星形成ゼミ (SFN #301 36-42) 2018/2/23 辰馬

36. Episodic accretion in binary protostars emerging from self-gravitating solar mass cores, Riaz et al., http://arxiv.org/pdf/1712.09646

37. On fragmentation of turbulent self-gravitating discs in the long cooling time regime, Rice & Nayakchin, http://arxiv.org/pdf/1712.05610

38. Phosphorus-bearing molecules in the Galactic Center, Rivilla et al., https://arxiv.org/pdf/1712.07006

39. A new compact young moving group around V1062 Sco, Riser et al., http://arxiv.org/pdf/1712.10143

40. Intensity-Corrected Herschel Observations of Nearby Isolated Low-Mass Clouds, Sadavoy et al., http://arxiv.org/pdf/1712.00017

41. Accretion signatures in the X-shooter spectrum of the substellar companion to SR12, Santamaría-Miranda et al., http://arxiv.org/pdf/1712.09297

42. The HR 4796A Debris System: Discovery of Extensive Exo-Ring Dust Material, Schneider et al., http://arxiv.org/pdf/1712.08599

37. On fragmentation of turbulent self-gravitating discs in the long cooling time regime

Ken Rice, Sergei Nayakshin

It has recently been suggested that in the presence of driven turbulence discs may be much less stable against gravitational collapse than their non turbulent analogs, due to stochastic density fluctuations in turbulent flows. This mode of fragmentation would be especially important for gas giant planet formation. Here we argue, however, that stochastic density fluctuations due to turbulence do not enhance gravitational instability and disc fragmentation in the long cooling time limit appropriate for planet forming discs. These fluctuations evolve adiabatically and dissipate away by decompression faster than they could collapse. We investigate these issues numerically in 2D via shearing box simulations with driven turbulence and also in 3D with a model of instantaneously applied turbulent velocity kicks. In the former setting turbulent driving leads to additional disc heating that tends to make discs more, rather than less, stable to gravitational instability. In the latter setting, the formation of high density regions due to convergent velocity kicks is found to be quickly followed by decompression, as expected. We therefore conclude that driven turbulence does not promote disc fragmentation in protoplanetary discs and instead tends to make the discs more stable. We also argue that sustaining supersonic turbulence is very difficult in discs that cool slowly.

- Hopkins & Christiansen (2013)で提唱された、原始惑星系円盤内の超音速乱流によるガスの密度ゆらぎによって、高密度ガス領域が形成され、その領域が重力不安定になり収縮するという理論をシミュレーションで確かめた。
- 原始惑星系円盤は冷却時間が局所的な力学時間(~1/Ω)に対して長いため、乱流により円盤が加熱されると冷却が不十分となり重力不安定にならないことがわかった。
- また、冷却時間の長い円盤内で超音速乱流を維持することが難しいこともわかった。

- 2Dシミュレーション（乱流なし）
  - β=(冷却時間)/(力学時間)=(冷却時間)Ω
  - β≤4で円盤が分裂
  - Gammie (2001)の条件β≤3とほぼ一致

シミュレーション結果

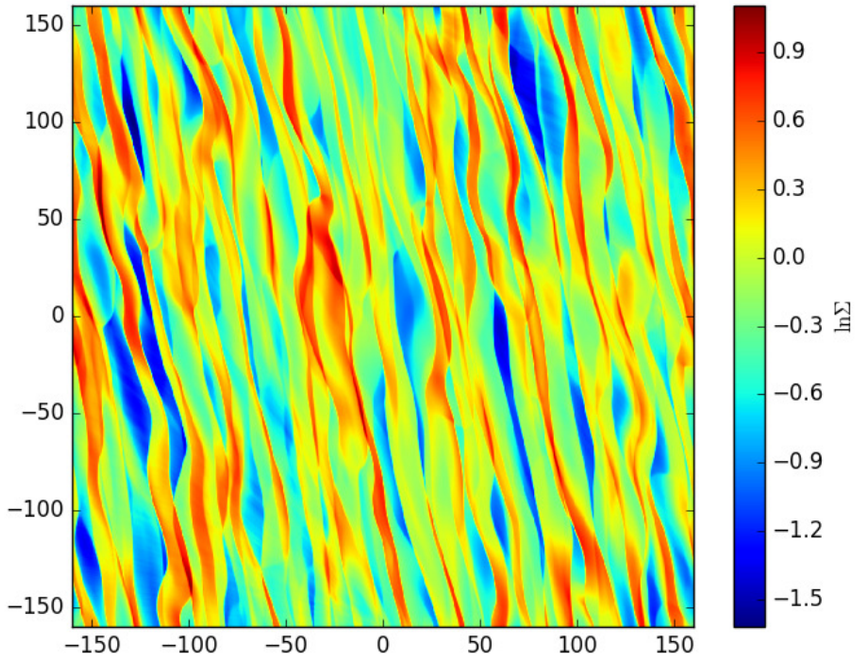
β	Disc fragments?
4	Yes
5	?
7	No
8	No
10	No

- 2Dシミュレーション（乱流あり）
  - パラメータ: 乱流強度fo、波数k → マッハ数Mが計算できる

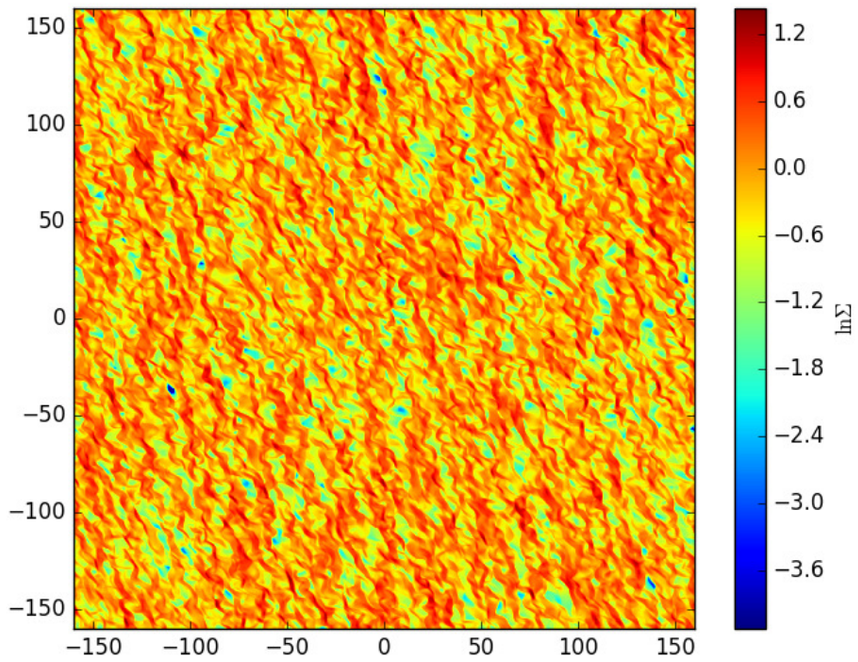
乱流パラメータ

f_o	k	$\mathcal{M}$
0.1	0.1	0.14
0.1	1.0	0.27
0.25	0.1	0.30
0.25	1.0	0.57
0.5	0.1	0.57
0.5	1.0	0.95
1.0	0.1	1.09
1.0	1.0	1.5
2.0	0.1	2.0
2.0	1.0	2.32
5.0	0.1	3.90

