A population of eruptive variable protostars in VVV

C. Contreras Peña, P.W. Lucas, D. Minniti, R. Kurtev, W. Stimson, C. Navarro Molina, J. Borissova, N. Kumar, M.A. Thompson, T. Gledhill, R. Terzi, D. Froebrich, and A. Caratti o Garatti

Accepted by MNRAS
http://arxiv.org/pdf/1602.06267

VISTA Variables in the Via Lactes (VVV) survey

- VISTA = Visible and Infrared Survey Telescope for Astronomy <= 4m望遠鏡 at Chile
- 赤外で初の時間変動に関する大規模サーベイ
  - 5 near-infrared bands (*Z, Y, J, H, K*)
  - 2010年-2014年の間にmulti-epoch観測
  - Milky Way + bulge 560deg^2
  - 3 x 10^8 point sources

目的は変光星サンプルを増やすこと。そして、FU ori. やEX Lupi.のような特殊なフレア・変光YSOを見つけること

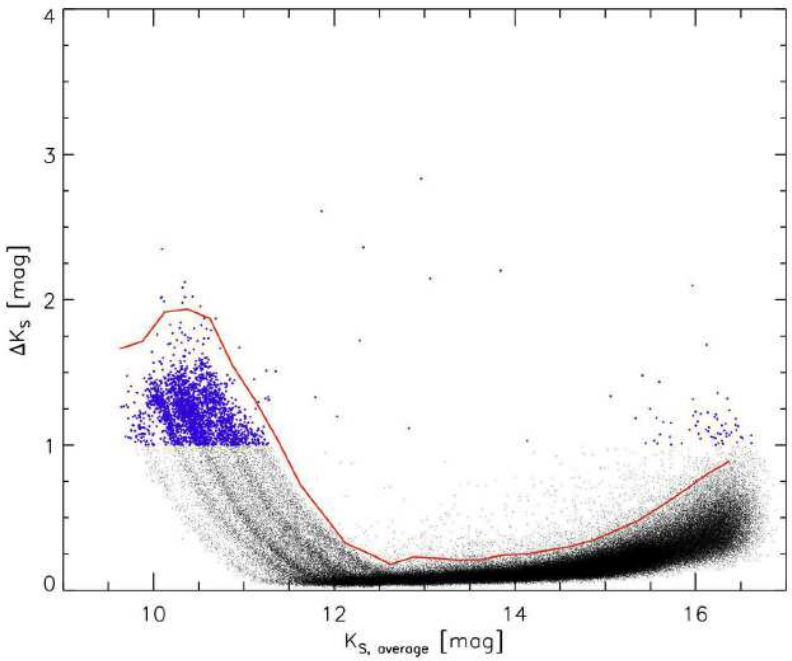


Fig 2 青丸がDK>1 magの変光星候補
赤線は、3σの追加制限。これより上の星は視覚的な調査をした。

Short –Term Variability (周期<100day)

Eclipsing Binaries

周期測定不可 ↓

Short –Term Variability

Fader

Dipper

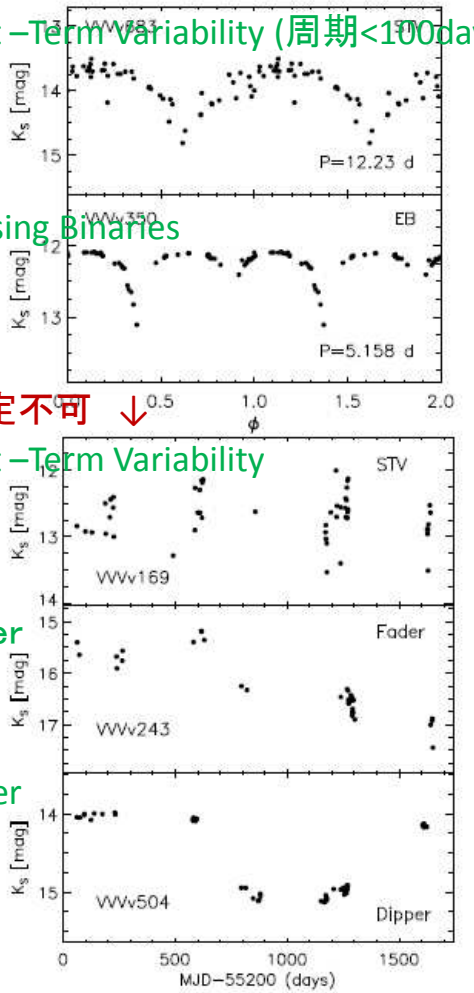


Figure 17. Examples of K_s light curves for the different classifications as explained in the text. (top) Phased light curves of short-term variable star with a measured period, VVVv683 and eclipsing binary VVVv350. (bottom) Light curves of short-term variable star, without a measured period, VVVv169, the fader VVVv243 and the dipper VVVv504.

