

Stellar encounters and protoplanetary disks

Lu, Li et al. 2022 Nature Astronomy

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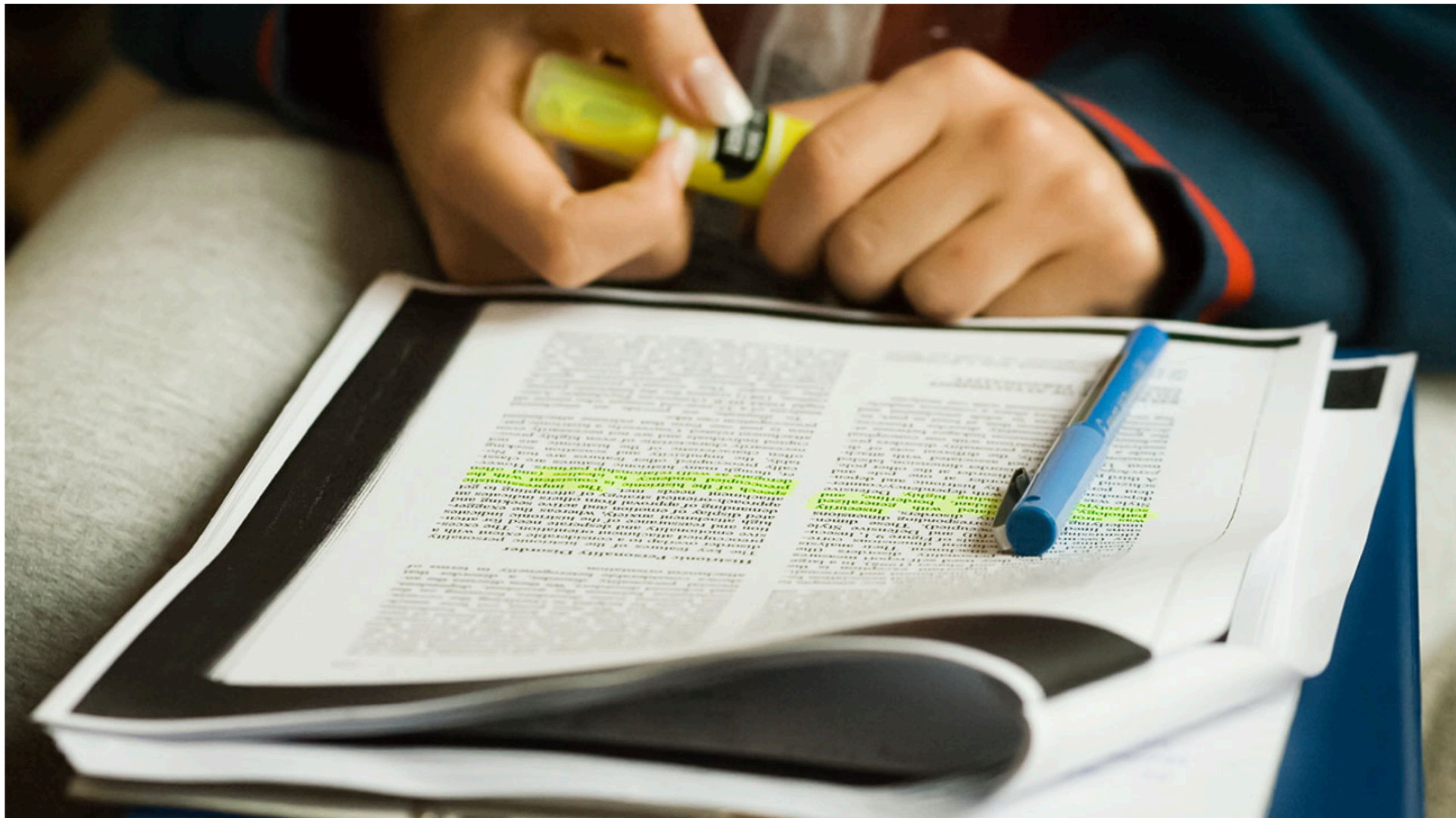
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Mathematics

How to (seriously) read a scientific paper

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Why Most Published Research Findings Are False

From Wikipedia, the free encyclopedia

"**Why Most Published Research Findings Are False**" is a 2005 essay written by [John Ioannidis](#), a professor at the [Stanford School of Medicine](#), and published in *[PLOS Medicine](#)*.^[1] It is considered foundational to the field of [metascience](#).

In the paper, Ioannidis argued that a large number, if not the majority, of published [medical research](#) papers contain results that cannot be [replicated](#). In simple terms, the essay states that scientists use [hypothesis testing](#) to determine whether scientific discoveries are significant. "[Significance](#)" is formalized in terms of probability, and one formalized calculation ("[P value](#)") is reported in the scientific literature as a screening mechanism. Ioannidis posited assumptions about the way people perform and report these tests; then he constructed a statistical model which indicates that most published findings are [false positive results](#).

Argument [\[edit\]](#)

Suppose that in a given scientific field there is a known baseline probability that a result is true, denoted by $\mathbb{P}(\text{True})$. When a study is conducted, the probability that a positive result is obtained is $\mathbb{P}(+)$. Given these two factors, we want to compute the [conditional probability](#) $\mathbb{P}(\text{True} \mid +)$, which is known as the [positive predictive value](#) (PPV). [Bayes' theorem](#) allows us to compute the PPV as:

$$\mathbb{P}(\text{True} \mid +) = \frac{(1 - \beta)\mathbb{P}(\text{True})}{(1 - \beta)\mathbb{P}(\text{True}) + \alpha[1 - \mathbb{P}(\text{True})]}$$

where α is the [type I error rate](#) (false positives) and β is the [type II error rate](#) (false negatives); the [statistical power](#) is $1 - \beta$. It is customary in most scientific research to desire $\alpha = 0.05$ and $\beta = 0.2$. If we assume $\mathbb{P}(\text{True}) = 0.1$ for a given scientific field, then we may compute the PPV for different values of α and β :



Why Most Published Research Findings Are False

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Argument [edit]

Suppose that in a given scientific field there is a known baseline probability that a result is true, denoted by



Metascience

Article

Talk

From Wikipedia, the free encyclopedia

For the journal, see [Metascience \(journal\)](#).

Not to be confused with [Science studies](#), or with the obsolete synonym 'Meta-science' for the [Philosophy of science](#).

Metascience (also known as **meta-research**) is the use of [scientific methodology](#) to study [science](#) itself.

Metascience seeks to increase the quality of scientific research while reducing [inefficiency](#). It is also known

ary in most
PPV for different

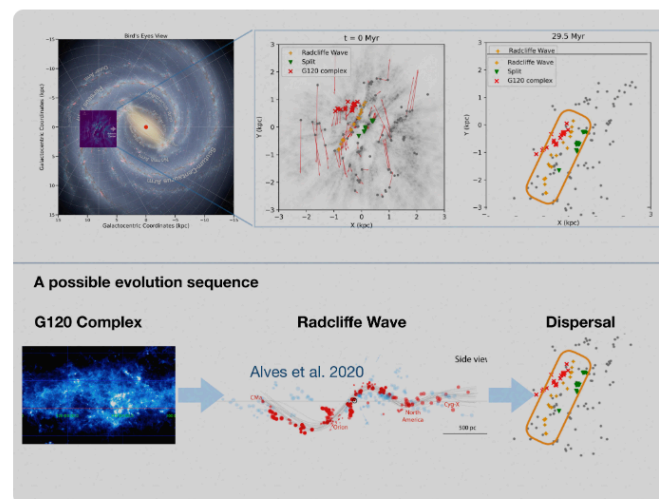
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Guang-Xing Li, Associate Professor of
Astrophysics, Yunnan University

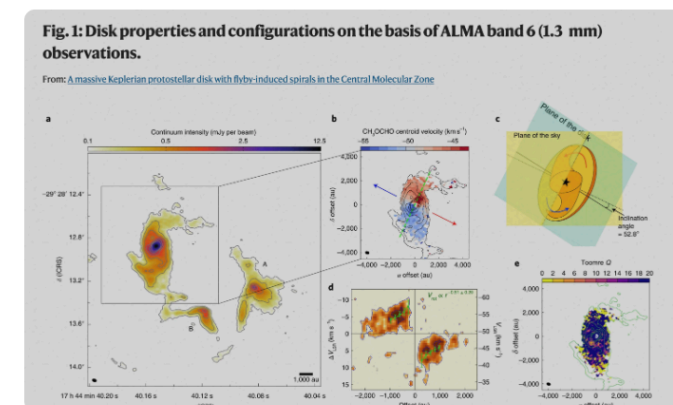
I am a theoretical astrophysicist with close ties to observations, specializing on the dynamics of the interstellar medium and star formation, and my general interests include the evolution of galaxy disks, galaxy centers, and the evolution of protostellar and protoplanetary disks. Check out my [CV](#) and [publications, Research ID Profile](#).

Highlights



Gaia predicts the future of the Milky Way Interstellar Medium

In [Weather Forecast of the Milky Way: Shear and Stellar feedback determine the lives of Galactic-scale filaments](#) we trace the evolution of the molecular ISM using a sample of Young Stellar Objects (YSO) association --molecular cloud complex (YSO-MC complex). See [Here](#) for more details.