波数k=0.1



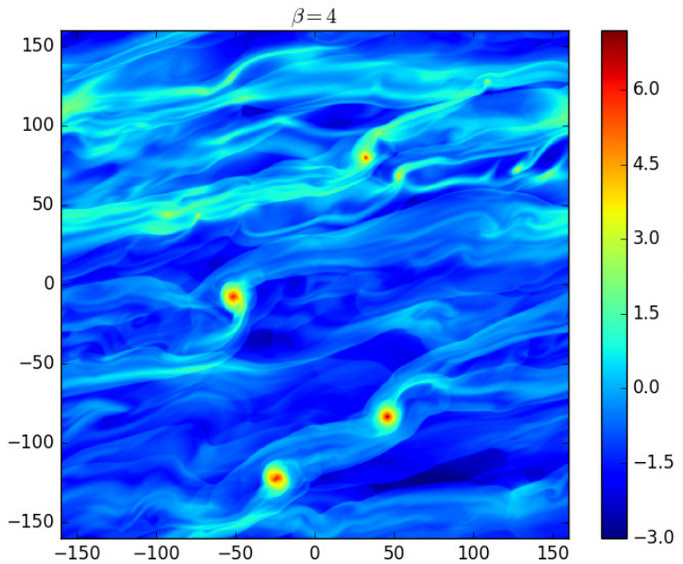
波数k=1.0



- 2Dシミュレーション（乱流あり）
  - β=4: 乱流なしで唯一分裂

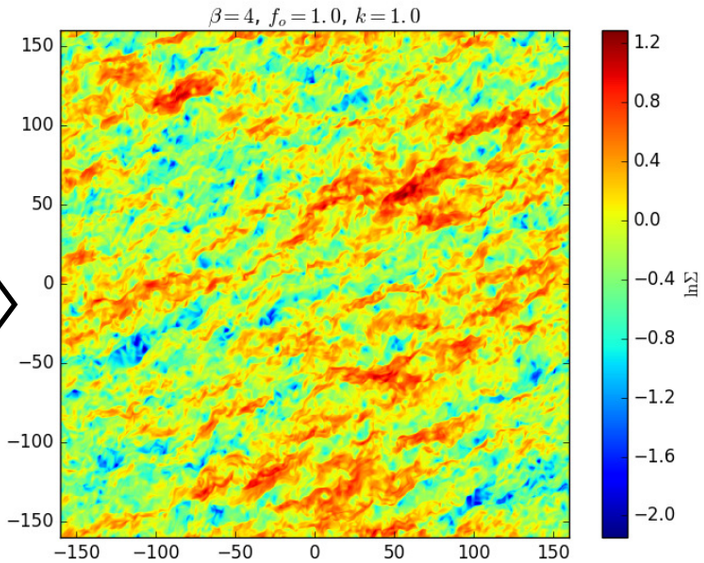
f_o	k	$\mathcal{M}$	
0.1	0.1	0.14	分裂
0.1	1.0	0.27	分裂
0.25	0.1	0.30	分裂
0.25	1.0	0.57	
0.5	0.1	0.57	分裂
0.5	1.0	0.95	
1.0	0.1	1.09	分裂
1.0	1.0	1.5	
2.0	0.1	2.0	分裂
2.0	1.0	2.32	
5.0	0.1	3.90	分裂

乱流なし



乱流

乱流ありで分裂しなくなる(波数1.0)



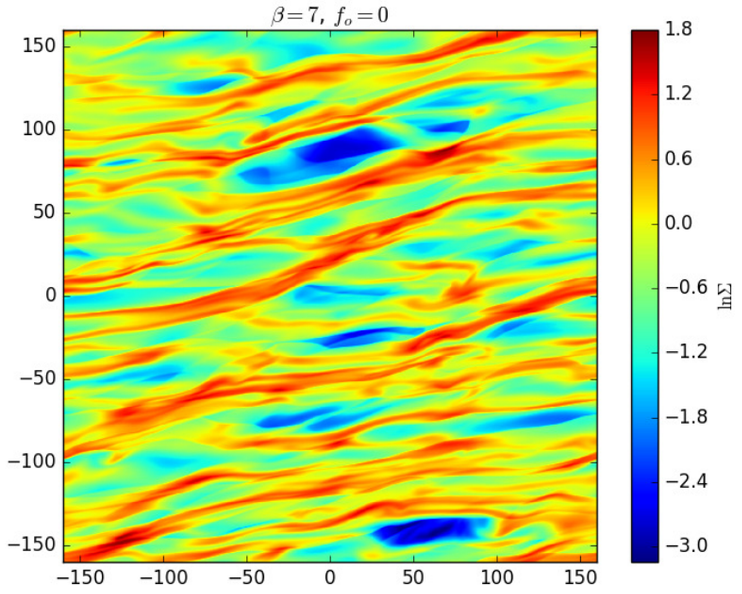
  - β=5

f_o	k	$\mathcal{M}$	
0.1	0.1	0.14	
0.1	1.0	0.27	
0.25	0.1	0.30	
0.25	1.0	0.57	
0.5	0.1	0.57	分裂
0.5	1.0	0.95	
1.0	0.1	1.09	分裂
1.0	1.0	1.5	
2.0	0.1	2.0	分裂
2.0	1.0	2.32	
5.0	0.1	3.90	分裂

  - β=7

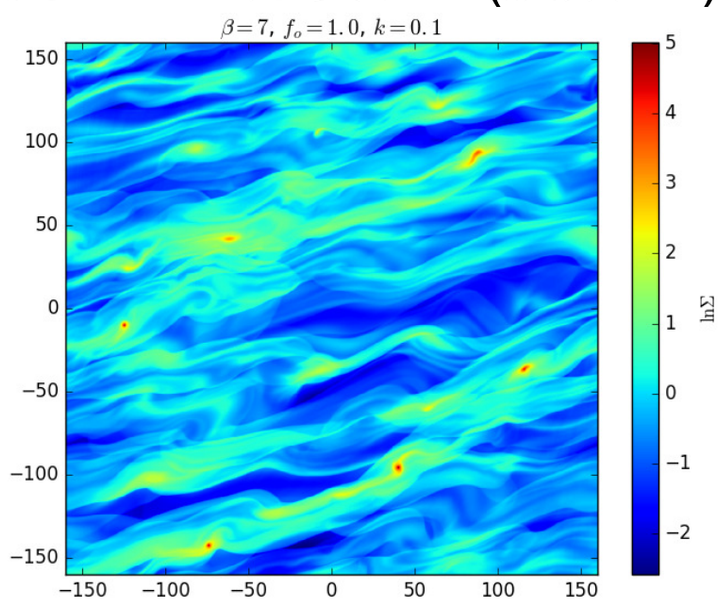
f_o	k	$\mathcal{M}$
0.1	0.1	0.14
0.1	1.0	0.27
0.25	0.1	0.30
0.25	1.0	0.57
0.5	0.1	0.57
0.5	1.0	0.95
1.0	0.1	1.09
1.0	1.0	1.5
2.0	0.1	2.0
2.0	1.0	2.32
5.0	0.1	3.90

