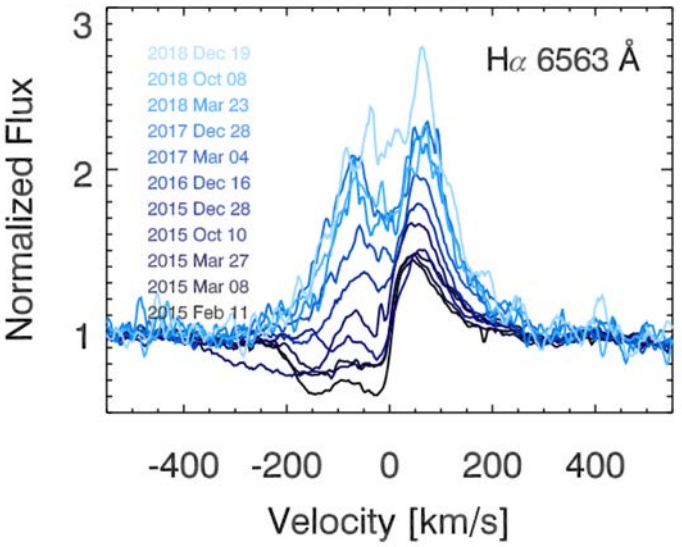
イントロ

- FUori天体は間欠的降着の観測的証拠
- バースト現象の物理過程を知るために、高分散分光観測をすることが重要
- V960Monは2014年11月にアウトバーストが起きる
- バースト後、高分散(R~30,000)でモニタリング

観測結果まとめ

- Wind-features: Hα (P Cygni prof.), Hβ と Na I(青側の吸収線)
  - 時間経過と共に吸収線は浅くなり、Hα では輝線が現れる
  - 変動は~1年のタイムスケール
  - 降着率が時間と共に減少することで(wind-rate が減少し？)説明可能
- Disk features:
  - Optical とNIRでdouble peak profileを検出
  - 高温のKeplerian diskを示唆
    - 5000K at 90 Rsun , 4600K at 110 Rsun
- Outflow Jet features:
  - Emission lines: [S II] と H_2 (FUorsで初検出)





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A protostellar system fed by a streamer of 10,500 au length

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Binary formation is an important aspect of star formation. One possible route for close-in binary formation is disk fragmentation. Recent observations show small scale asymmetries (<300 au) around young protostars, although not always resolving the circumbinary disk, are linked to disk phenomena. In later stages, resolved circumbinary disk observations (<200 au) show similar asymmetries, suggesting the origin of the asymmetries arises from binary-disk interactions. We observed one of the youngest systems to study the connection between disk and dense core. We find for the first time a bright and clear streamer in chemically fresh material (Carbon-chain species) that originates from outside the dense core (>10,500 au). This material connects the outer dense core with the region where asymmetries arise near disk scales. This new structure type, 10× larger than those seen near disk scales, suggests a different interpretation of previous observations: large-scale accretion flows funnel material down to disk scales. These results reveal the under-appreciated importance of the local environment on the formation and evolution of disks in early systems and a possible initial condition for the formation of annular features in young disks.

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- 原始星周囲でコアから円盤に至る、明るく化学的に新鮮な流れを初めて観測的に発見した。
- 円盤サイズよりも10倍大きい：大局的な降着流によって物質が円盤に送り込まれる
- 円盤形成・進化やリング構造の初期条件

内容：５ページ

イントロ

- Per-emb-2 (IRAS 03292+3039)
  - 連星系 (連星間距離20au)
  - 原始星周囲の化学環境から、最近降着バーストが起きたことが示唆されている
    → 原始星降着の変動における周囲環境の役割を調べる上で良いターゲット
  - 円盤スケール(ケプラー円盤自体は未検出)に、羽のような構造が見られる：重力不安定円盤の可能性
- 非軸対称な降着？
  - 星形成のイメージ：孤立系で、軸対称エンベロープからの円盤に降着
  - 分子雲中の星形成シミュレーション：非対称な降着流
  - 非対称な降着流は、軸対称な場合と比べると降着率が異なりうる
- 最近の観測では1000auスケール以下の降着流の存在が明らかになっているが、
  それより大きなスケールの大局的な降着流は観測されていない

観測結果概要 (Fig. 1)

- NOEMA(the NOrthern Extended Millimeter Array)で分子輝線観測
- 10,500auから300auスケールの流れ(streamer)を発見
- 化学的に新鮮な物質(まだ炭素原子がCOに変換されていない)