Flyby-induced spirals structures in massive protoplanetary disks

In [A massive Keplerian protostellar disk with flyby-induced spirals in the Central Molecular Zone](#), Lu, Li et al. [Nature Astronomy](#) we report the discovery of a first case of flyby-induced formation of spiral structures in a massive protoplanetary disk.

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FEEDBACK

Scale-free gravitational collapse as the origin of $\rho \sim r^{-2}$ density profile - a possible role of turbulence in regulating gravitational collapse

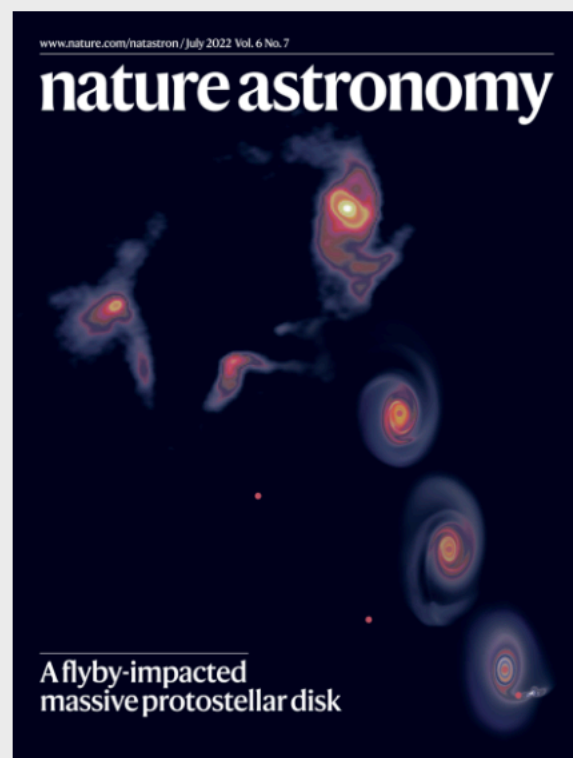
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Li, Guang-Xing

Astrophysical systems, such as clumps that form star clusters share a density profile that is close to $\rho \sim r^{-2}$. We prove analytically this density profile is the result of the scale-free nature of the gravitational collapse. Therefore, it should emerge in many different situations as long as gravity is dominating the evolution for a period that is comparable or longer than the free-fall time, and this does not necessarily imply an isothermal model, as many have previously believed. To describe the collapse process, we construct a model called the turbulence-regulated gravitational collapse model, where turbulence is sustained by accretion and dissipates in roughly a crossing time. We demonstrate that a $\rho \sim r^{-2}$ profile emerges due to the scale-free nature the system. In this particular case, the rate of gravitational collapse is regulated by the rate at which turbulence dissipates the kinetic energy such that the infall speed can be 20-50 per cent of the free-fall speed (which also depends on the interpretation of the crossing time based on simulations of driven turbulence). These predictions are consistent with existing observations, which suggests that these clumps are in the stage of turbulence-regulated gravitational collapse. Our analysis provides a unified description of gravitational collapse in different environments.

| | |
|--------------|--|
| Publication: | Monthly Notices of the Royal Astronomical Society, Volume 477, Issue 4, p.4951-4956 |
| Pub Date: | July 2018 |
| DOI: | 10.1093/mnras/sty657  10.48550/arXiv.1803.03273  |
| arXiv: | arXiv:1803.03273  |
| Bibcode: | 2018MNRAS.477.4951L  |

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A flyby-impacted massive protostellar disk

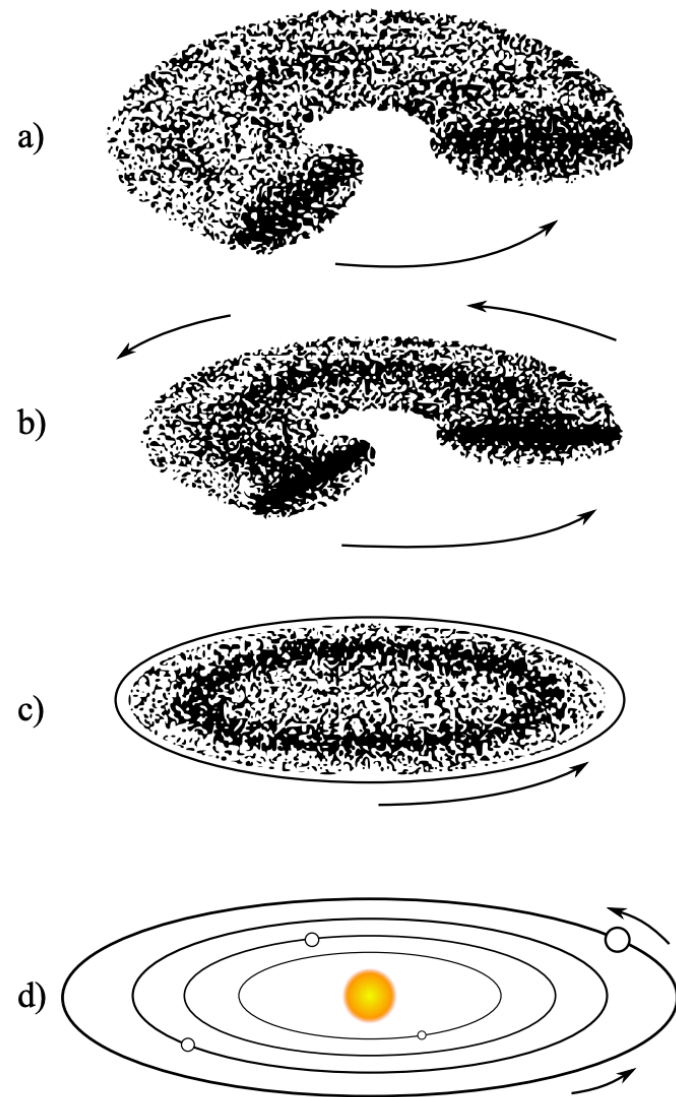
ALMA observations of a massive protostar near the Galactic Centre reveal a large disk with two embedded spirals. A combined analytical and numerical analysis suggests that the spirals were formed by a close flyby. The study concludes that massive stars can form in a similar way as low-mass stars: through disk-mediated accretion subject to flybys.

See [Lu et al.](#)