乱流なし



乱流

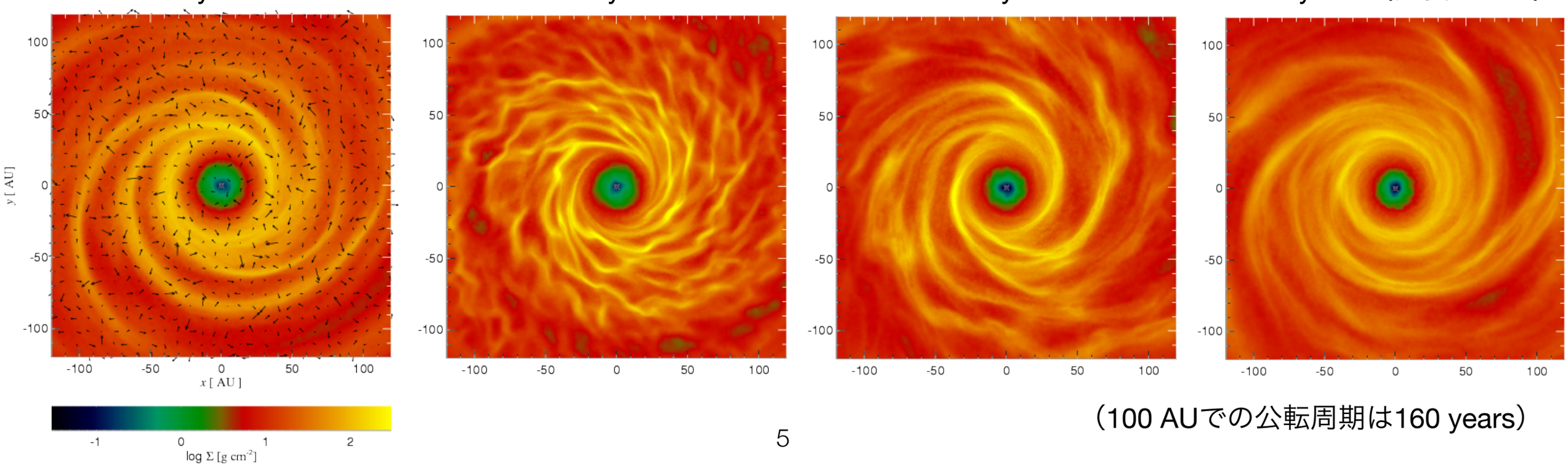
乱流ありで分裂する(波数0.1)



  - β=8, 10: 乱流ありでも分裂しない

- 波数の小さい（空間的には大きな）乱流で、冷却時間と比べて絶妙な強度（小さすぎるとあまり効かず、大きすぎると壊してしまう）であれば、乱流は重力不安定を促進させる。
- Hopkins & Christiansen (2013)で言われていた、乱流があるとβ≫5の円盤でさえ分裂する、というのはシミュレーションにより否定された。
- 3Dシミュレーション（乱流あり）
  - 乱流なしだとβ≤8で分裂、β>9は分裂しない
  - 初期条件はβ=10とする（理論通りだと乱流があれば分裂するはず）
  - 乱流はvelocity kick fieldとして計算に含める（z方向は無視）

0 years　80 years　320 years　800 years（分裂しない）



（100 AUでの公転周期は160 years）

- なぜHopkins & Christiansen (2013)と異なる結果が得られたのか？
  - 原始惑星系円盤は冷却時間が長い($\beta \gg 1$)ため、等温ではない。
    - Toomre parameter $Q=c_s\Omega/\pi G\Sigma$と乱流強度が独立という仮定が成立しない。
    - 乱流が超音速になるとQとc_sが両方増加する。
    - c_sが増加するのは、乱流による加熱とガスの冷却を釣り合わせるため。
    - c_sが増加すると、最初は超音速であった乱流が亜音速になる。

    → 超音速乱流を維持することは難しい

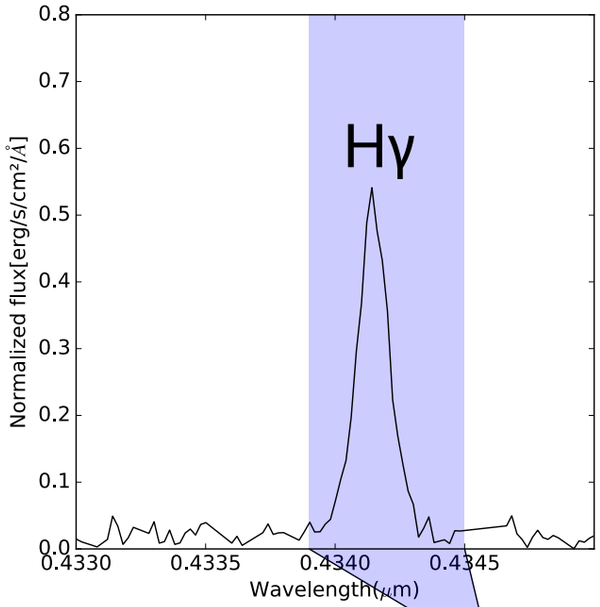
    - そもそも超音速乱流では$\alpha>1$となるが、観測による円盤のαはもっと小さい（HL Tauで$\alpha\sim10^{-4}$ (Pinte et al. 2016)）

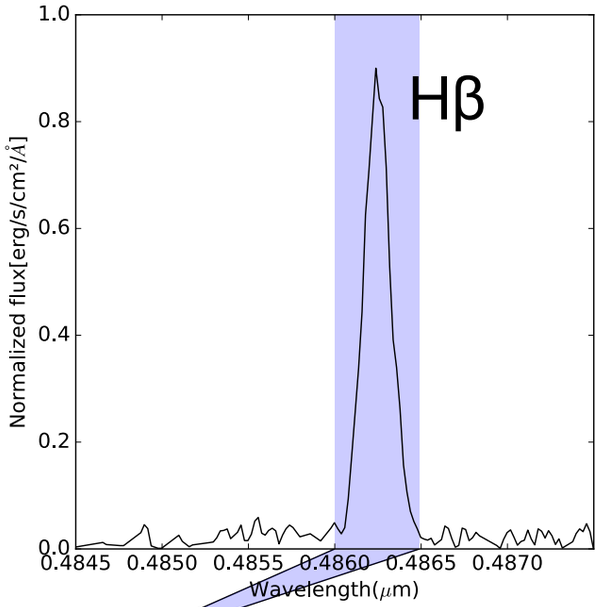
41. Accretion signatures in the X-shooter spectrum of the substellar companion to SR12

