#GAEP1004-10 71-141

6. arXiv:2410.07032 [pdf, other]
Exploring Magnetic Fields in Molecular Clouds through Denoising Diffusion Probabilistic Models
Authors: Duo Xu, Jenna Karcheski, Chi-Yan Law, Ye Zhu, Chia-Jung Hsu, Jonathan C. Tan

参考　Denoising Diffusion Probabilistic Models to Predict the Density of Molecular Clouds
Duo Xu, Jonathan C. Tan, Chia-Jung Hsu, and Ye Zhu
The Astrophysical Journal, 950:146 (14pp), 2023 June 20

参考　High-accuracy estimation of magnetic field strength in the interstellar medium from dust polarizatio
Raphael Skalidis and Konstantinos Tassis A&A 647, A186 (2021)

111. arXiv:2410.04227 [pdf, other]
Star formation in cosmic-dawn galaxies
Authors: Sandro Tacchella

Exploring Magnetic Fields in Molecular Clouds through Denoising Diffusion Probabilistic Models

Duo Xu, Jenna Karcheski, Chi-Yan Law, Ye Zhu, Chia-Jung Hsu, and Jonathan C. Tan, arXiv:2410.07032v1

Davis--Chandrasekhar-Fermi

$$B_{POS} = f\sqrt{4\pi\rho}\frac{\sigma_V}{\sigma_{PA}},$$

Modified DCF

$$B_{POS} = \sqrt{2\pi\rho}\frac{\sigma_V}{\sqrt{\sigma_{PA}}}.$$

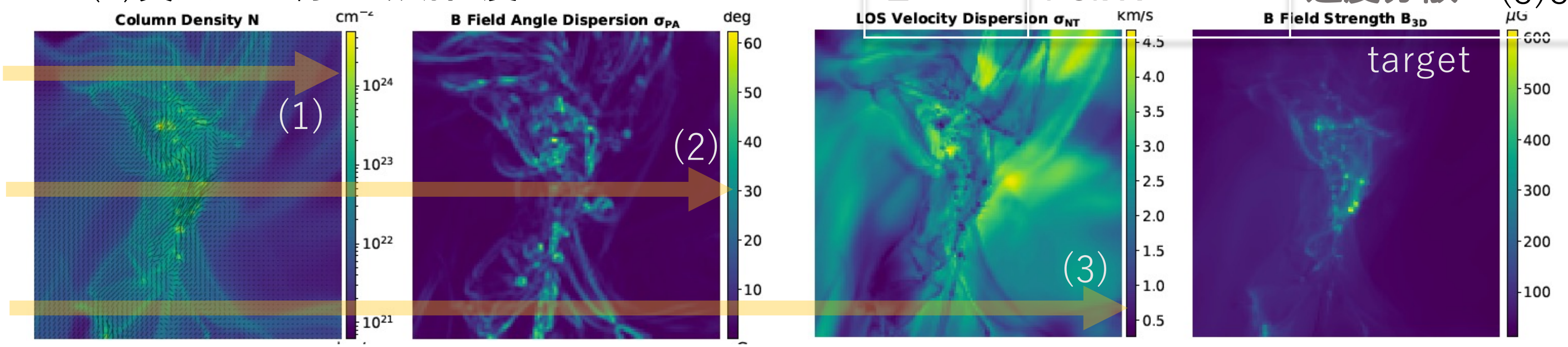
問題 (1) non-isotropic turbulence,
(2) incorrect angular dispersion tracing,
(3) the lack of energy equipartition

(a) ordered magnetic fields
(b) line-of-sight averaging
(c) beam-smoothing
(d) other observational effects

(A) trained on all initial conditions, covering all magnetic field strengths and both colliding and non-colliding GMC scenarios.
(B) trained only on colliding GMC scenarios and tested on non-colliding ones.
(C) An trained only on the 10 μG and 50 μG cases and tested on the 30 μG case.