Image: Image courtesy of Xing Lu. Cover Design: Bethany Vukomanovic

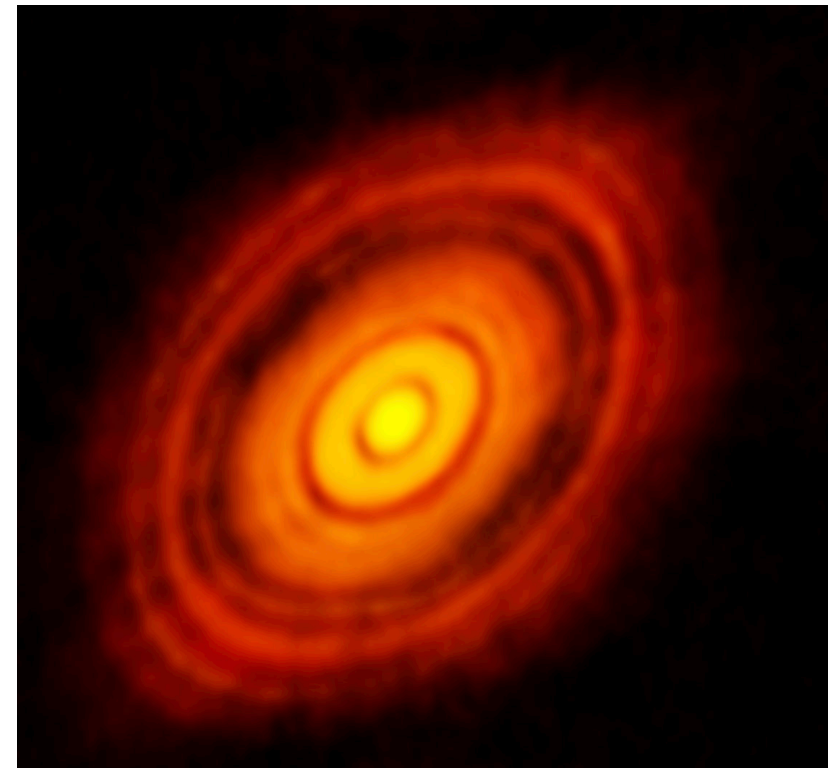
Nebula Hypothesis

Isolated

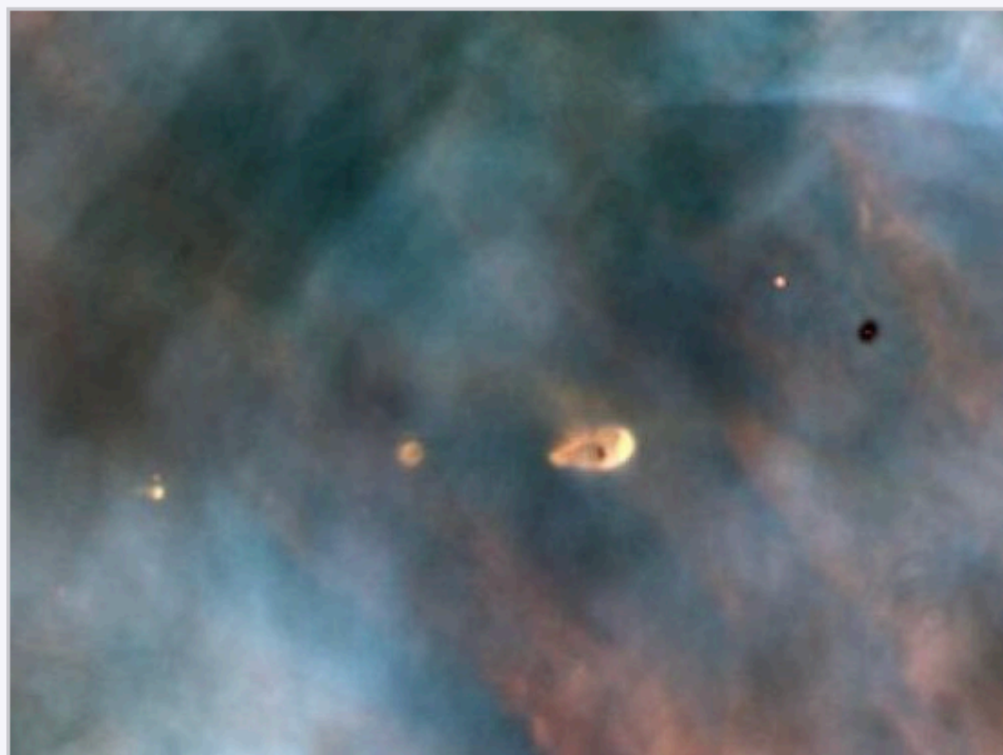



Proposal by P.S. Laplace

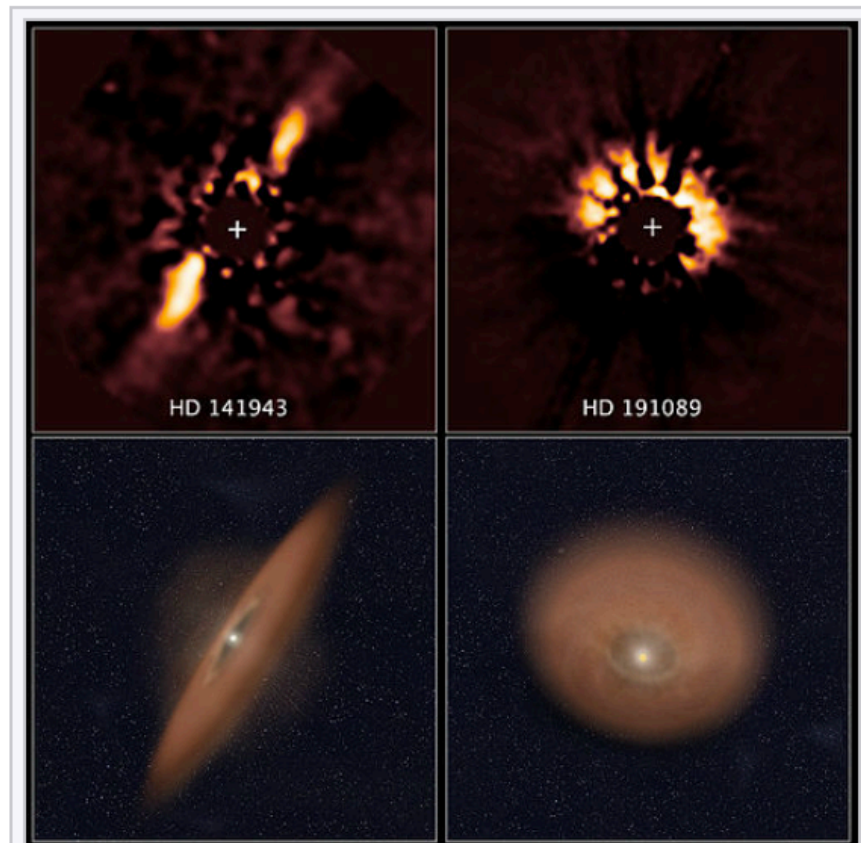
ALMA image of HL Tau disk




Protoplanetary disks



A protoplanetary disk forming in the [Orion Nebula](#) 



[Debris disks](#) detected in [HST](#) archival 
images of young stars, HD 141943 and HD 191089, using improved imaging processes
(24 April 2014).^[48]