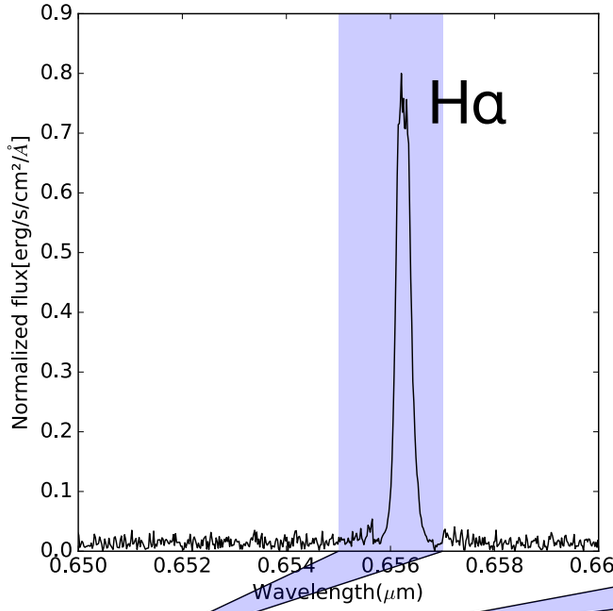
Alejandro Santamaría-Miranda, Claudio Cáceres, Matthias R. Schreiber, Adam Hardy, Amelia Bayo, Steven G. Parsons, Mariusz Gromadzki, Aurora Belén Aguayo Villegas

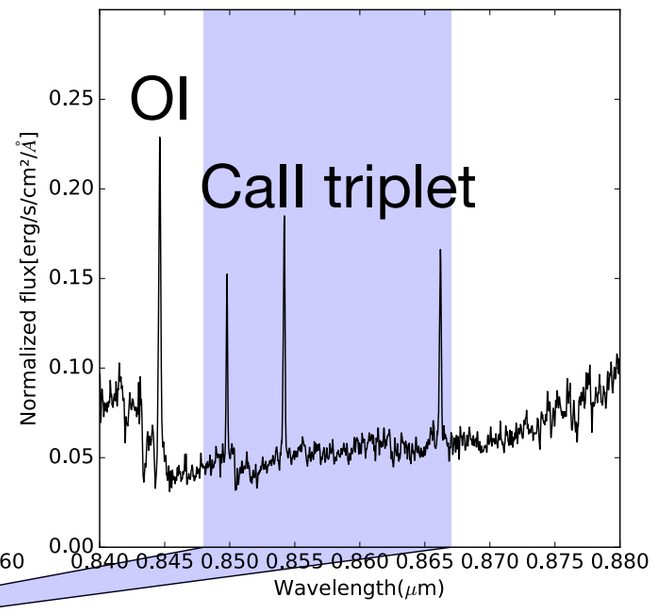
About a dozen substellar companions orbiting young stellar objects or pre-main sequence stars at several hundred au have been identified in the last decade. These objects are interesting both due to the uncertainties surrounding their formation, and because their large separation from the host star offers the potential to study the atmospheres of young giant planets and brown dwarfs. Here, we present X-shooter spectroscopy of SR 12 C, a ∼2 Myrs young brown dwarf orbiting SR 12 at an orbital separation of 1083 au. We determine the spectral type, gravity, and effective temperature via comparison with models and observational templates of young brown dwarfs. In addition, we detect and characterize accretion using several accretion tracers. We find SR 12 C to be a brown dwarf of spectral type L0±1, $\log g = 4 \pm 0.5$, an effective temperature of 2600±100 K. Our spectra provide clear evidence for accretion at a rate of $\sim 10^{-10}\ M_{\odot}\ \mathrm{yr}^{-1}$. This makes SR 12 one of the few sub-stellar companions with a reliable estimate for its accretion rate. A comparison of the ages and accretion rates of sub-stellar companions with young isolated brown dwarfs does not reveal any significant differences. If further accretion rate measurements of a large number of substellar companions can confirm this trend, this would hint towards a similar formation mechanism for substellar companions at large separations and isolated brown dwarfs.

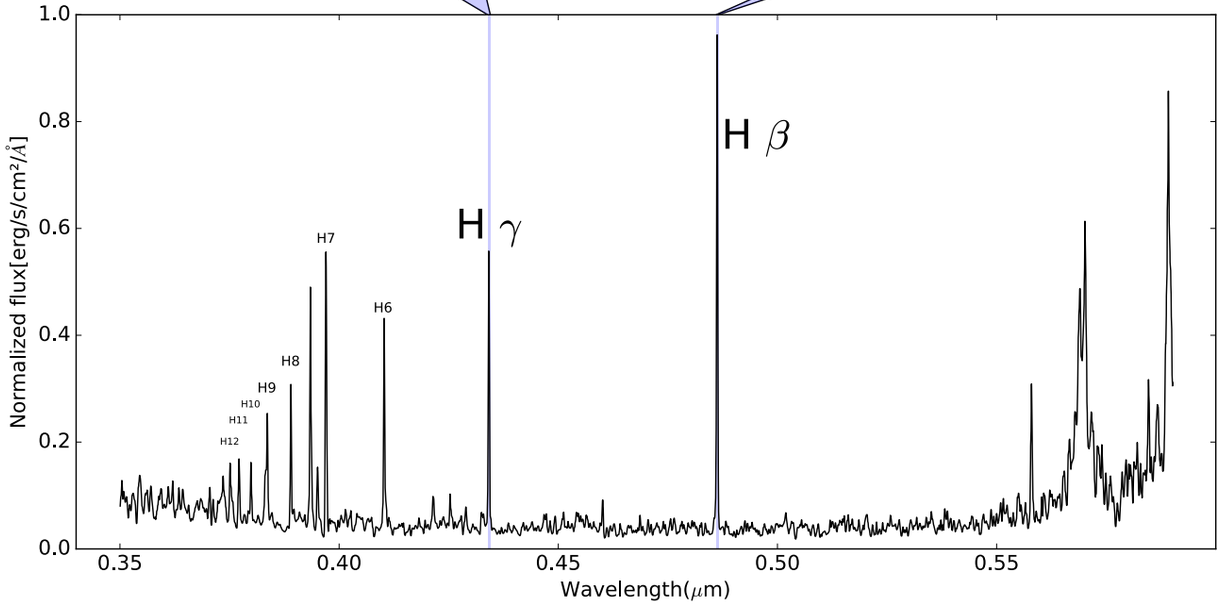
- 100 au以上も離れている惑星/褐色矮星の形成メカニズムは謎に包まれている。降着率を測ろうにも中心星に近すぎると観測できない。
- SR 12 C (~ 2 Myrs, 0.013±0.007 M_{sun}, 1083±217 au) のX-shooter分光観測をした。
- 他のsubstellar companionや孤立した若い褐色矮星の質量降着率と明確な違いはないため、これらの形成メカニズムは似ているかもしれない。