Σ mapにDDPM法、磁場強度が求められるか？
(1) Σ
(2)質量重み付け偏光向きベクトル
(3)質量重み付け（視線？）速度分散
(4)質量重み付け磁場強度

Σ	(1)Single Channel	75%training 25%test
Σ	Pol. V.	(2)2 Channels
Σ	Pol.V.	速度分散 (3)3 Channels

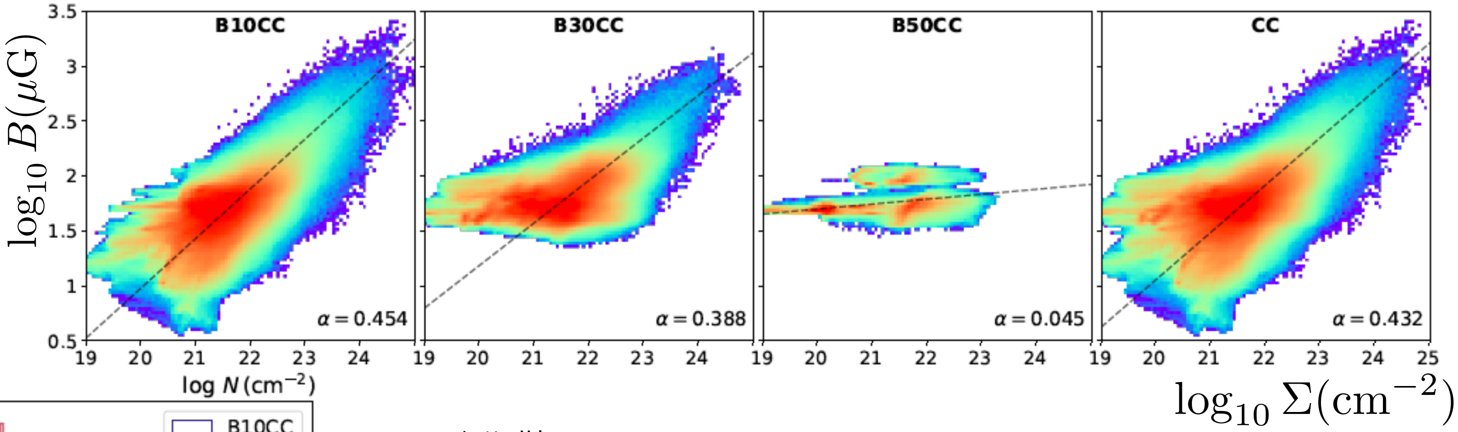


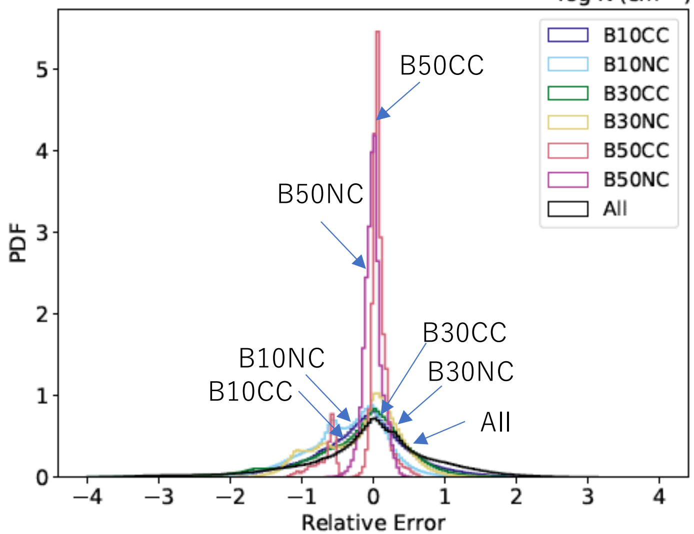
B-Σ関係