Protoplanetary disks



PROTOPLANETARY DISKS

RH J1615

Light-years from Earth: 600
Instrument: SPHERE

HD 163296

Light-years from Earth: 600
Instrument: ALMA

HD 169142

Light-years from Earth: 380
Instrument: ALMA

Specimens exhibiting
rings, gaps, & spirals

TW HYDRAE

Light-years from Earth: 194
Instrument: ALMA

ELIAS 2-27

Light-years from Earth: 450
Instrument: ALMA

HD 135344B

Light-years from Earth: 450
Instrument: SPHERE

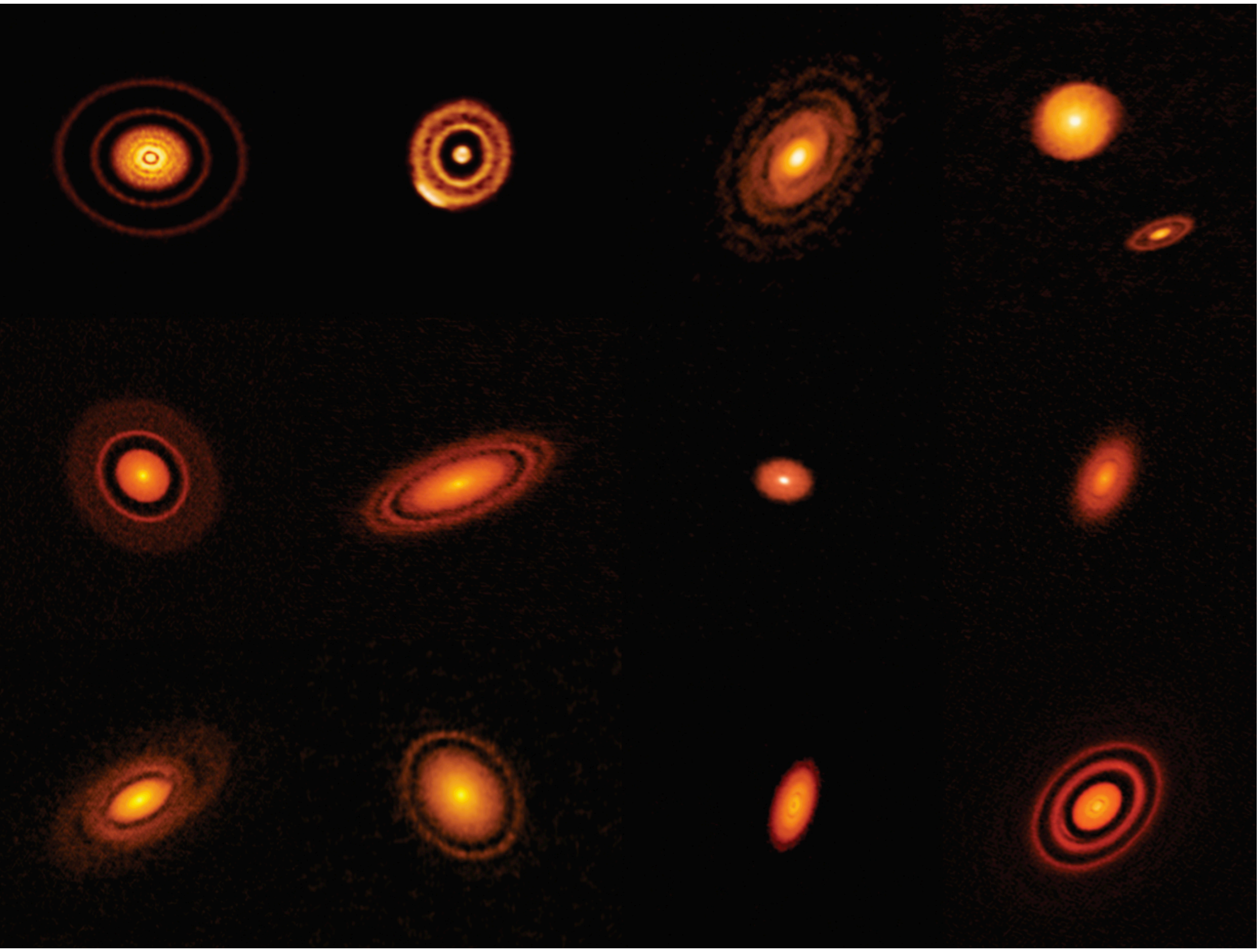
HL TAURI

Light-years from Earth: 450
Instrument: ALMA

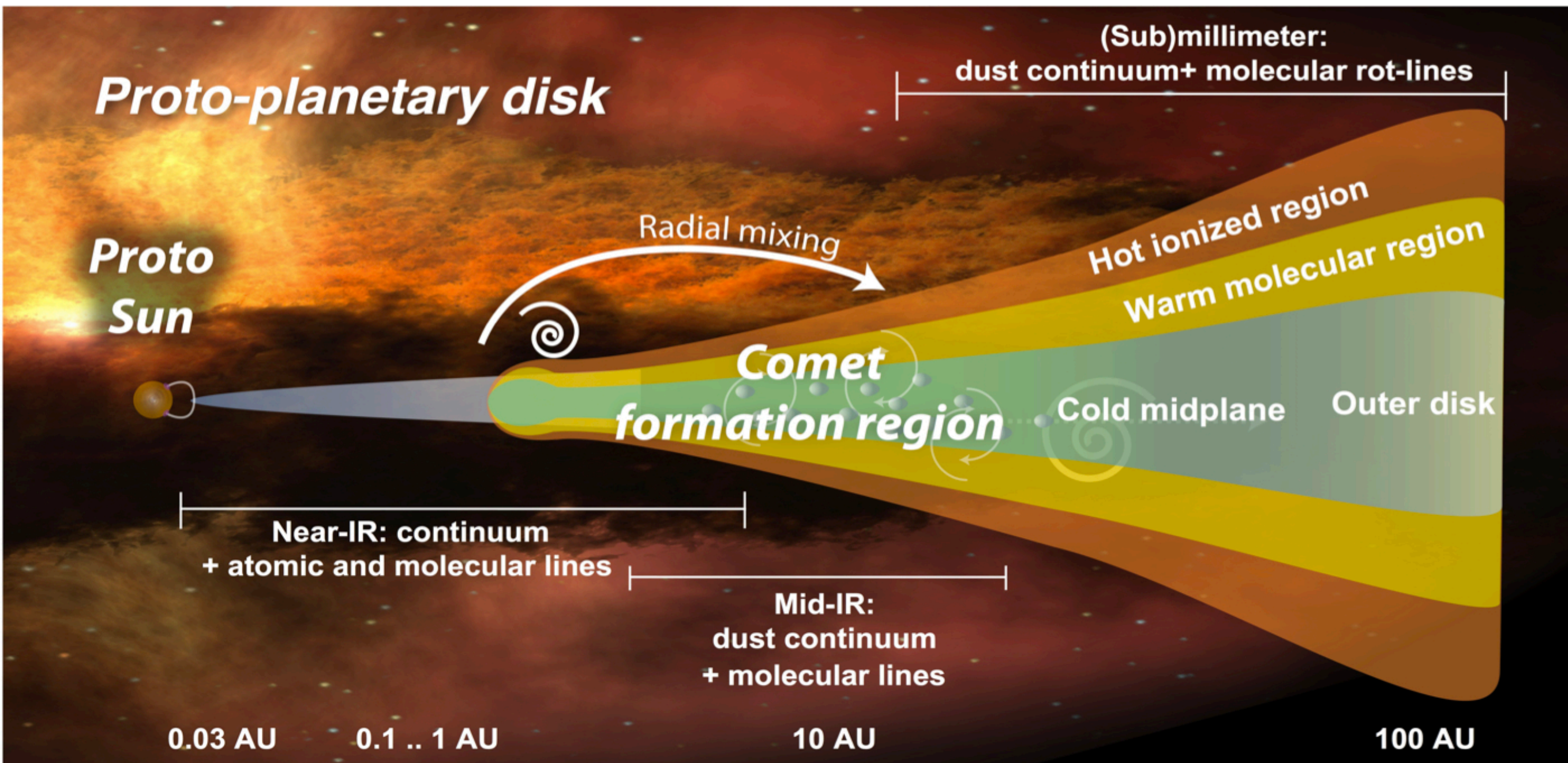
AS 209

Light-years from Earth: 400
Instrument: ALMA

WARNING: OBJECTS NOT TO SCALE



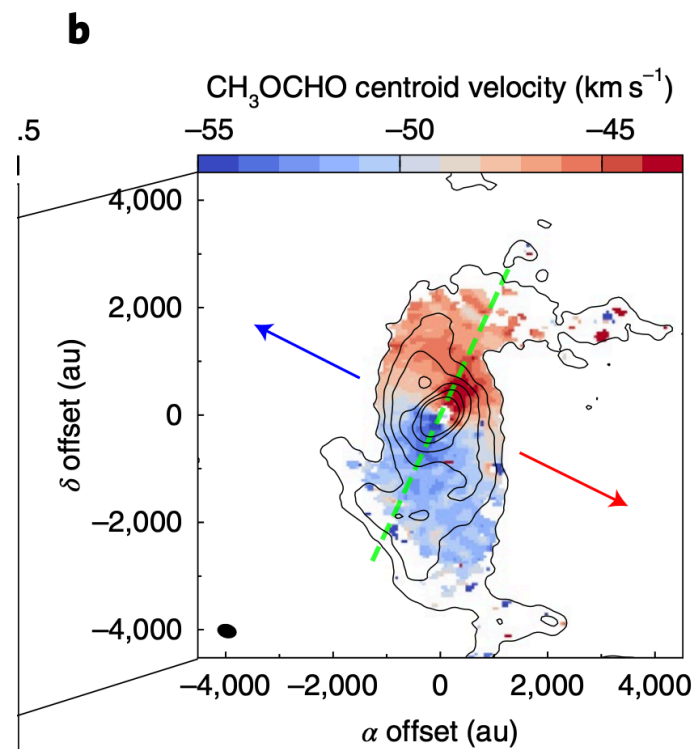
disks are complex



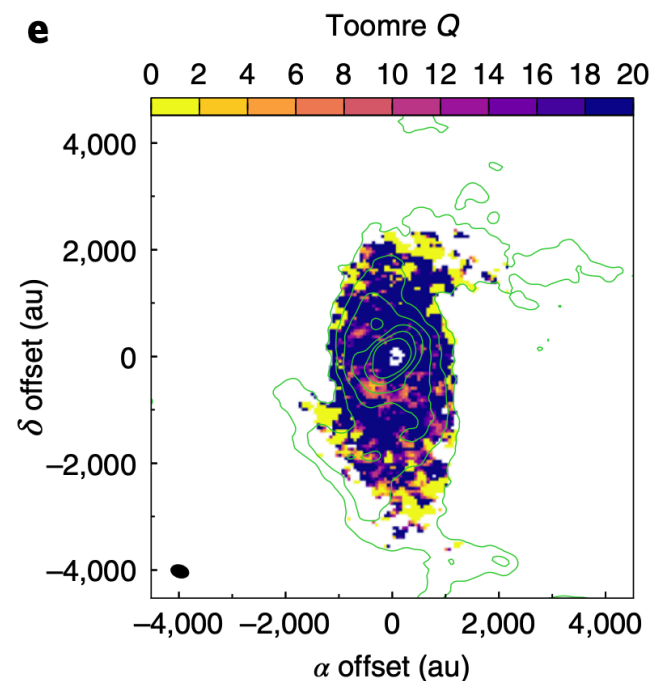
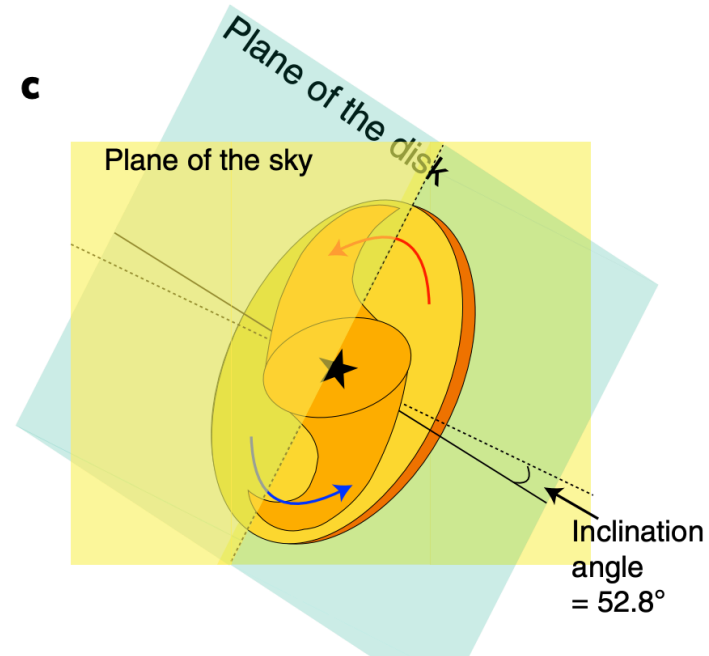
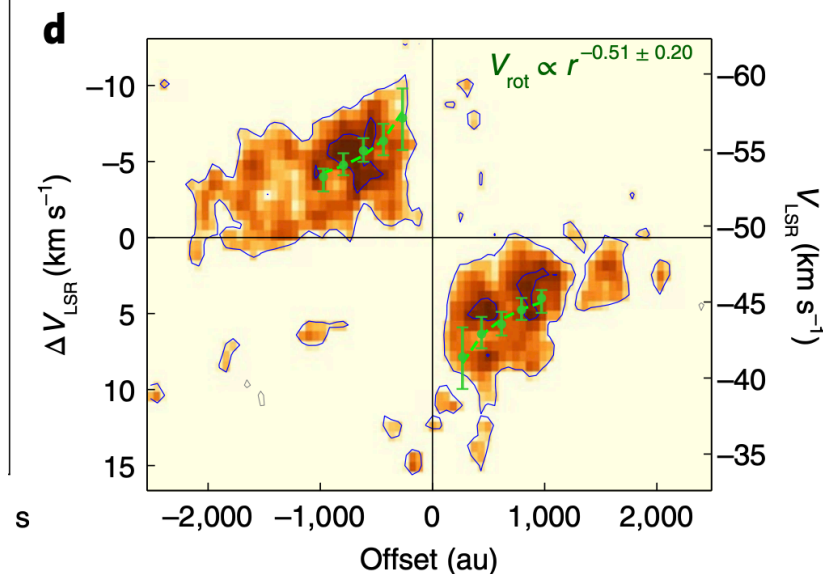
**protoplanetary disk with
spiral arms**

Star formation in the CMZ

Velocity map



Velocity



Surface density

Galaxy have spiral arms



by Toomre &
formation of a tidal
ky-galaxy

Rafael

ght.