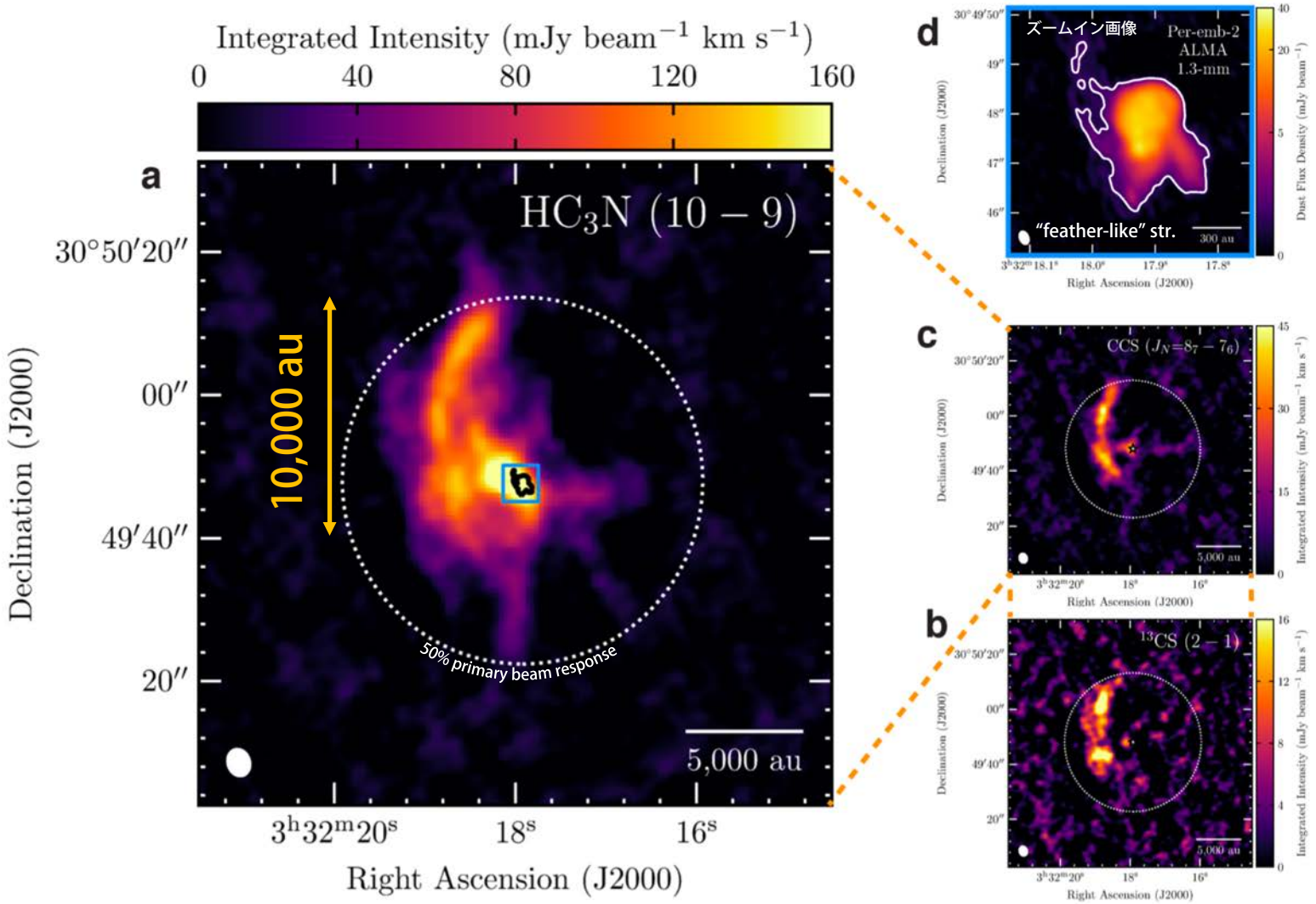


Figure 1 Image of the "chemically fresh" material surrounding the protostar (panels a, b, and c) and zoomed-in high-angular resolution image of the material near disks scales (panel d). The panels a, b, and c reveal a streamer of fresh material starting at a distance on the sky of 10,500 au from the central protostar. The streamer is seen in two carbon-chain molecules and a S-bearing species, all known to be abundant in chemically young material. The black contour in panel a corresponds to the asymmetrical and feather-like feature near disk scales, and it is also shown as a white contour in the zoomed-in image in the panel d. The angular resolution of the observations and scalebar are shown in the bottom left and bottom right corner, respectively. The 50% primary beam response is shown by the white dotted circle. The ALMA 1.3-mm contour levels are shown in panels a and d at 1mJy beam^{-1}, where the noise level is 0.166 mJy beam^{-1}.