指数関数近似

$$B = A\Sigma^{\alpha}$$

$$\delta_B = \frac{B_{Pred} - B_{True}}{min(B_{Pred}, B_{True})}.$$

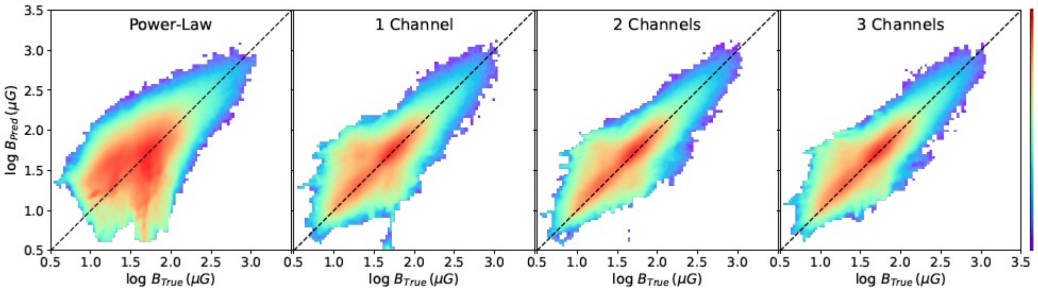




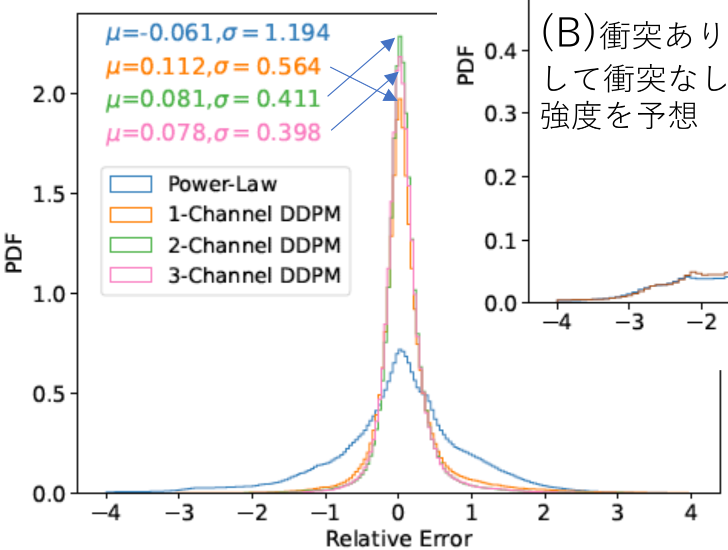
50μGが分散最小:due to the narrower dynamic range of magnetic field strength