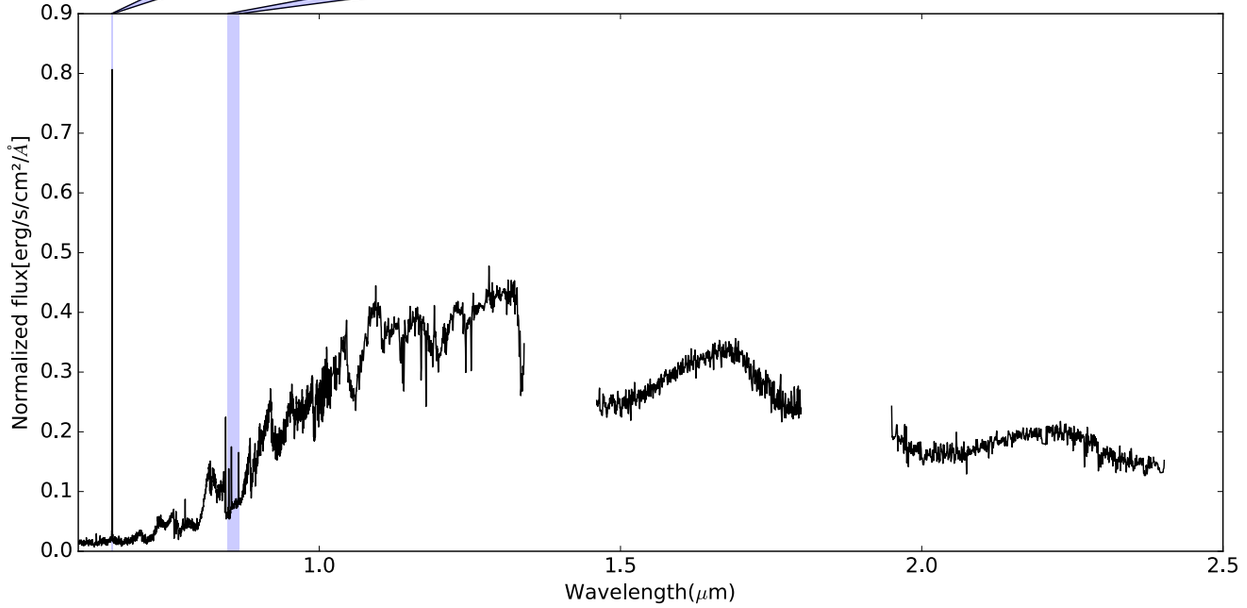


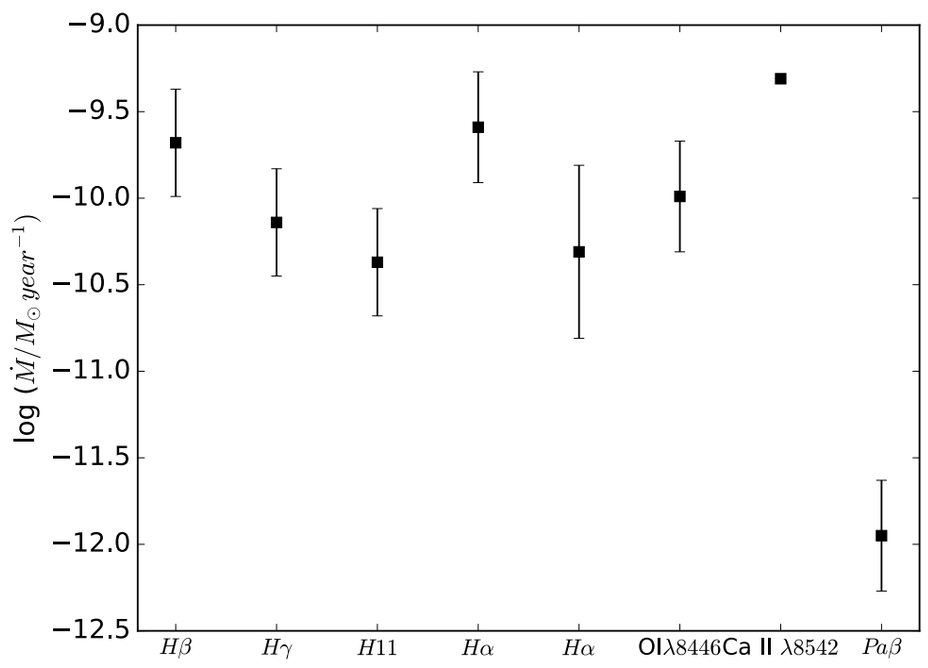




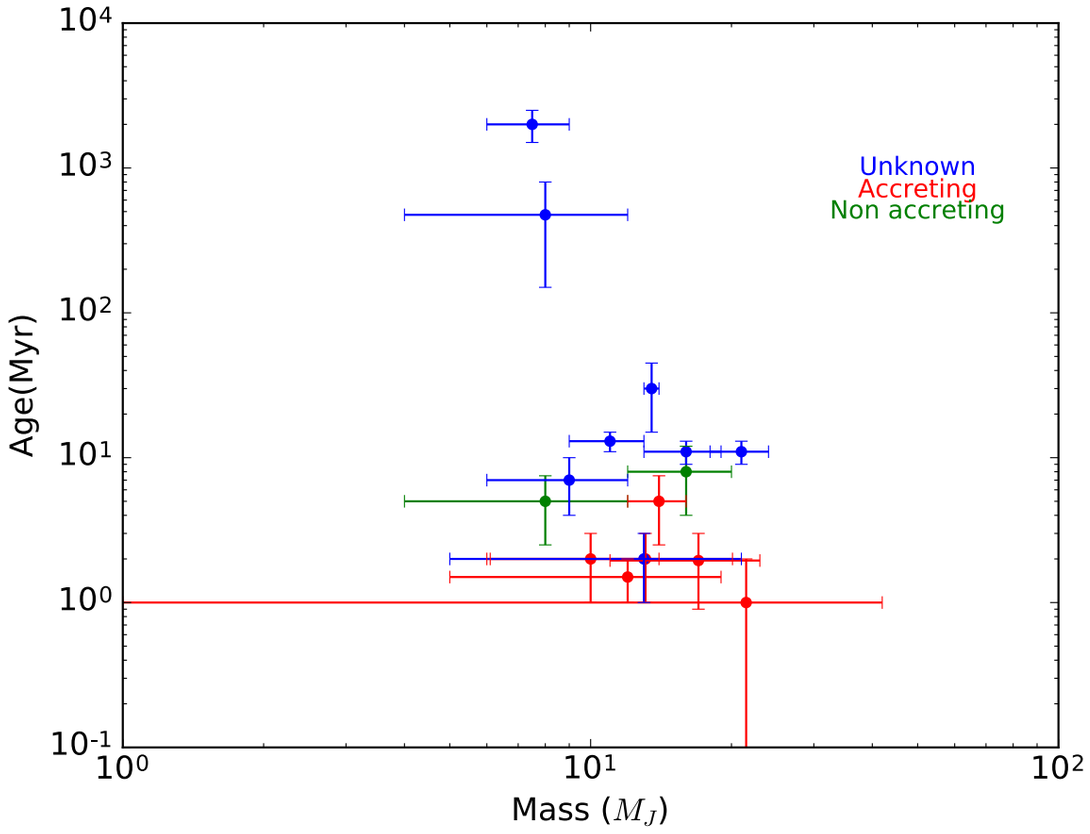


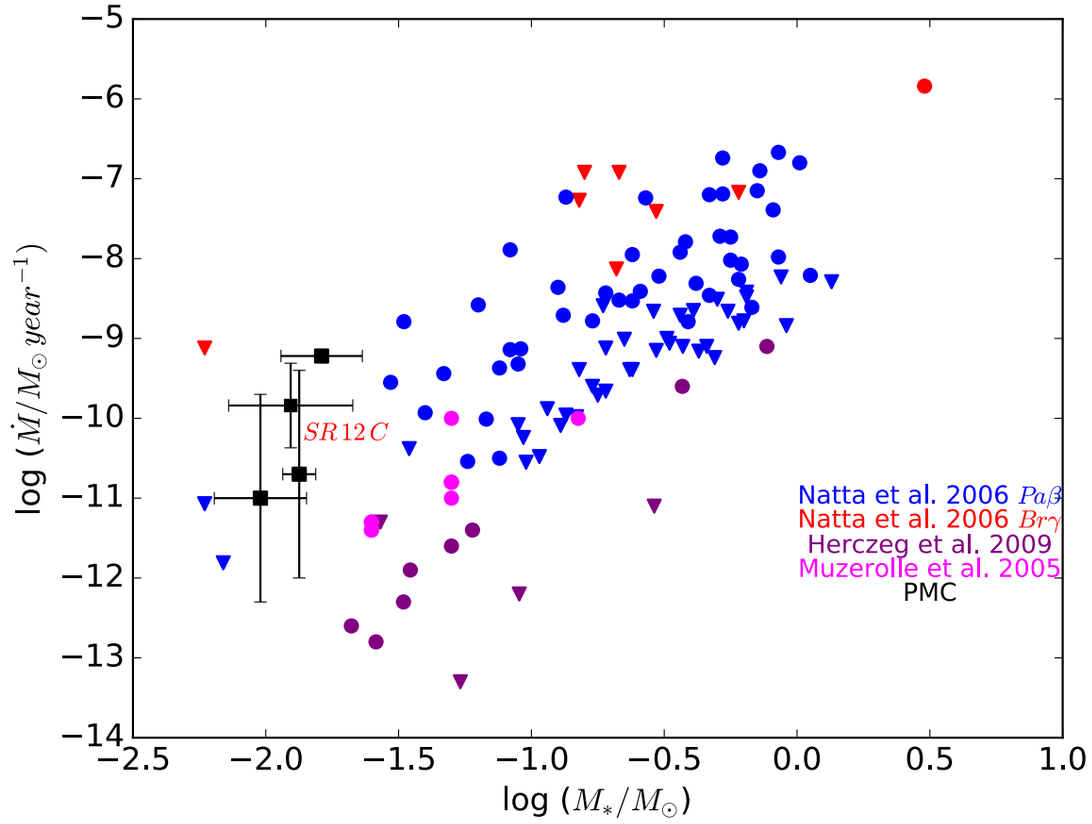






- SEDフィッティングより: L0±1, log g = 4±0.5, 2600±100 K
- それぞれの輝線の幅から質量降着率を求めた
  - Paβを除くとほぼ一致
  - ~ $10^{-10} M_{sun}$/yr





- （左）> 100 au, < 15 M_{Jup}のsubstellar companionの年齢、質量、降着の有無
  - < 10 Myrsで降着が見られる
- （右）substellar companion、孤立した低質量星、褐色矮星の降着率vs質量
  - 4つの黒四角がsubstellar companion