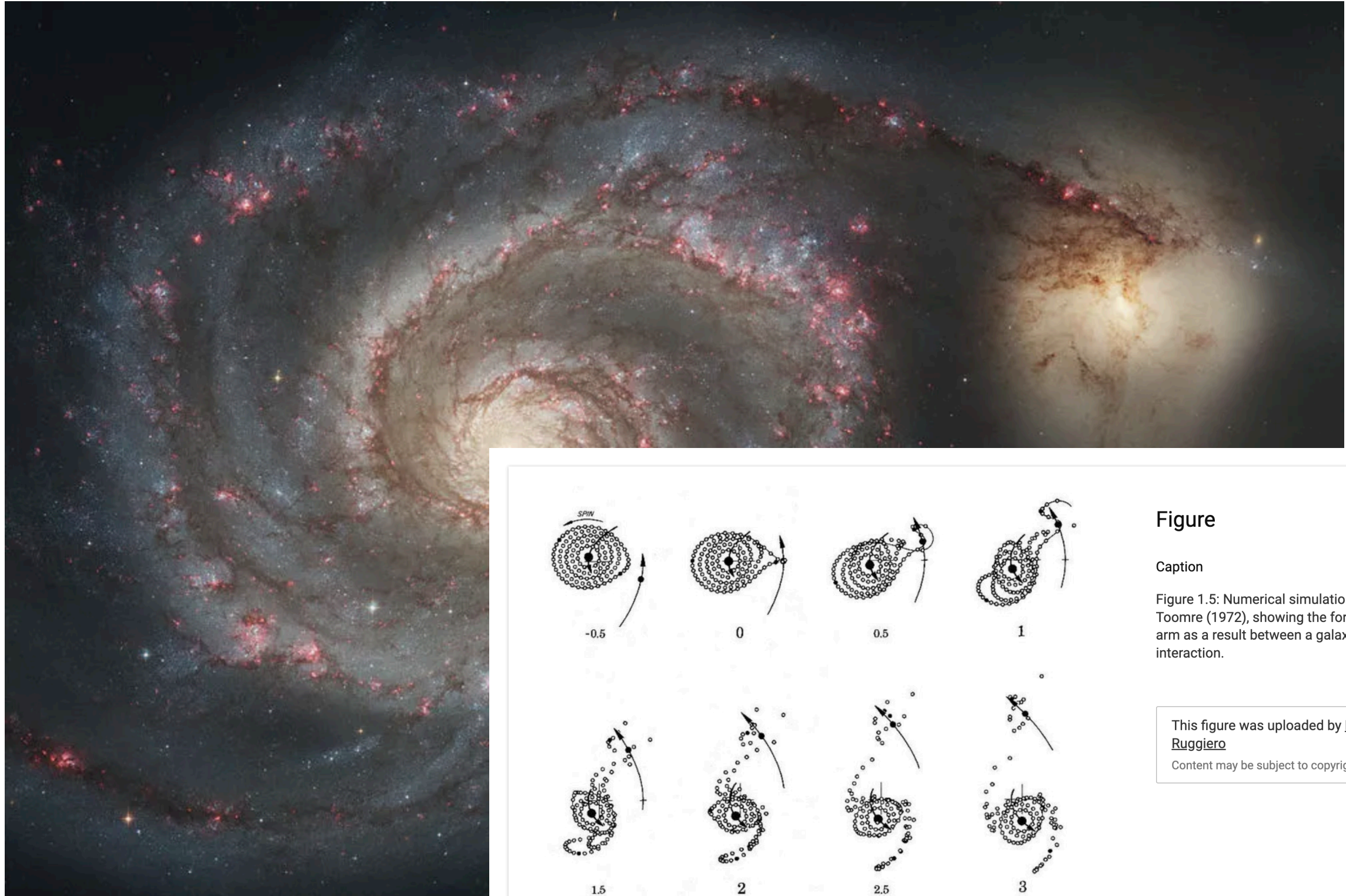
1.5

2

2.5

3

Galaxy have spiral arms



Figure

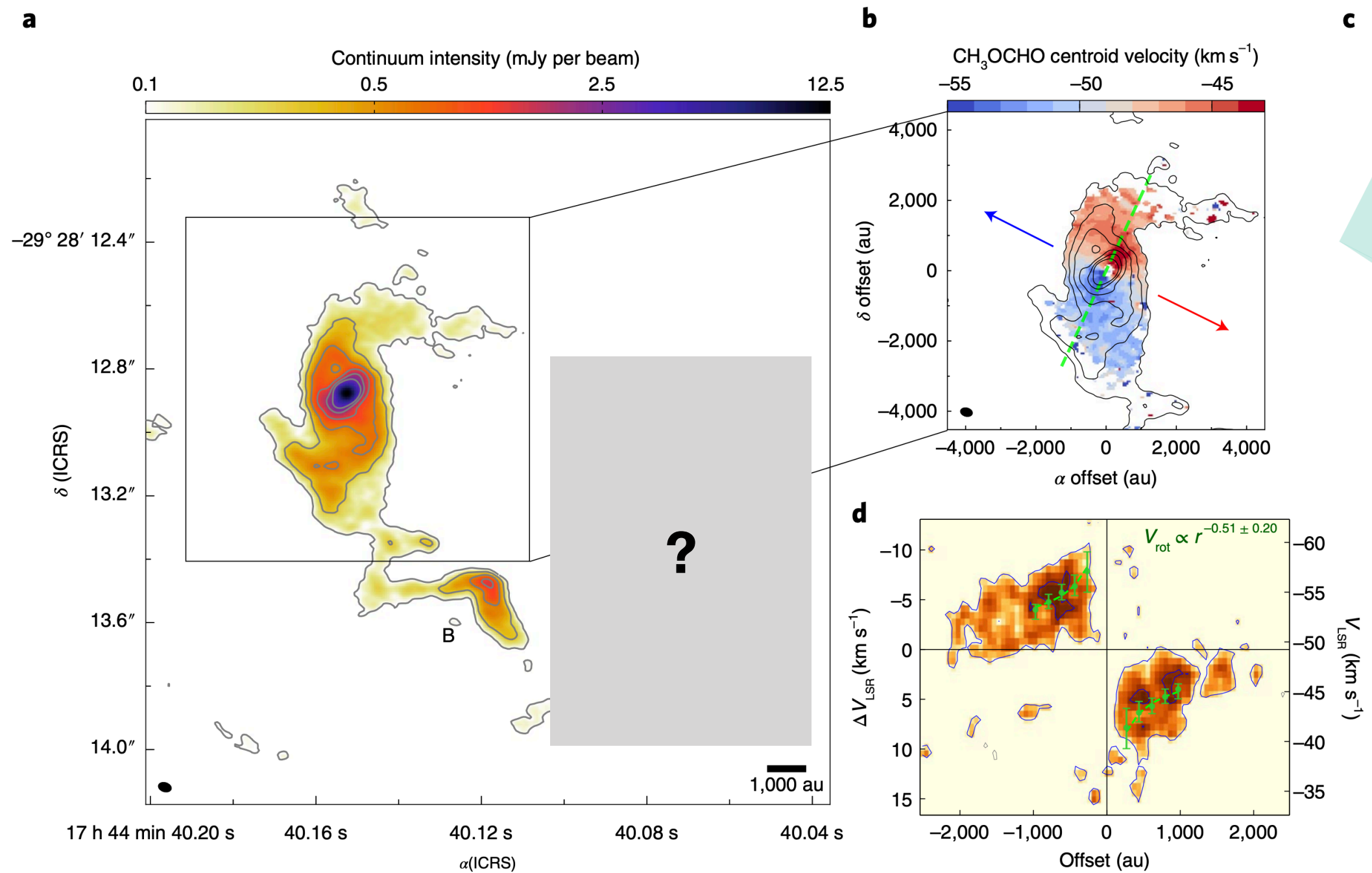
Caption

Figure 1.5: Numerical simulation by Toomre & Toomre (1972), showing the formation of a tidal arm as a result between a galaxy-galaxy interaction.