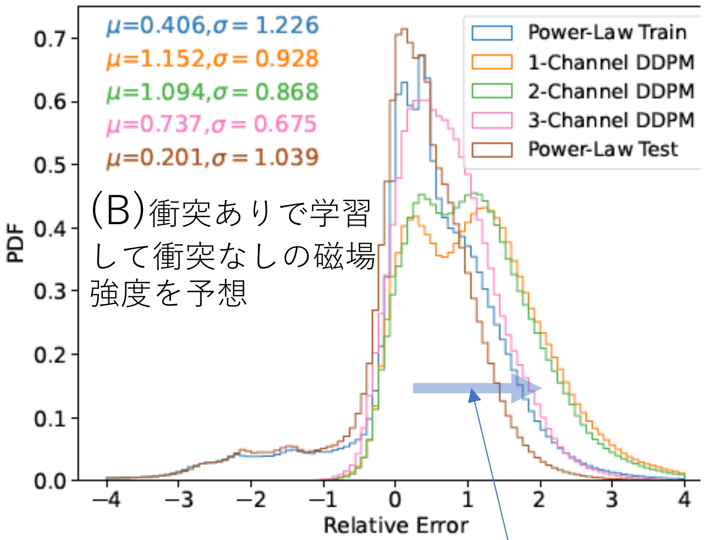
DDPM

指数関数近似より予想はよくなるが、1 Channel→ 3 Channelにすると若干の改善。



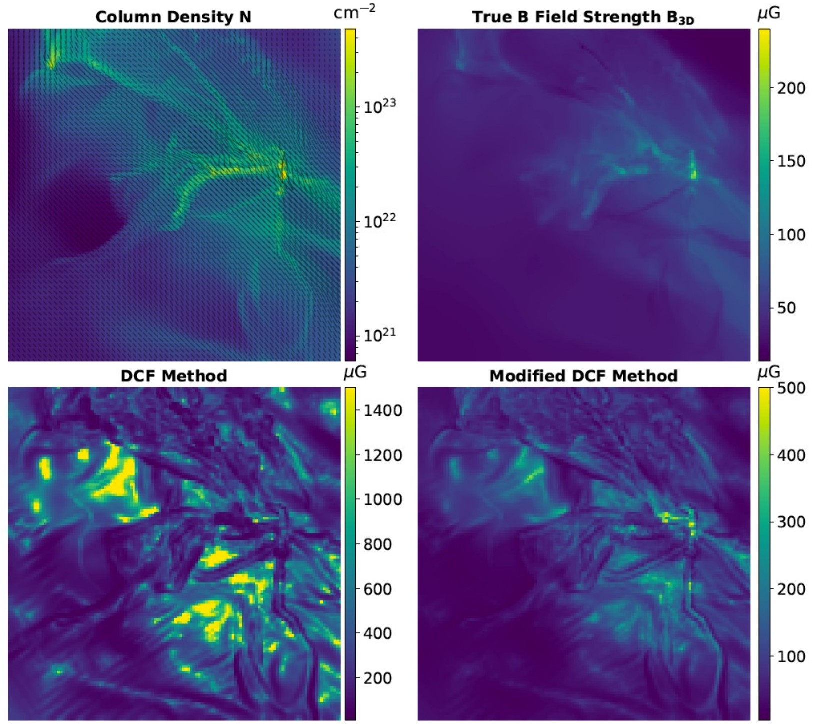
(A)