Fader: 徐々に光度低下or突然光度低下

Dipper: 突然、通常光度に復帰

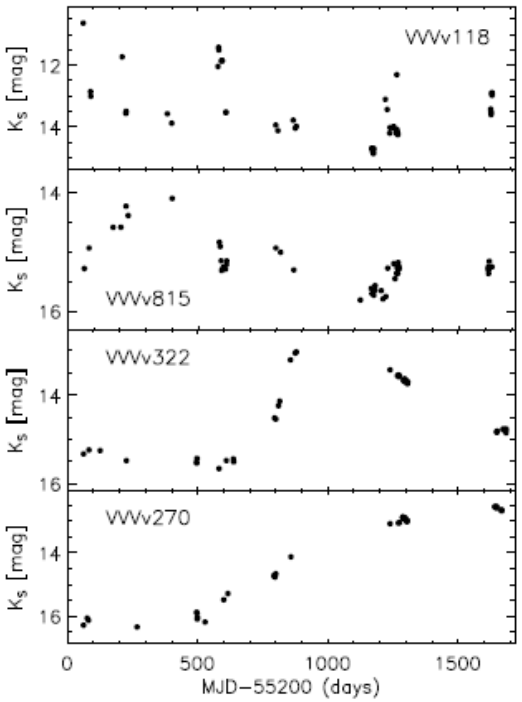


Figure 18. Examples of K_s light curves for different objects in the eruptive classification as explained in the text. From top to bottom we show objects VVVv118, VVVv815, VVVv322 and VVVv270.

Eruptive: 1－4年のバースト

おまけ 光度別個数

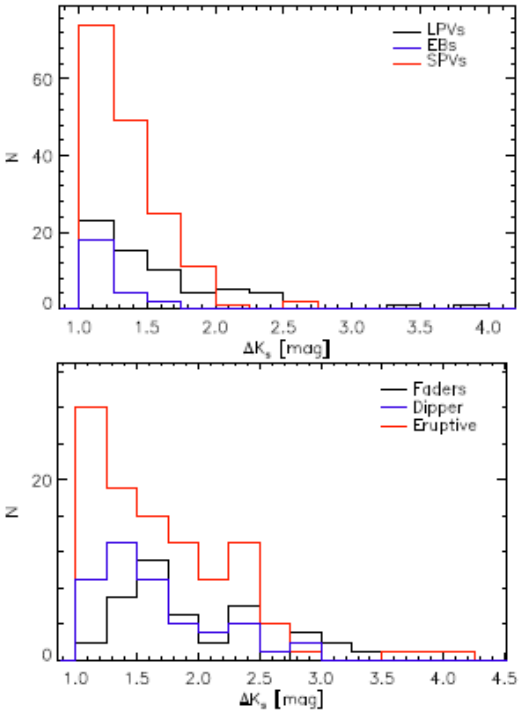


Figure 20. ΔK_s distribution for the different light curve morphology YSO classes. (top) Distribution for LPVs (black line), STVs (red line) and EBs (blue line). (bottom) Distribution for aperiodic variables, faders (black line), dippers (blue line) and eruptive objects (red line).

65 Long-term periodic(100>day)
162 Short-term periodic(100<day)
39 Fader
45 Dipper
24 Eclipsing binaries
106 Eruptive ←サンプル数を5倍に増やした!

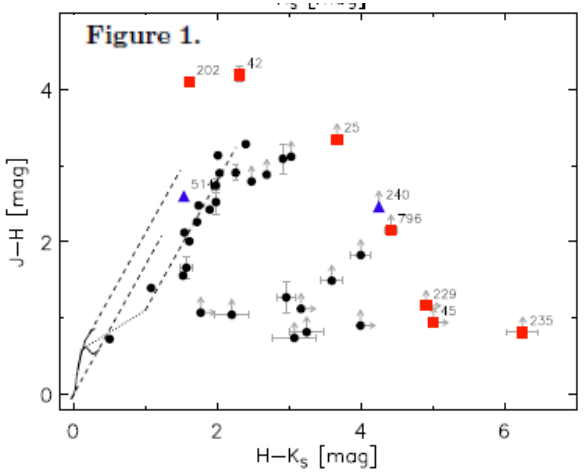
Infrared spectroscopy of eruptive variable protostars from VVV