  - Natta et al. (2006)はclass II天体のみプロット
  - 若い星とsubstellar companionは同じ相関を持つ
- 降着率が似ていることから、substellar companionの形成シナリオは、コア集積+散乱ではなく、円盤不安定性かprotostellar cloudsの収縮だと思われる。

42. The HR 4796A Debris System: Discovery of Extensive Exo-Ring Dust Material

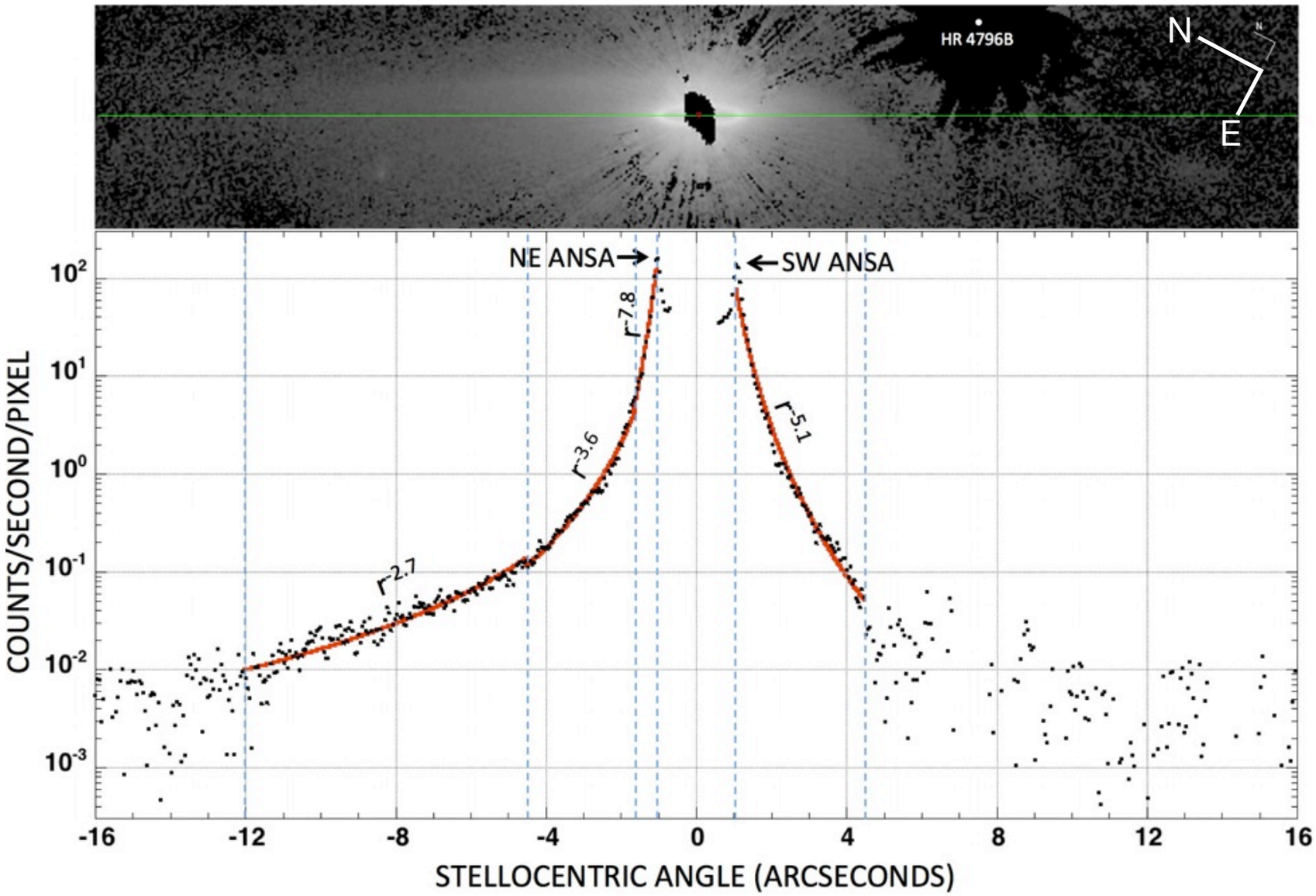
Glenn Schneider, John H. Debes, Carol A. Grady, Andras Gáspár, Thomas Henning, Dean C. Hines, Marc J. Kuchner, Marshall Perrin, John P. Wisniewski