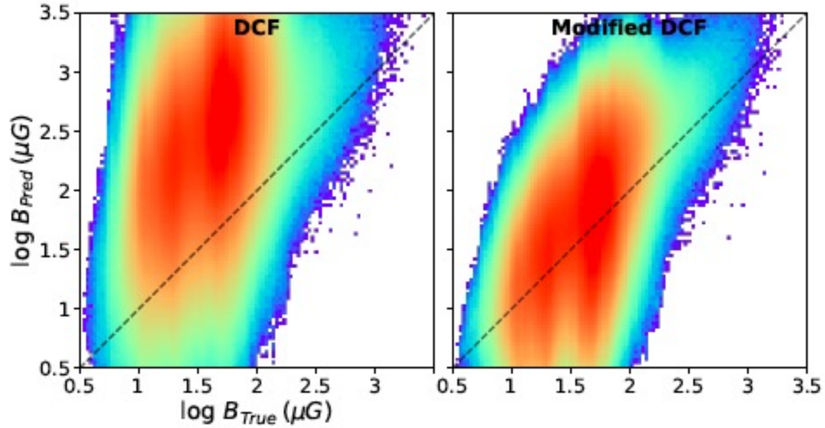


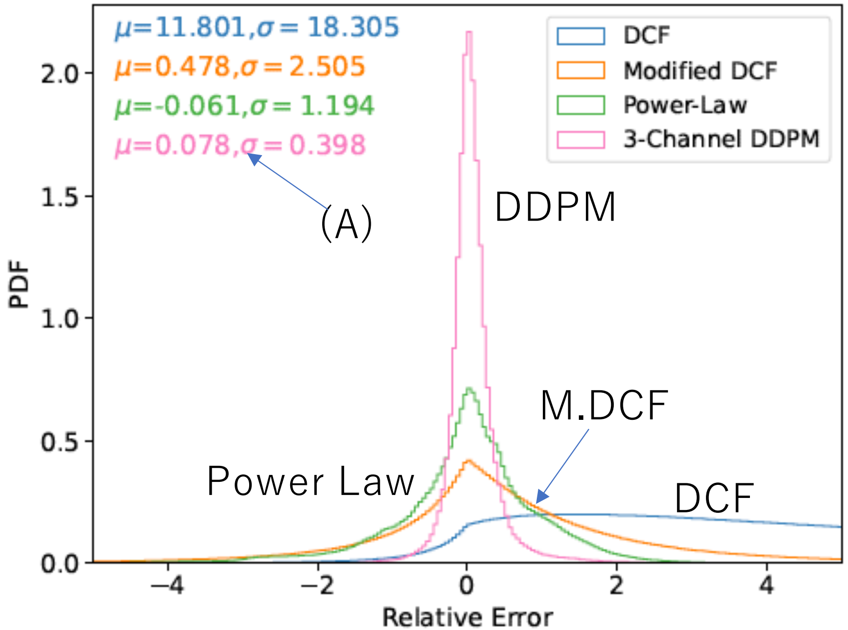
B-Σの冪が衝突ありの方が大きい。こちらを学習すると衝突なしでも強過ぎる磁場を予想する。

DCFとの比較



$$B_{POS} = f\sqrt{4\pi\rho}\frac{\sigma_V}{\sigma_{PA}}, \qquad B_{POS} = \sqrt{2\pi\rho}\frac{\sigma_V}{\sqrt{\sigma_{PA}}}.$$





Denoising Diffusion Probabilistic Models to Predict the Density of Molecular Clouds
Duo Xu, Jonathan C. Tan, Chia-Jung Hsu, and Ye Zhu
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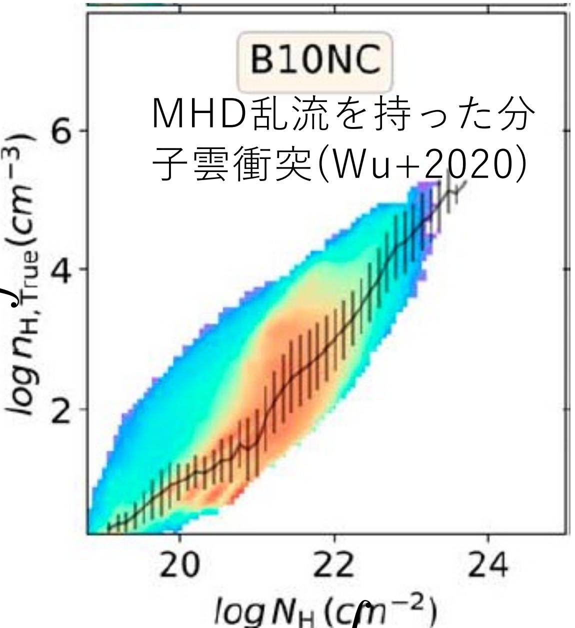
Nのマップから質量で重みづけられた密度のマップを推定

$$q(\boldsymbol{x}_t|\boldsymbol{x}_{t-1}) = \mathcal{N}(\sqrt{1-\beta_t}\boldsymbol{x}_{t-1}, \beta_t \boldsymbol{I}),$$