C. Contreras Peña, P.W. Lucas, R. Kurtev, D. Minniti, A. Caratti o Garatti, F. Marocco, M.A. Thompson, D. Froebrich, N. Kumar, W. Stimson, C. Navarro Molina, J. Borissova, T. Gledhill, and R. Terzi

Accepted by MNRAS
http://arxiv.org/pdf/1602.06269

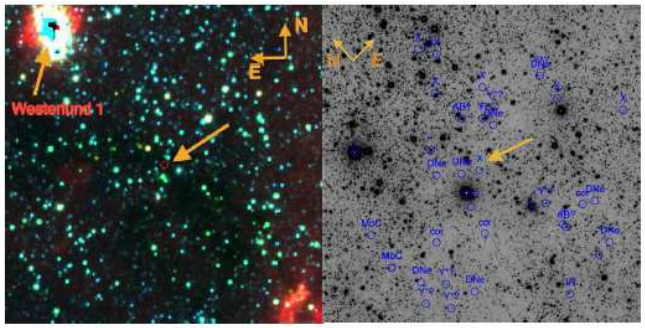
- VISTA Variables in the Via Lactes (VVV) surveyのサンプルのうち37天体に対してSpectroscopy観測。
  Accretionなどの兆候を調べる
- 望遠鏡・装置: Magellan Baade/FIRE (0.8-2.5micron) R~250-350 with 0.6”slit
- Sample: VVVより 37 Sourcesを選定
  - Ks < 14.5mag (もっとも最近のVVV観測)
  - 距離 < 2kpc
  - 内訳: 18 Eruptive、2 Fader、3 Dipper、5 Long-term、3 Short-term、6 Mira-like

- SED fittingで星の物理量を導出(WISE,Spitzer, ,,,)
  by Robitaille et al. (2007) SED fitter



VVV v322 (Eruptive)

- d = 3.55kpc
- age = 4-5My
- M = 2.3Msun



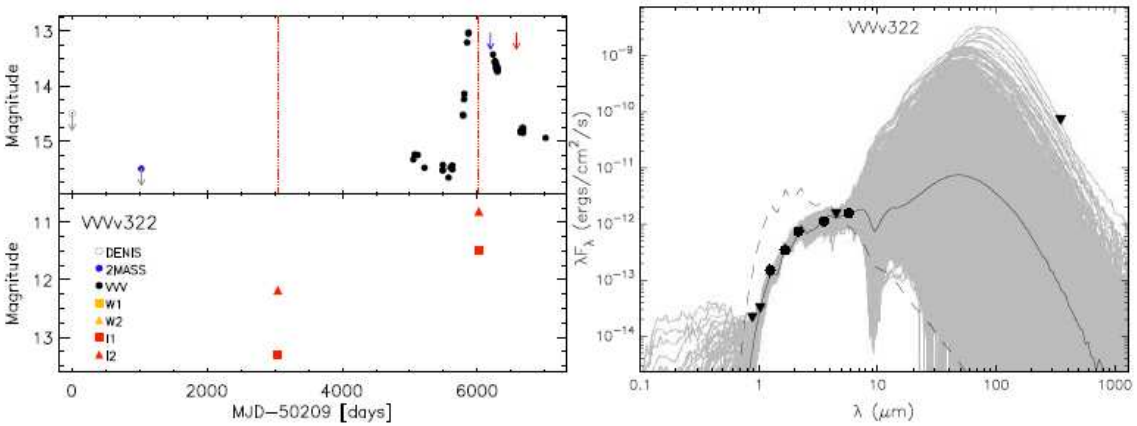
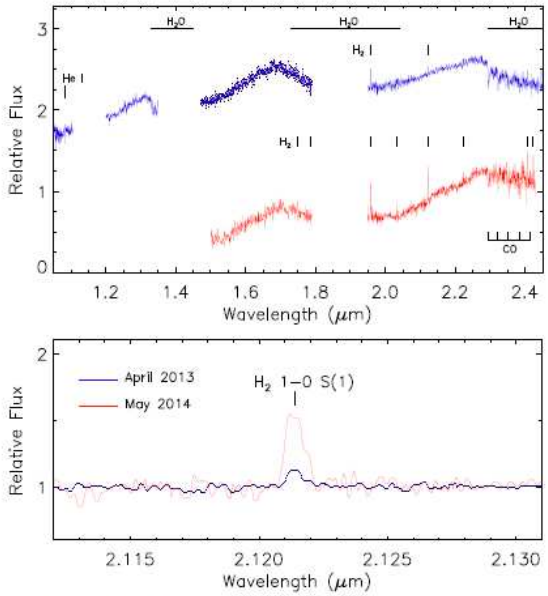