The optically and IR bright, and starlight-scattering, HR 4796A ring-like debris disk is one of the most (and best) studied exoplanetary debris systems. The presence of a yet-undetected planet has been inferred (or suggested) from the narrow width and inner/outer truncation radii of its $r = 1\farcs05$ (77 au) debris ring. We present new, highly sensitive, Hubble Space Telescope (HST) visible-light images of the HR 4796A circumstellar debris system and its environment over a very wide range of stellocentric angles from $0\farcs32$ (23 au) to $\sim 15''$ (1100 au). These very high contrast images were obtained with the Space Telescope Imaging Spectrograph (STIS) using 6-roll PSF-template subtracted coronagraphy suppressing the primary light of HR 4796A and using three image plane occulters and simultaneously subtracting the background light from its close angular proximity M2.5V companion. The resulting images unambiguously reveal the debris ring embedded within a much larger, morphologically complex, and bi-axially asymmetric exoring scattering structure. These images at visible wavelengths are sensitive to, and map, the spatial distribution, brightness, and radial surface density of micron size particles over 5 dex in surface brightness. These particles in the exo-ring environment may be unbound from the system and interacting with the local ISM. Herein we present a new morphological and photometric view of the larger than prior seen HR 4796A exoplanetary debris system with sensitivity to small particles at stellocentric distances an order of magnitude greater than has previously been observed.

- HR 4796Aはリング状(77 au)のデブリ円盤を持ち、惑星があると考えられている。
- HSTのSpace Telescope Imaging Spectrograph (STIS) 6-roll PSF template subtracted coronagraphy (6R/PSFTSC)による観測と、近くのM型伴星による光を除去して、HR 4796Aのデブリリングを詳細に調べた。

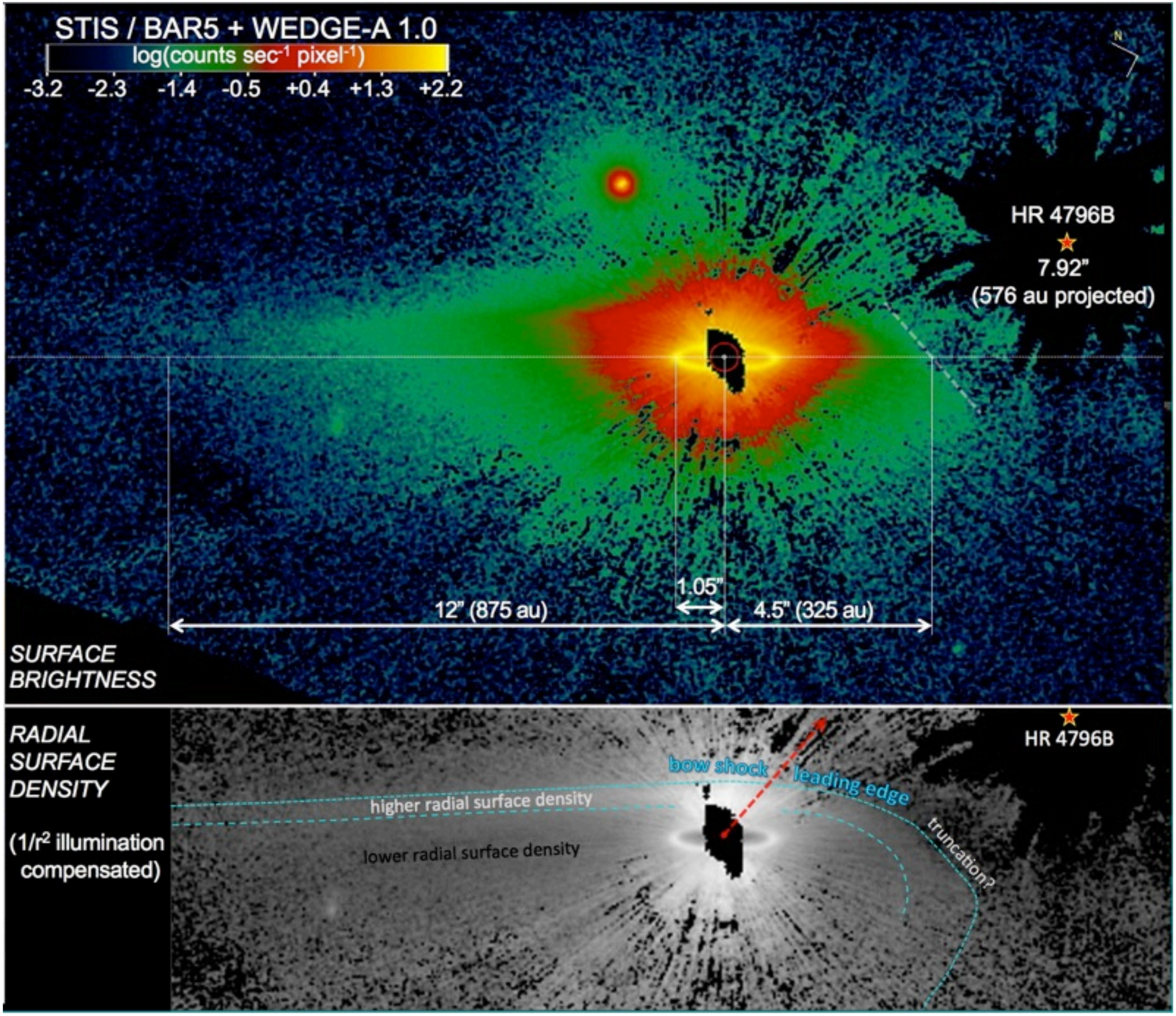
(A) Primary Star and Debris Disk								
Target	**Vmag** [b]	**B-V** [b]	**Spec** [a]	**Dist.** [c] **(pc)**	**Age** [d] **(Myr)**	**Disk** L_{IR}/L_{star} [e]	**Initial *HST* Disk Imaging**	
							Instrument	**Reference**
HR 4796 A	5.774	+0.012	A0V	72.8	8 ± 2	0.0042	NICMOS	Schneider et al. 1999