diffusion process

Denoising Diffusion Probabilistic Models (DDPM)略してDiffusion Model

$$< n > \equiv \int n^2 d\ell / N$$



$$N \equiv \int n d\ell$$

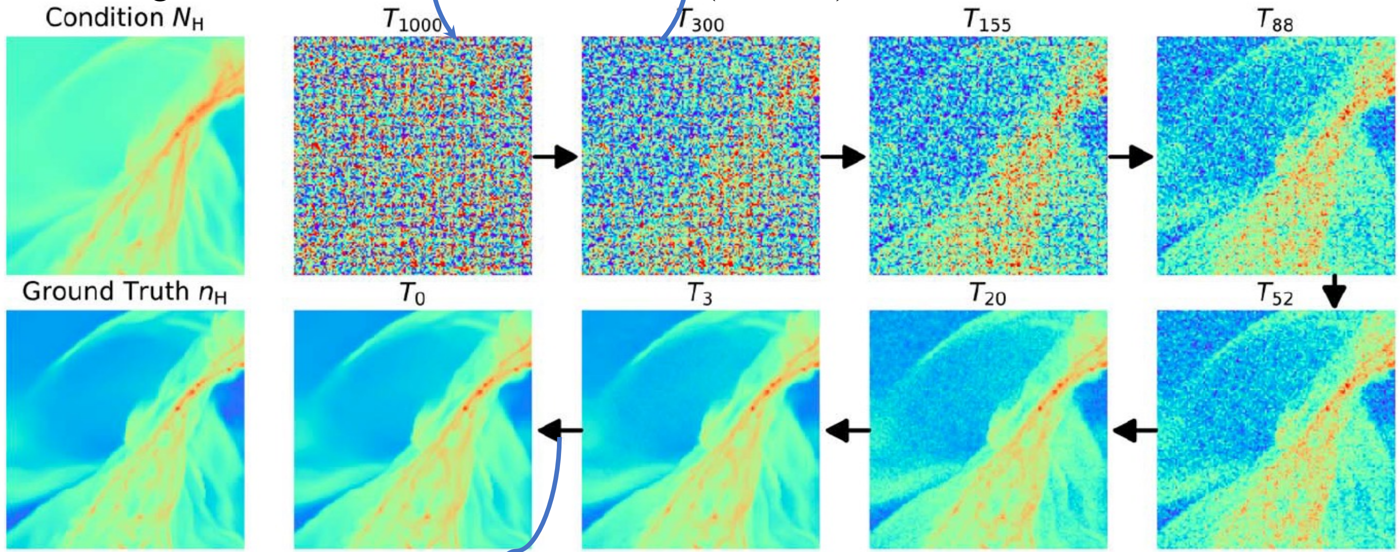


Figure 2. Demonstration of the diffusion process (reverse) on a sample in the test set.

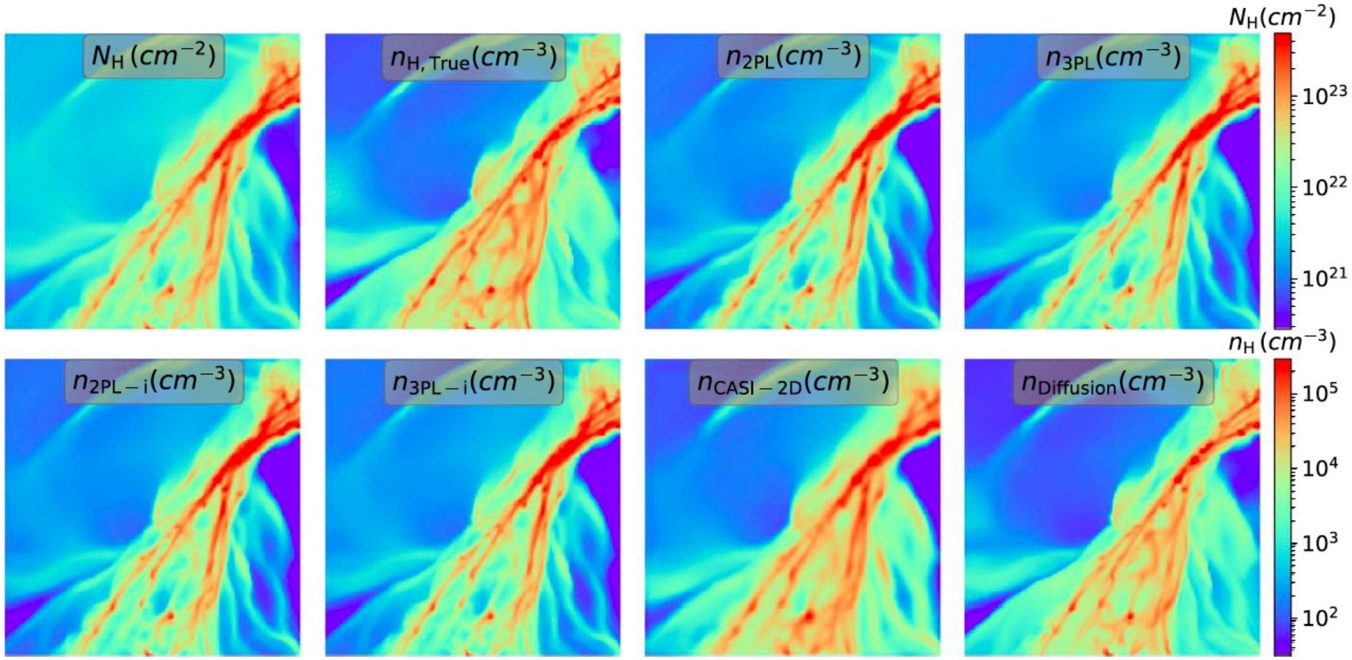
$$\boldsymbol{x}_{t-1} = \frac{1}{\sqrt{1-\beta_t}}\left(\boldsymbol{x}_t - \frac{\beta_t}{\sqrt{1-\alpha_t}}\epsilon_t^{\theta}(\boldsymbol{x}_t)\right) + \sigma_t z_t,$$