Figure 10. (top left) False colour WISE image (blue=3.5 μm, green=4.6 μm, red=12 μm) of a $20' \times 20'$ area centred on VVVv322. The location of the object is marked by the arrow. The SFR Westerlund 1 is also shown in the image. (top right) K_s image of a $10' \times 10'$ area centred on VVVv322. The location of the object is marked by the arrow. In addition, blue circles and labels mark objects found in a SIMBAD query with a $5'$ radius. (botton, left) Near- and mid-infrared photometry of VVVv322. The approximate dates of spectroscopic follow up are marked by blue (2013) and red(2014) arrows. (bottom, right) SED of VVVv322 along with Robitaille et al. (2007) YSO models that fulfil the criteria of $\chi^2 - \chi^2_{best} < 3N$, with N the number of data points used to generate the fits. This image is generated by the fitting tool.



ure 11. (top) Graph comparing the 2013 (blue) and 2014 (red) FIRE spectra of VVVv322, where we mark the observed absorption res of H_2O and CO, along with emission lines from H_2. (bottom) 2013 and 2014 observations in the region 2.10-2.13 μm comparing 1.12 μm 1-0 S(1) H_2 emission line.

- VVV v322の2013年（青）のスペクトルは高い質量降着時のFU Ori.とそっくり（1.3-1.4,1.7-2,2.3-2.5micron H2O and 2.29 micronCO 吸収、弱いH2 1-0 emission)。しかし、これはEX Lup.タイプ（短いバースト）。謎。
- 15/18 Eruptive、1/2 Fader、3/5 Long-termで大きな質量降着があった。

Submillimeter Array Observations of NGC 2264-C: Molecular Outflows and Driving Sources

Nichol Cunningham, Stuart Lumsden, Claudia Cygnaowski, Luke Maud and Cormac Purcell

Accepted by MNRAS
http://arxiv.org/pdf/1602.06196

NGC2264-C

- もっとも近い大質量星形成領域 in Red MSX Source (RMS) Survey
  d ~ 738±50pc (Kamazaki et al. 2014)
- 2-40Msun の１３のミリ波連続波コアがある（典型的サイズ ~ 0.04pc)
- AndreがIRAM 30m (~11”分解能）で観測
- SMAでは　原始星コアC-MMS3の観測があり、outflowが検出されている。
- 本観測は、最初のSiO(5-4)の高分解能(~3”)観測でｷﾀﾈ

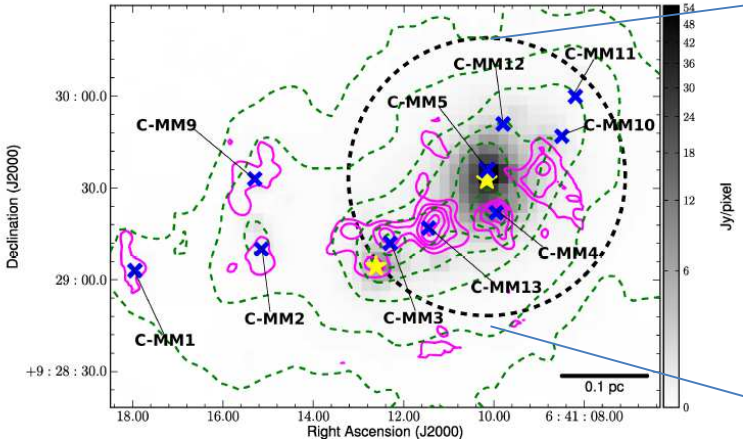
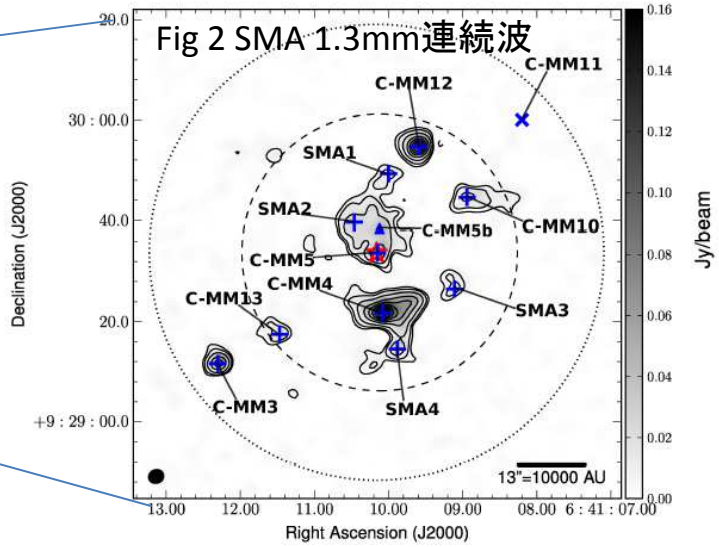