Streamerの空間的な運動について(Fig.2)

- 天球面上の分布が空間的な分布を直接意味するわけではないので、物体の空間的な運動を知るために速度と速度分散を導出
- 滑らかな速度勾配：連続的な物体であることを示唆
- 中心付近の速度は星の速度と一致
- 速度分散は小さい(亜音速乱流の速度分散と整合的)
- 観測の速度勾配は、中心質量の重力がstreamerの運動を支配していることを示唆
- 初期自転を伴うガス流のモデルによって位置・速度は説明可能(Fig3)

streamerはfree-fallする、分子雲コアから円盤スケールに至るガスの流れ

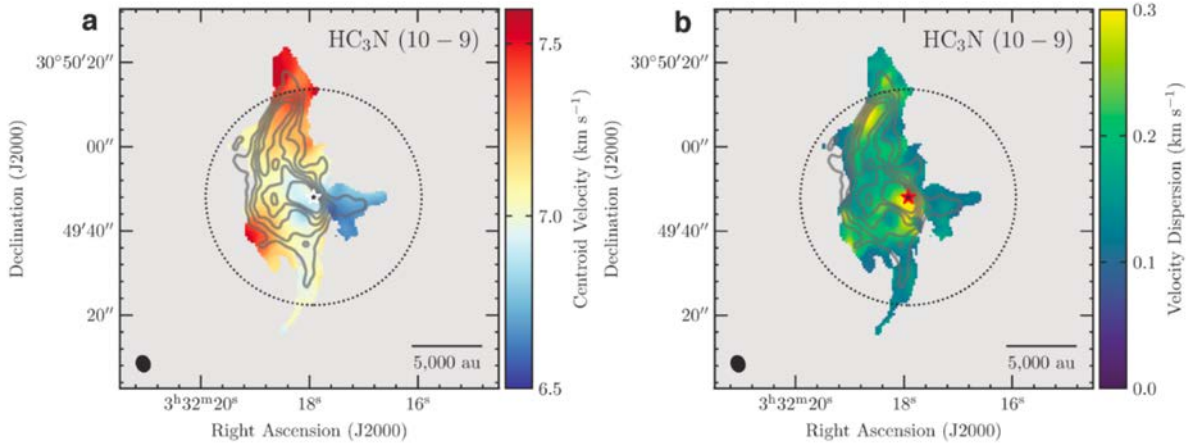


Figure 2 Centroid velocity and velocity dispersion of the streamer tracing HC_3N (10-9) emission in panels a and b, respectively. The velocity field is smooth and shows a clear velocity gradient. The velocity dispersion shows subsonic levels of turbulence, and therefore the material is not affected