(B) M-Star Companion					
Companion	**Spec** [a]	**Vmag** [b]	**ΔMag** [b]	**Separation/ P.A.** [f] **(2015)**	**References**
HR 4796 B	M2.5	13.3	7.5	7.92" ± 0.02" / 29.81°	Jura et al. 1995, Lagrange et al. 2012



長軸方向の表面輝度

- 緑線が長軸方向
- 右上の白ドットはHR 4796 Bの位置
- 左右で軌道長半径依存性が異なる



HR 4796Aは Local Interstellar Cloud (LIC)と Hyades Cloud の中を進んでいるため、bow shockが生じている。

もしくはHR 4796Bの輻射圧が影響している。

発表しなかった論文のアブストラクト

36. Episodic accretion in binary protostars emerging from self-gravitating solar mass cores

R. Riaz, S. Vanaverbeke, and D.R.G. Schleicher

Observations show a large spread in the luminosities of young protostars, which are frequently explained in the context of episodic accretion. We here test this scenario using numerical simulations following the collapse of a solar mass molecular cloud using the GRADSPH code, varying the strength of the initial perturbations and the temperature of the cores. A specific emphasis of this paper is to investigate the role of binaries and multiple systems in the context of episodic accretion, and to compare their evolution to the evolution in isolated fragments. Our models form a variety of low mass protostellar objects including single, binary and triple systems with binaries more active in exhibiting episodic accretion than isolated protostars. We also find a general decreasing trend for the average mass accretion rate over time, suggesting that the majority of the protostellar mass is accreted within the first 10^5 years. This result can potentially help to explain the surprisingly low average luminosities in the majority of the protostellar population.

38. Phosphorus-bearing molecules in the Galactic Center

V. M. Rivilla, I. Jiménez-Serra, S. Zeng, S. Martín, J. Martín-Pintado, J. Armijos-Abendaño, S. Viti, R. Aladro, D. Riquelme, M. Requena-Torres, D. Quénard, F. Fontani, and M. T. Beltrán

Phosphorus (P) is one of the essential elements for life due to its central role in biochemical processes. Recent searches have shown that P-bearing molecules (in particular PN and PO) are present in star-forming regions, although their formation routes remain poorly understood. In this Letter, we report observations of PN and PO towards seven molecular clouds located in the Galactic Center, which are characterized by different types of chemistry. PN is detected in five out of seven sources, whose chemistry is thought to be shock-dominated. The two sources with PN non-detections correspond to clouds exposed to intense UV/X-rays/cosmic-ray radiation. PO is detected only towards the cloud G+0.693−0.03, with a PO/PN abundance ratio of ∼1.5. We conclude that P-bearing molecules likely form in shocked gas as a result of dust grain sputtering, while are destroyed by intense UV/X-ray/cosmic ray radiation.

39. A new compact young moving group around V1062 Sco

Siegfried Röser, Elena Schilbach, Bertrand Goldman, Thomas Henning, Attila Moor, and Aliz Derekas

Aims. We are searching for new open clusters or moving groups in the Solar neighbourhood.
Methods. We used the Gaia-TGAS catalogue, cut it into narrow proper motion and parallax slices and searched for significant spatial over-densities of stars in each slice. We then examined stars forming over-densities in optical and near-infrared colour-magnitude diagrams to determine if they are compatible with isochrones of a cluster.
Results. We detected a hitherto unknown moving group or cluster in the Upper Centaurus Lupus (UCL) section of the Sco-Cen OB-association at a distance of 175 pc from the Sun. It is a group of 63 co-moving stars with ages of less than 10 to about 25 Myr. For the brightest stars, which are present in the Gaia-TGAS catalogue the mean difference between kinematic and trigonometric distance moduli is about 0:01 mag with a standard deviation of 0.11 mag. Fainter cluster candidates are found in the HSOY catalog, where no trigonometric parallaxes are available. For a subset of our candidate stars, we obtained radial velocity measurements at the MPG/ESO 2.2-metre telescope in La Silla. Altogether we found twelve members with confirmed radial velocities and parallaxes, 31 with parallaxes or radial velocities, and 20 candidates from the convergent point method. The isochrone masses of our 63 members range from 2.6 $M_\odot$ to 0.7 $M_\odot$.

40. Intensity-Corrected Herschel Observations of Nearby Isolated Low-Mass Clouds

Sarah I. Sadavoy, Eric Keto, Tyler L. Bourke, Michael M. Dunham, Philip C. Myers, Ian W. Stephens, James Di Francesco, Kristi Webb, Amelia Stutz, Ralf Launhardt, John Tobin

We present intensity-corrected Herschel maps at 100 μm, 160 μm, 250 μm, 350 μm, and 500 μm for 56 isolated low-mass clouds. We determine the zero-point corrections for Herschel PACS and SPIRE maps from the Herschel Science Archive (HSA) using Planck data. Since these HSA maps are small, we cannot correct them using typical methods. Here, we introduce a technique to measure the zero-point corrections for small Herschel maps. We use radial profiles to identify offsets between the observed HSA intensities and the expected intensities from Planck. Most clouds have reliable offset measurements with this technique. In addition, we find that roughly half of the clouds have underestimated HSA-SPIRE intensities in their outer envelopes relative to Planck, even though the HSA-SPIRE maps were previously zero-point corrected. Using our technique, we produce corrected Herschel intensity maps for all 56 clouds and determine their line-of-sight average dust temperatures and optical depths from modified black body fits. The clouds have typical temperatures of $\sim$14–20 K and optical depths of $\sim 10^{-5}$–10^{-3}. Across the whole sample, we find an anti-correlation between temperature and optical depth. We also find lower temperatures than what was measured in previous Herschel studies, which subtracted out a background level from their intensity maps to circumvent the zero-point correction. Accurate Herschel observations of clouds are key to obtain accurate density and temperature profiles. To make such future analyses possible, intensity-corrected maps for all 56 clouds are publicly available in the electronic version.