Fig 1 Herschel 70micron+PdBIN2H+(1-0)



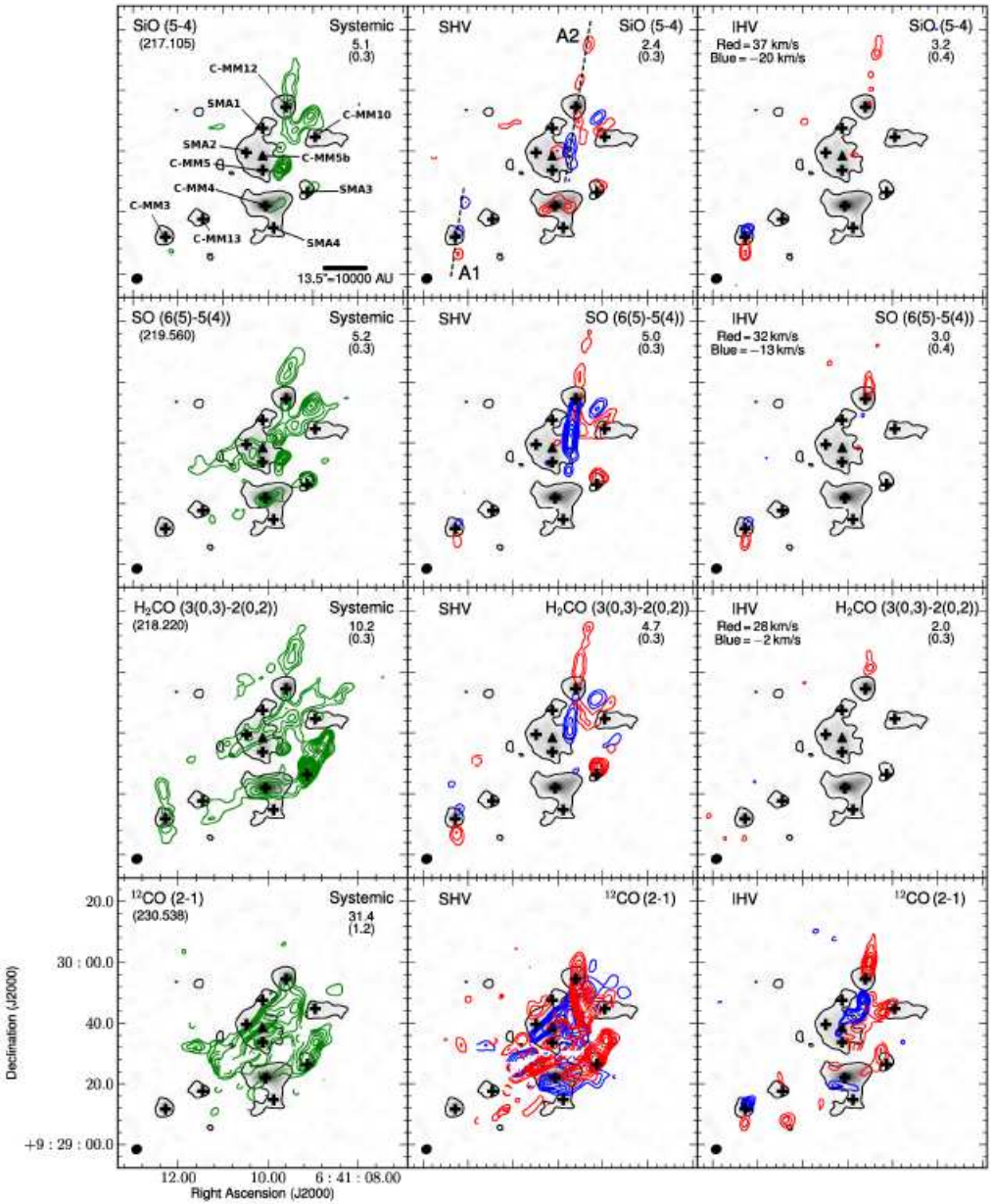


Fig. 6

- C-MM3 とC-MM12からのbipolar outflow発見。
- それらのOutflowの運動量やmm波強度は low-massとhigh-massの中間ぐらい(Fig.12)。
- コア間に進化段階のバラつき。