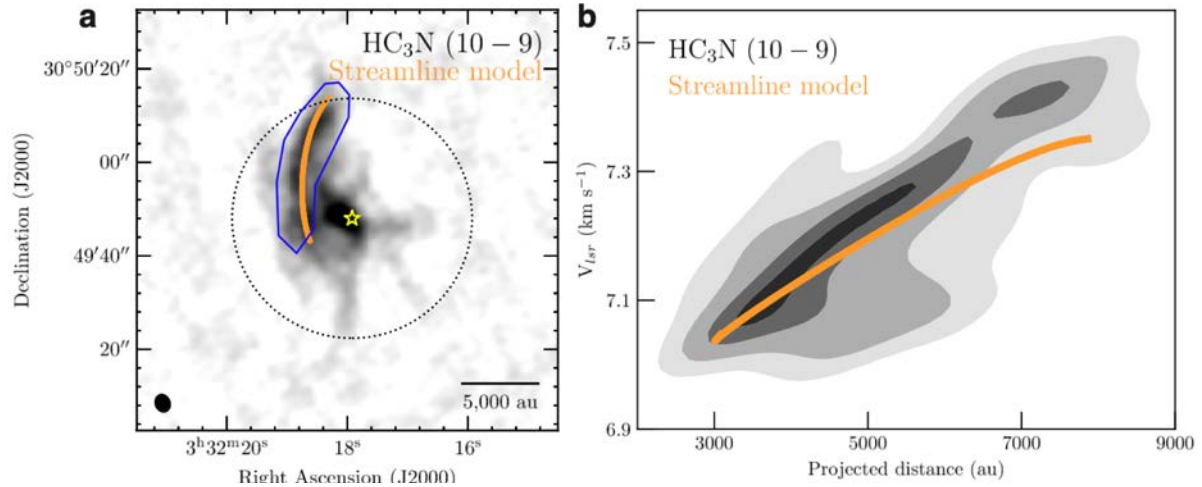
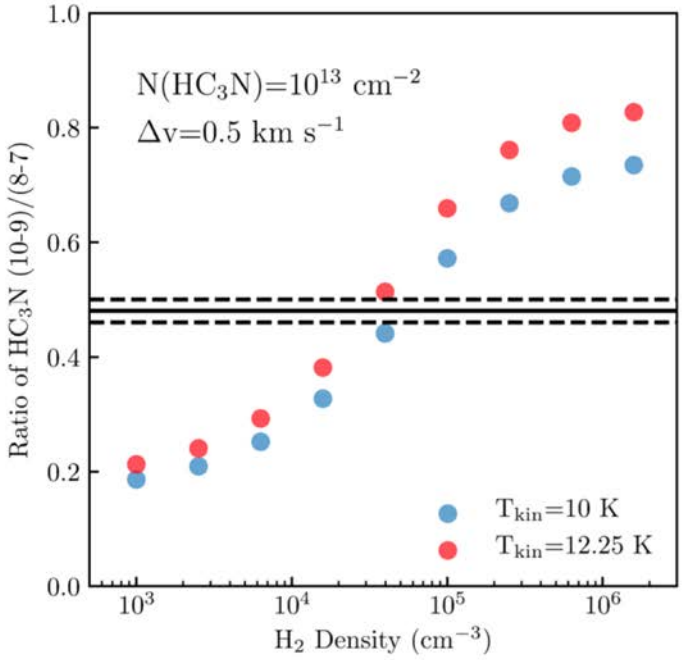


Figure 3 Sky position and velocity along the line-of-sight of the streamline model (in orange) overlaid on the observations (gray). The streamer is highlighted by the blue polygon in panel a. The panel b shows varying levels of kernel density estimation of the velocity as a function of projected distance from the central system. The contour levels are drawn starting at 0.5σ and progressing outwards in steps of 0.5σ, where the σ-levels are equivalent to that of a bivariate normal distribution. The streamline model provides a good match to the observations and it supports the interpretation of gravitational free-fall of the streamer towards the central regions of the dense core. The angular resolution of the observations and scalebar are shown in the bottom left and bottom right corner, respectively. The 50% primary beam response is shown by the black dotted circle.

Streamerの降着率について

- HC3N(10-9)と(8-7)でstreamerを検出
  - 平均H2密度：4e4 cm-3
  - HC3Nの柱密度：2e13 cm-2
  - HC3N/H2 ~ 7e-9
- Streamerの総質量 ~ 0.1 Msun
  - 中心質量3.2Msunと比べて
    なかなかな質量を持っている
  - streamerの降着過程の重要性を示唆
- streamerの降着率 ～ 1e-6 Msun/yr
  c.f.) 原始星への降着率 ～ 7e-7 Msun/yr
  - streamerは原始星への降着率を変化させる可能性
  - 実際にこの天体では過去１万年以内に10倍以上の降着バーストを経験
  - このような外側エンベロープからの降着イベントが若い天体の時間変動を
    駆動しているのかもしれない



Extended Data Figure 1: Ratio of the integrated intensity of HC_3N (10-9) to (8-7) transitions as a function of H_2 density. The ratio is calculated using RADEX, for kinetic temperatures of 10 and 12.25 K in blue and red, respectively. The measured average value and associated uncertainty of the ratio in the streamer is marked by the horizontal solid and dashed lines, respectively. This comparison shows that the average density in the streamer is $(4\pm2)\times10^4$ cm^{-3}.

Streamerの化学的特徴について

- 化学的に進化したコアの良い指標である N2H+とN2D+でも観測を行った
  - 内部エンベロープをトレース
  - しかしstreamerは検出しなかった(炭素鎖分子やS分子が良いトレーサー)
- 炭素鎖分子の枯渇(凍結)タイムスケール：
  - 内部エンベロープでは600yr
  - 外部エンベロープでは20,000yr (~ 自由落下時間)
  - 降着時間≲枯渇タイムスケールより、Streamerの降着時間は短い (c.f. class 0 ~100,000yr)

Streamerの降着によって化学的に新鮮な物質を円盤・原始星へと供給している