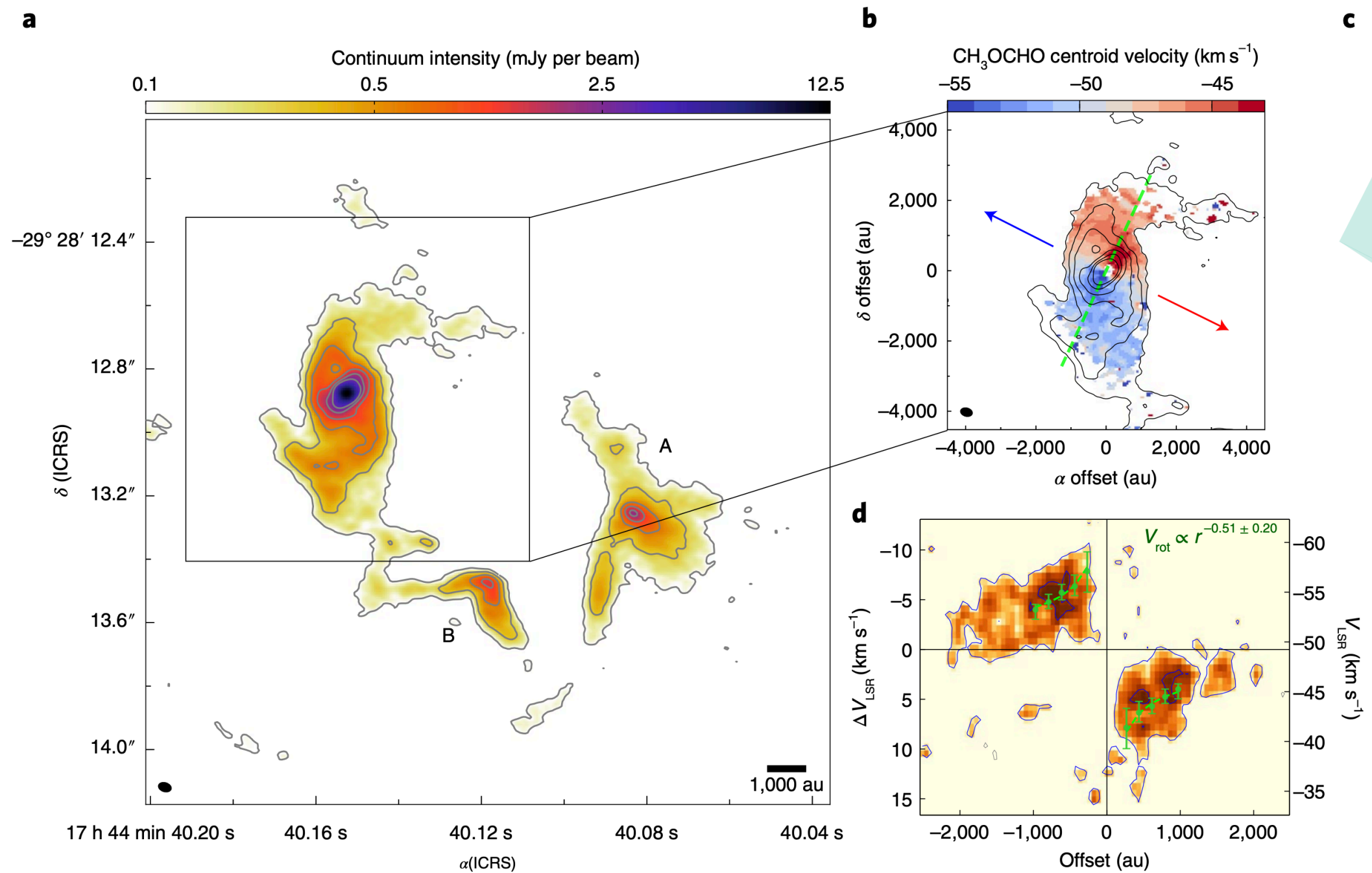
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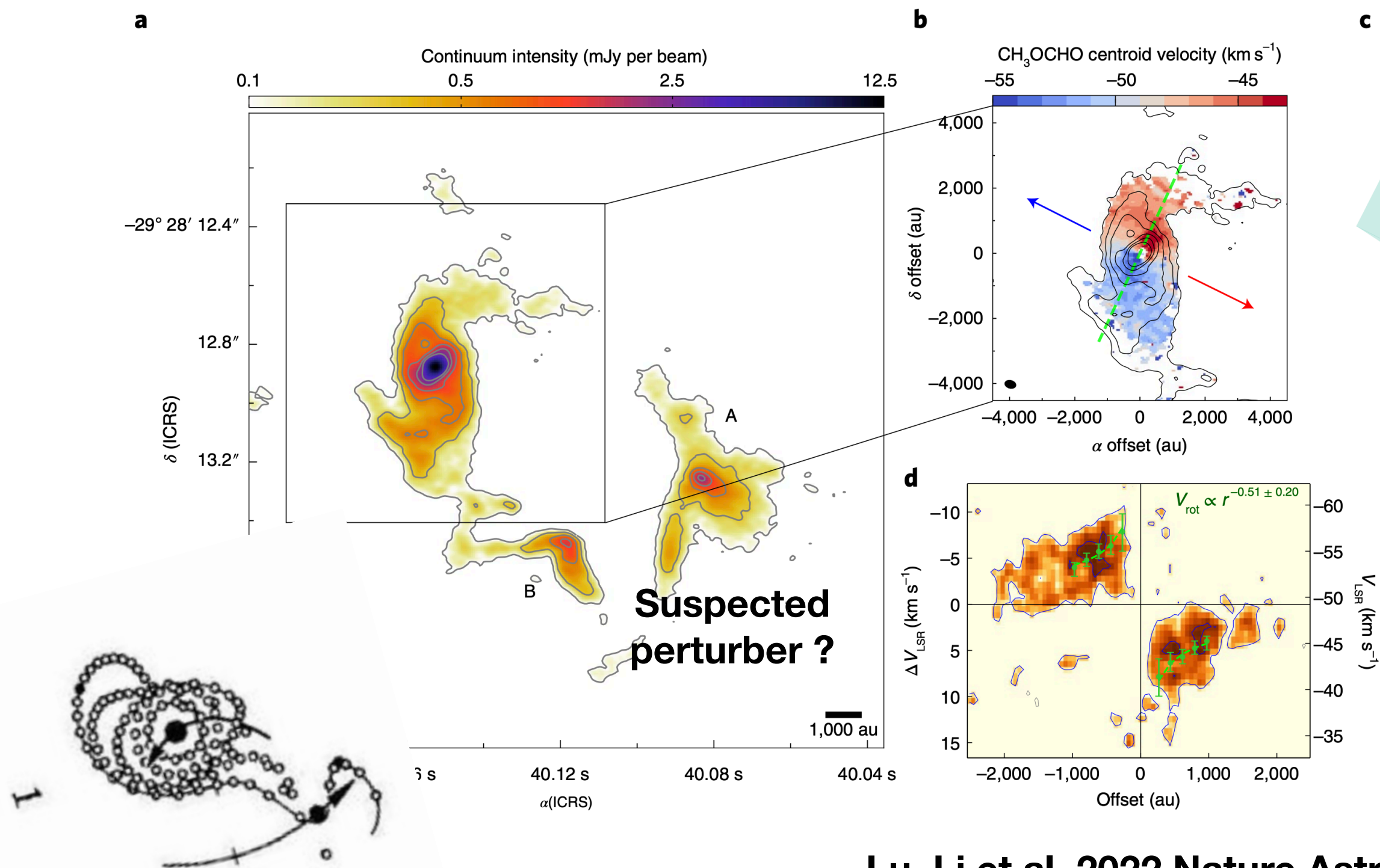
Zoom out: The disk is not isolated



Zoom out: The disk is not isolated

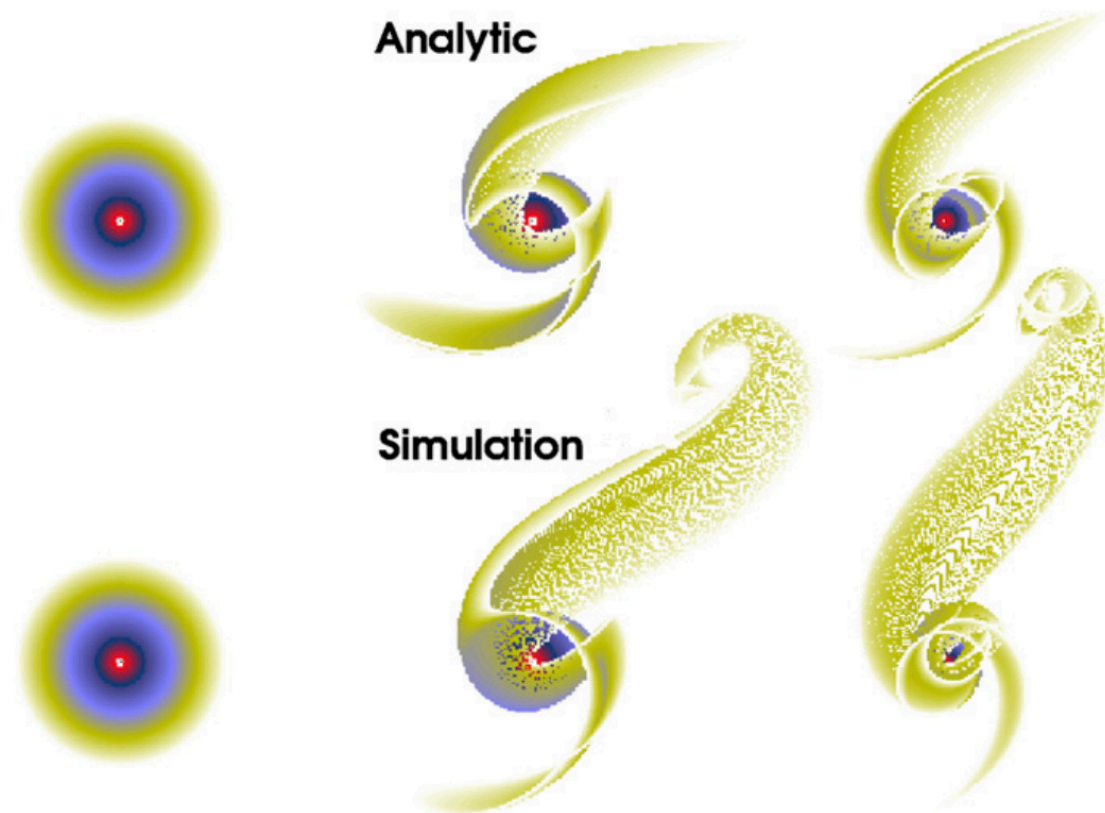


Zoom out: The disk is not isolated



Flyby-induced spirals

Scanning the parameter space (D'Onghia, E. et 2010) Simulation using Phantom code