C-MM4 hot core的に多くの分子輝線が付随
C-MM3, C-MM13, SMA-4に分子輝線が付随無し。

Two confirmed class I very low-mass objects in Taurus

C. Dang-Duc, N. Phan-Bao, and D.T. Dao-Van

Accepted by A&A Letters
http://arxiv.org/pdf/1602.06357

[GKH94] 41 and IRAS 04191+1523B

- Taurusにあるbrown dwarf candidates
- [GKH94] 41: M7.5±1.5のflat spectrum SED。Class I or 若いClass IIと分類 (Gomez et al. 1994)。Class II+diskとしても説明がつく(Furlan et al. 2011)。
- IRAS 04191+1523B : 6".1 separationのbinaryのsecondary。M7±1のClass I BD(Luhman et al. 2010)

長波長の観測を行い確かめる。

Observation

- Combined Array for Research in Millimeter-wave Astronomy(CARMA) 102GHz (or 2.9mm)

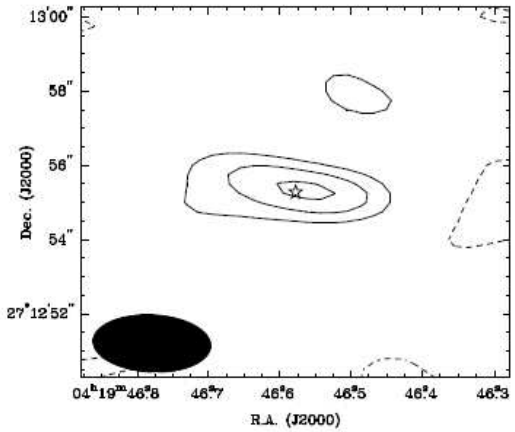


Fig. 1. Continuum map at 2.9 mm of [GKH94] 41. The star symbol indicates the 2MASS near-infrared position of [GKH94] 41. The contours are -3, 3, 5, and 7 times the rms of 0.2 mJy beam^{-1}. The synthesized beam is indicated in the bottom left corner.

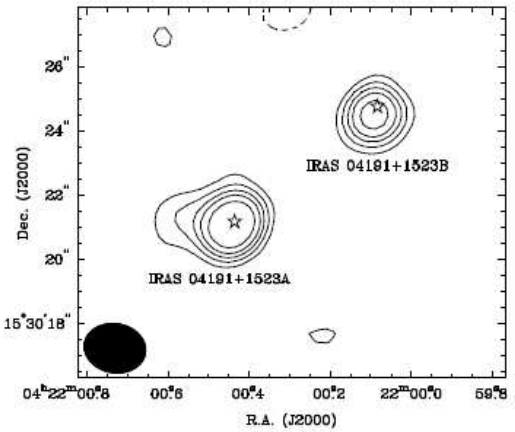


Fig. 2. Continuum map at 2.9 mm of IRAS 04191+1523A and IRAS 04191+1523B. Two components are spatially resolved with a separation of 6".1. The star symbols represent the 2MASS near-infrared positions of IRAS 04191+1523A and IRAS 04191+1523B. The contours are -3, 3, 5, 7, 9, and 12 times the rms of 0.4 mJy beam^{-1}. The synthesized beam is indicated in the bottom left corner.

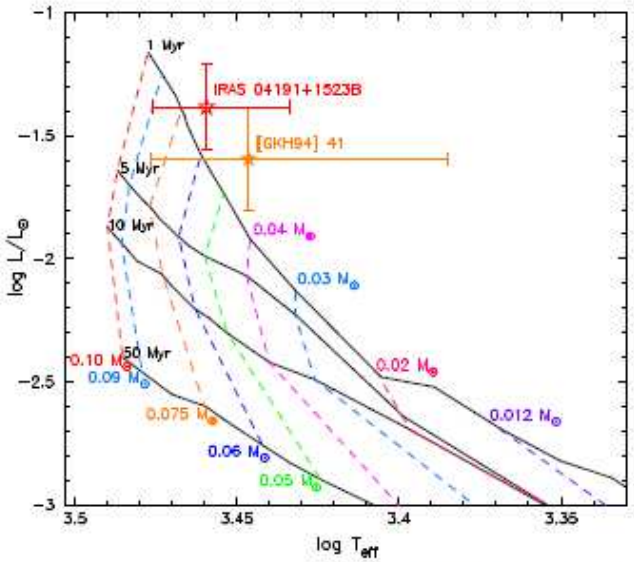


Fig. 3. H-R diagram for [GKH94] 41 and IRAS 04191+1523B. Isochrones and mass tracks from the theoretical evolutionary models of Chabrier et al. (2000) for $M \leq 0.075\ M_{\odot}$ and Baraffe et al. (1998) for $M > 0.075\ M_{\odot}$. The solid and open stars represent [GKH94] 41 (M7.5±1.5) and IRAS 04191+1523B (M7.0±1.0), respectively. The error bars reflect the uncertainties in the spectral type, 1.5 subclasses for [GKH94] 41 (Luhman et al. 2009) and 1.0 subclass for IRAS 04191+1523B (Luhman et al. 2010).

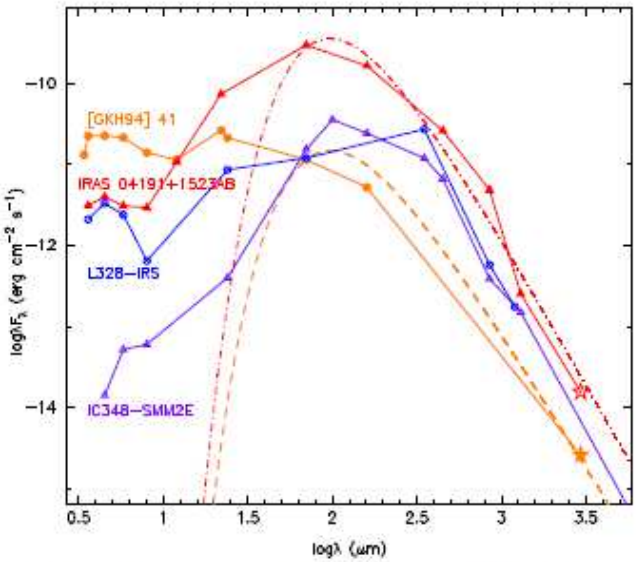


Fig. 4. SEDs of the class I VLM objects ([GKH94] 41: brown line, IRAS 04191+1523AB: red line) and previously reported class 0 proto-BDs: L328-IRS (Lee et al. 2013) (blue line) and IC348-SMM2E (Palau et al. 2014) (violet line). For [GKH94] 41 and IRAS 04191+1523AB, infrared to submm data are taken from Bulger et al. (2014) and references therein. The mm data measured in this paper are indicated by the open and solid stars for IRAS 04191+1523AB and [GKH94] 41, respectively. The brown dashed line shows the best fit for a modified blackbody of the dust envelope of [GKH94] 41 and the red dash-dotted line for IRAS 04191+1523AB.

[GKH94] 41: Class I , M~49M_J, M_{env}~2M_J (by 70micron),
04191+1523B : Class I, M~75M_J, M_{env}~33M_J (by 70micron),
これらがBD or very low-mass starであることを確認。我々は新たに2つこのサンプルを同定。

The inner structure of the TW Hya Disk as revealed in scattered light

John H. Debes, Hannah Jang-Condell, Glenn Schneider

Accepted by ApJL
http://arxiv.org/pdf/1602.02090

TW-Hya

- 最も近い原始惑星系円盤 d = 54pc
- ほぼface-on (i < 7deg), Age ~ 10 Myr, M = 0.5~0.8 Msun
- R ~ 30 AUにCO snow line (ALMAによるN2H+観測 by Qi et al, 2013)
- R ~ 80 AU に Gap (HST 近赤観測 by Debes et al. 2013)