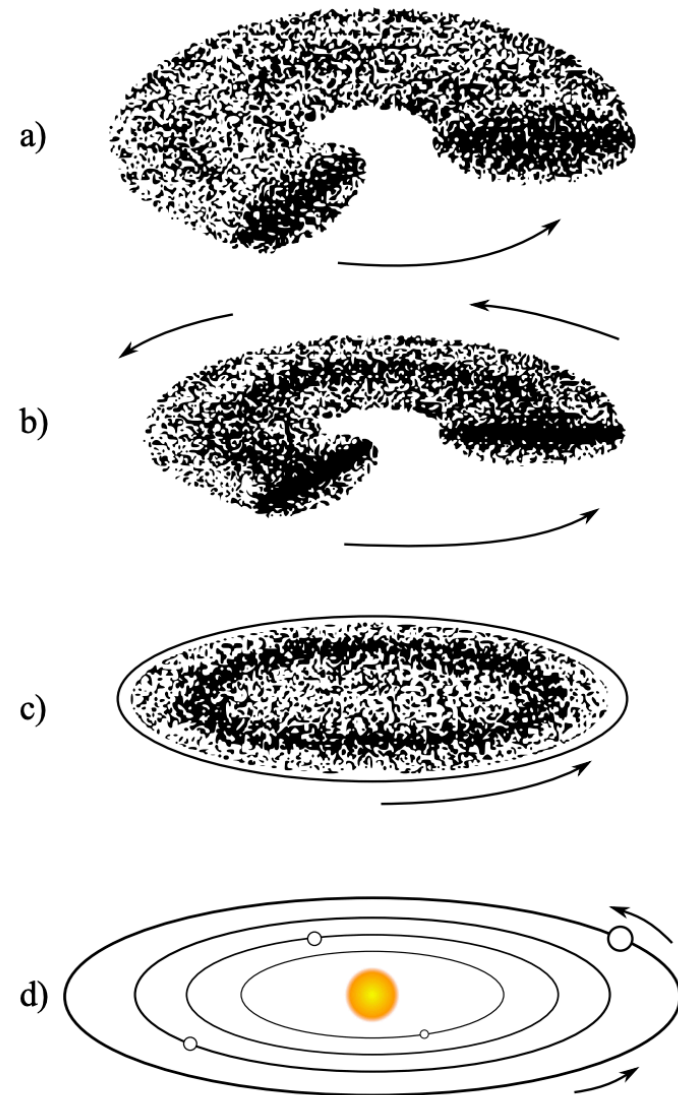
$$\Delta v_x = 2GM_{\text{pert}} \frac{r \cos \phi_0}{b^2 V_{\text{sl}}} \left[\alpha K_1(\alpha) + \alpha^2 \left(K_0(\alpha) \pm K_1(\alpha) \right) \right]$$