Observation

- HST NICMOS coronagraph（多分、F222Mが新しく追加されたデータ ↓ 少しだけ内側が観測できた。~0".4）

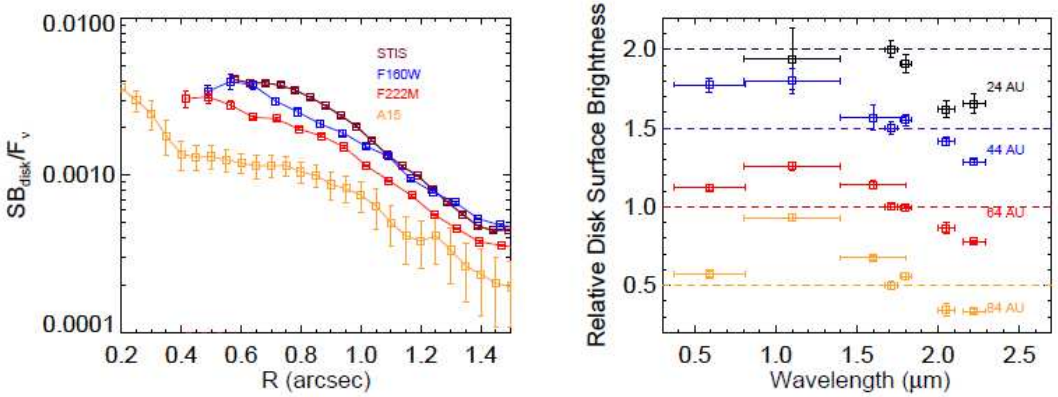


Fig. 1.— (left) SB profiles of the TW Hya disk. We show profiles from three HST images of TW Hya (STIS, F160W, F222M) and the profile from A15. The polarized intensity observed by A15 is 77% of the total intensity observed in F160W. (right) Photometry of the disk as a function of wavelength and distance from the central star. At each distance the normalized spectrum is offset by a constant factor. A depression in flux in 2.04 and 2.22μm strengthens interior to 80 AU.

A15 (Akiyama et al. 2015)
3つのベキ分布($\propto R^a$)
Zone1: R< 0".4 a = -1.39
Zone2: 0".4<R< 0".8 a = -0.33
Zone3: 0".8<R< 0".4 a = -2.65

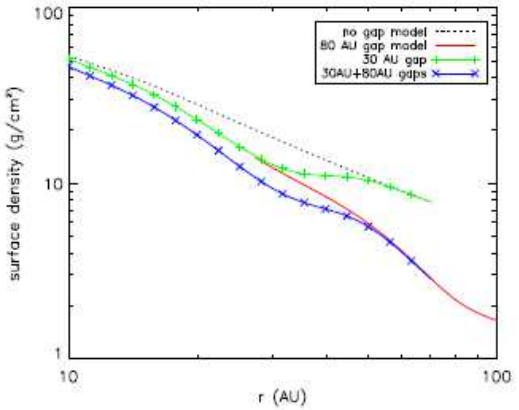
左図はDebes et al. (2013)の確認
＊Disk colorは中心星からの距離 Rに依存しない。

モデル Debes et al. (2013)と同じ。

星: α = 0.005, dM/dt = 10^-9 Msun/yr, M_* = 0.55 Msun, T_{eff} = 3741K, R_*=1.08Rsun

円盤: d = 0.3, width w = 10 AU, r_0 = 30 AU

$$\Sigma(r) = \Sigma_0(r)\{1 - d\exp[-(r - r_0)^2/(2w^2)]\}\exp[-(r/k)] \quad (1)$$



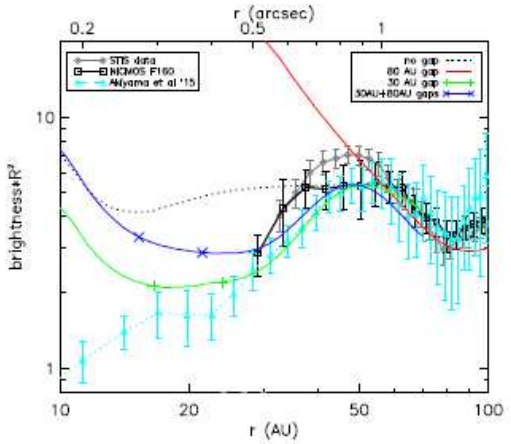


Fig .2

brightness profile. A disk with an inner 30 AU gap and an outer 80 AU gap qualitatively matches the observed behavior from 30-100 AU but overpredicts disk flux. The marked

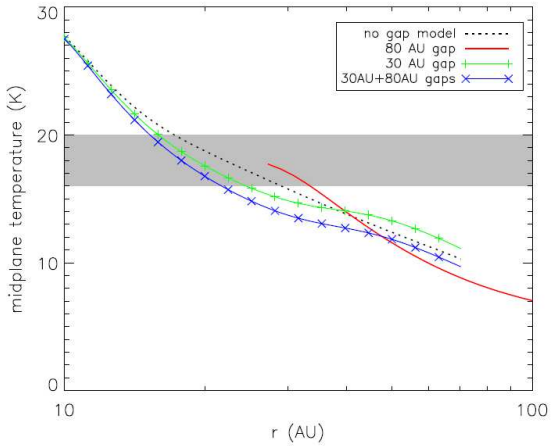


Fig. 3.— Midplane temperatures of the TW Hya disk under the assumption of various disk structures. Midplane temperatures are only weakly dependent on surface structures such as partially cleared gaps. We also overplot the expected CO condensation temperatures, which correlate roughly with where we observe the inner disk gap.

CO condensationの温度は、16-20K。=> これはモデルでは25-30AUになる。
CO snow lineを見つけたQi et al. (2013)のN2H+観測と合っている。