Find the parameters and simulations

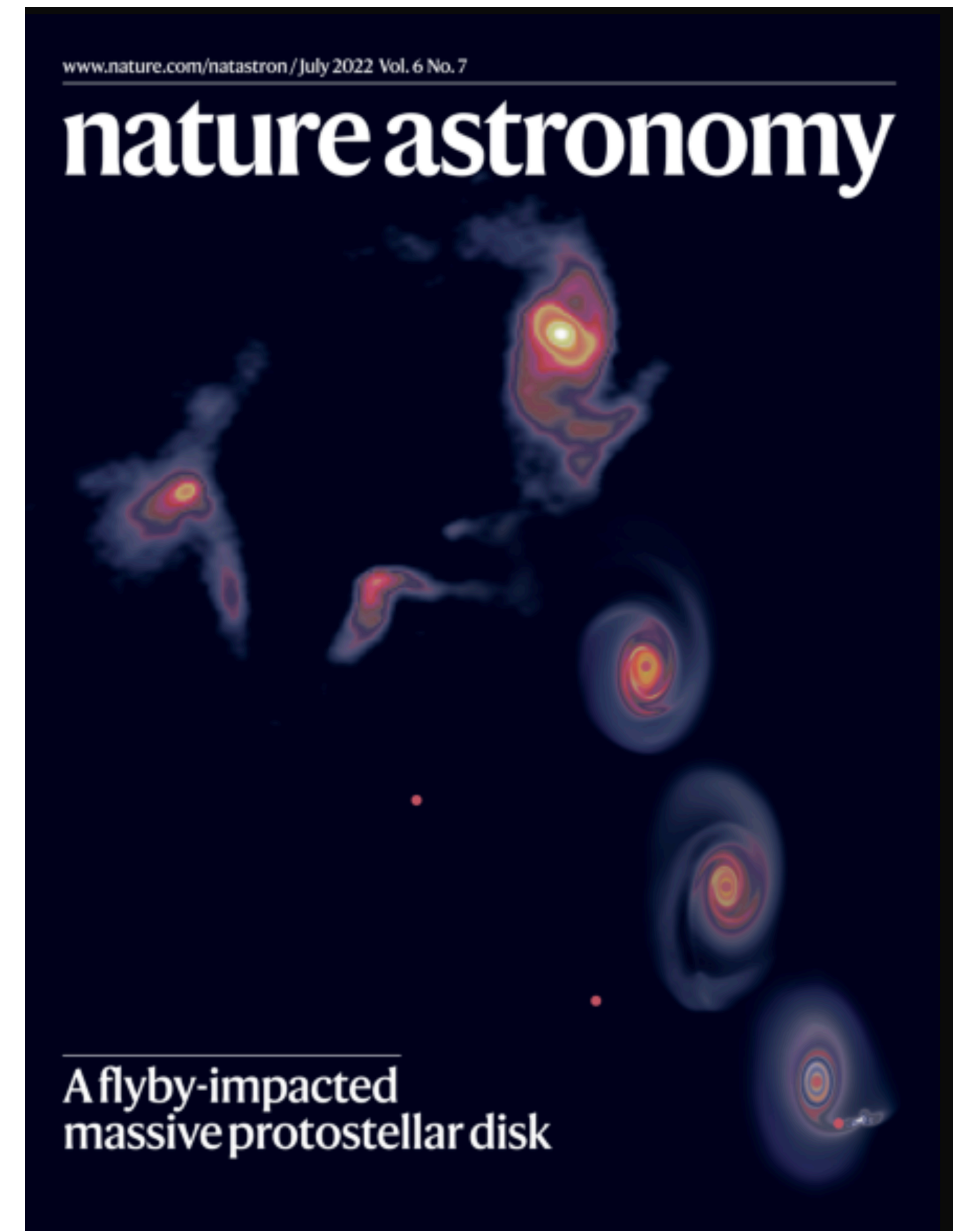
Lu, Li et al. 2022 Nature Astronomy

Isolated



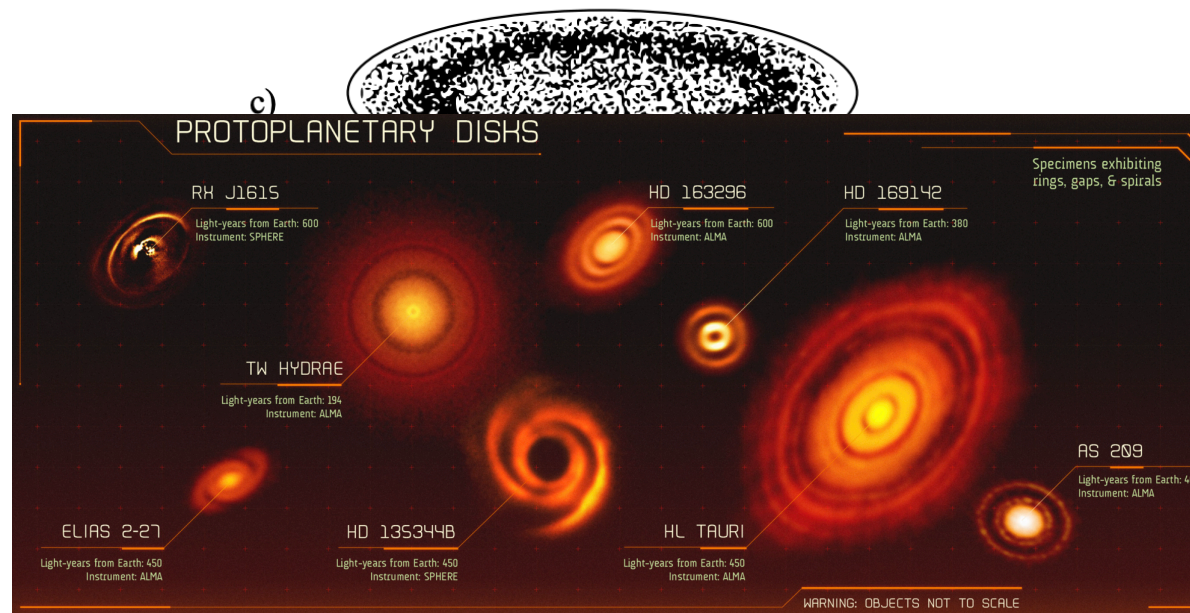
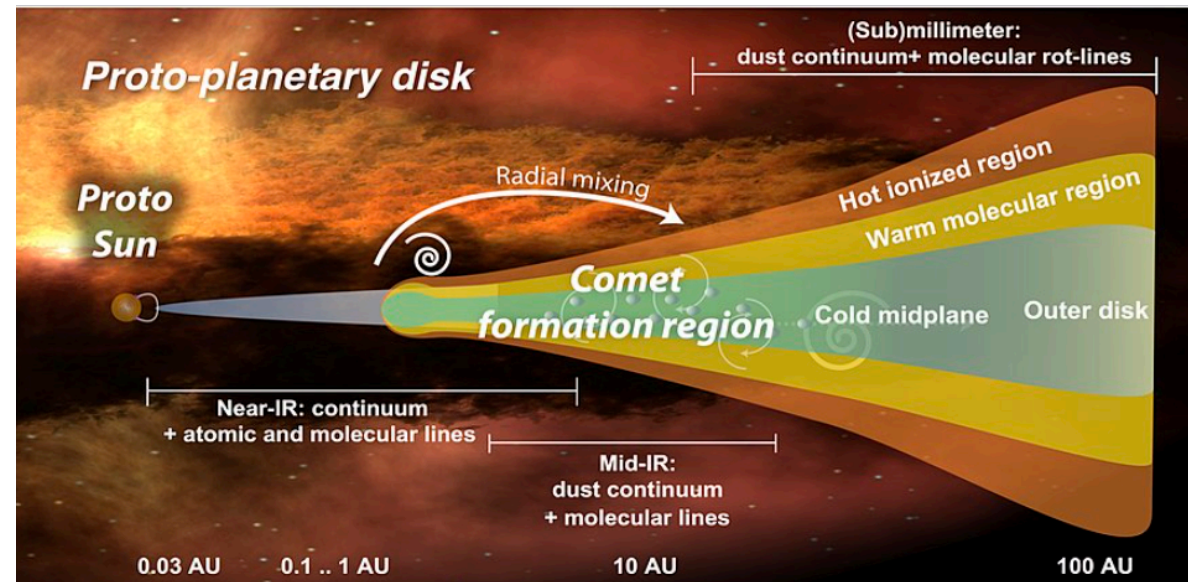
Nebula hypothesis

Perturbed



**Proposed by many theoretical studies,
e.g. Pfalzner et al. Cuello et al.**

Isolated



1000+ papers

Perturbed

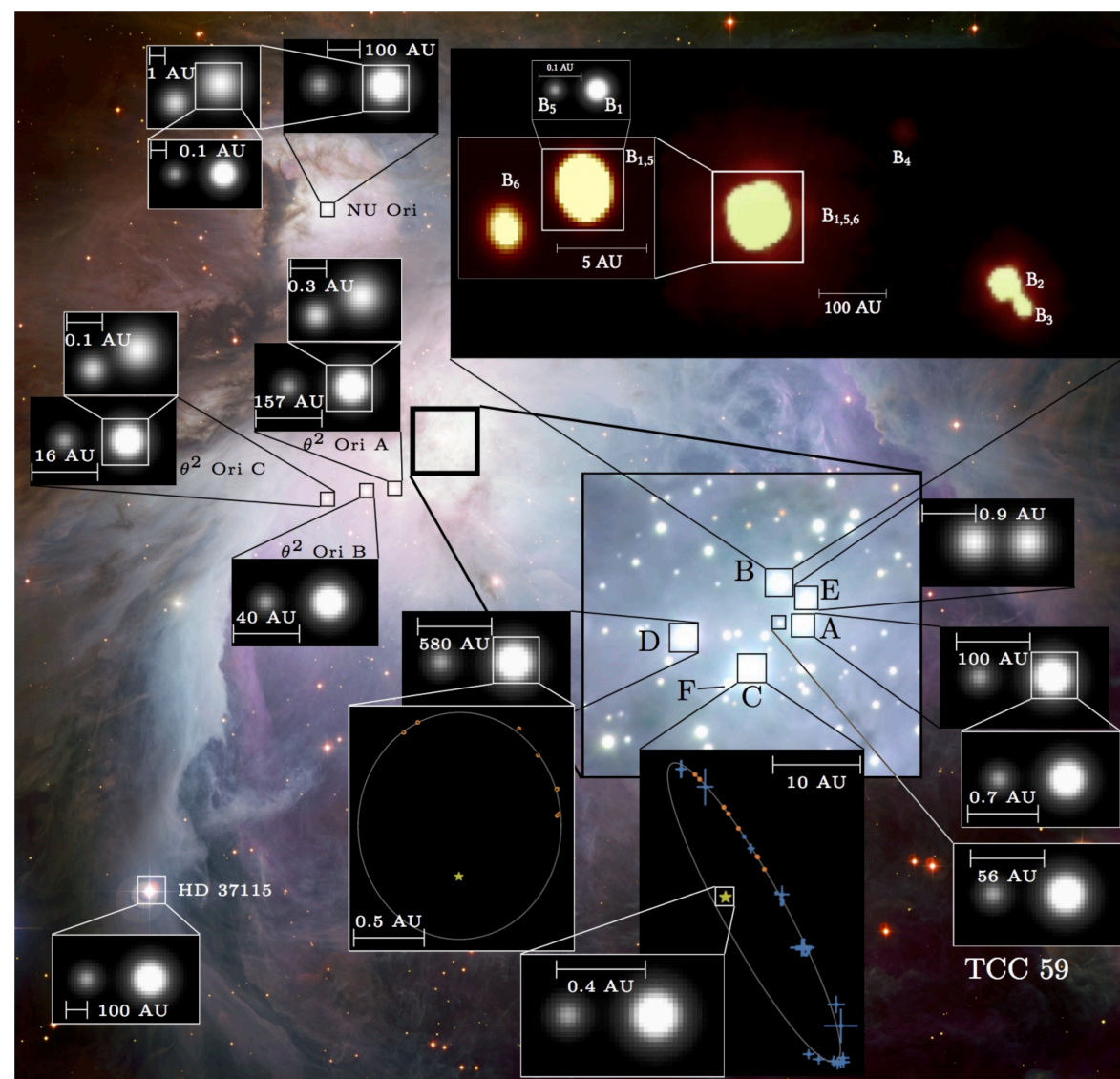


Proposed by many theoretical studies,
e.g. Pfalzner et al. Cuello et al.

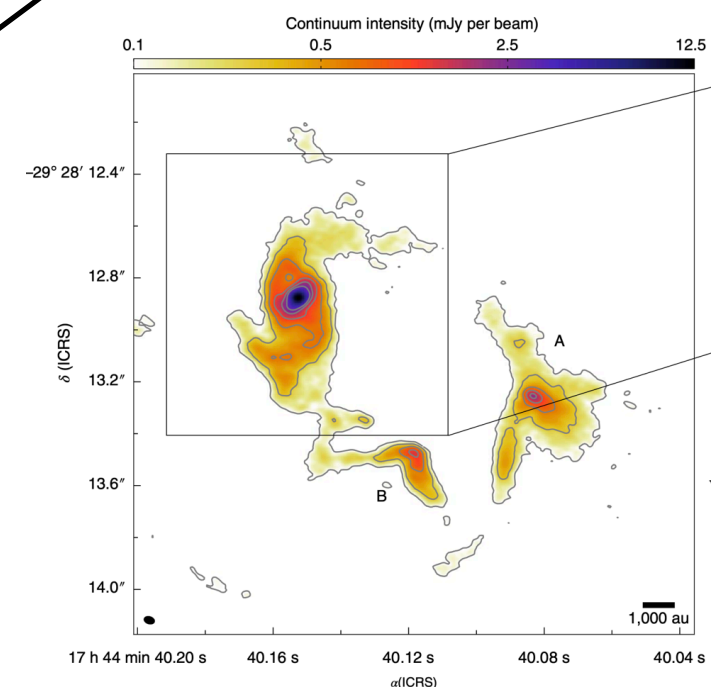
Stellar encounters are *relevant*

Reason 1: Planetary systems are Enormous (compared to stars)

Reason 2: Stars are born in hierarchies



Sometime ago



Remove of gas
Formation of jupiter
some binaries

Karl et al, 2018, Gravity collaboration

Lu, Li et al. 2022 Nature Astronomy