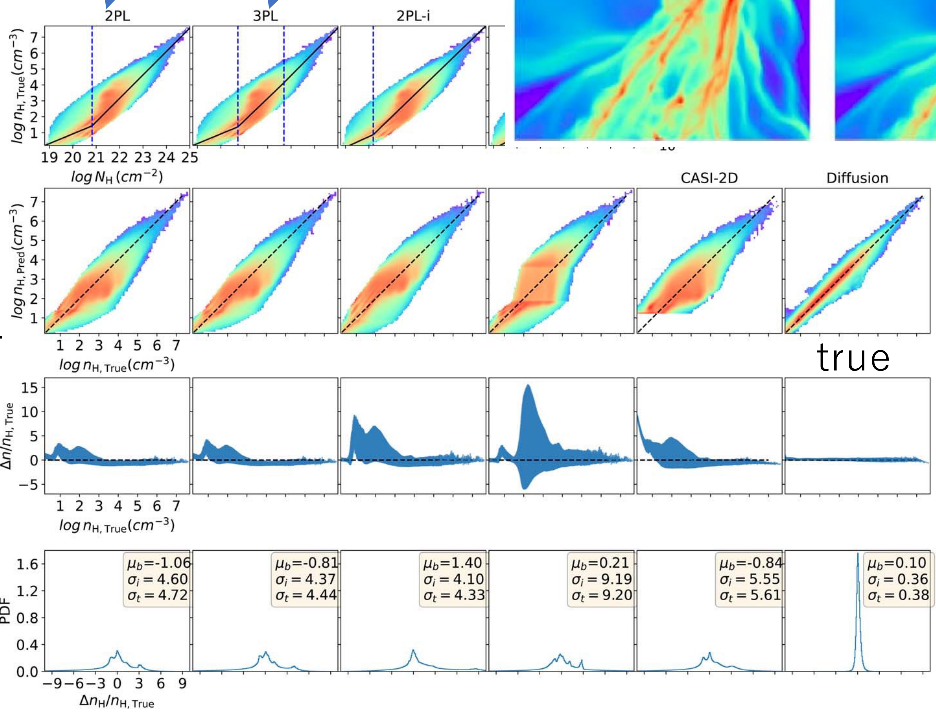
the learnable noise predictor

$$\mathcal{L} = \mathbb{E}_q\left[-\log p(\boldsymbol{x}_T) - \sum_{t \geqslant 1} \log \frac{p_\theta(\boldsymbol{x}_{t-1}|\boldsymbol{x}_t)}{q(\boldsymbol{x}_t|\boldsymbol{x}_{t-1})}\right]$$

two
power-law

three
power-law



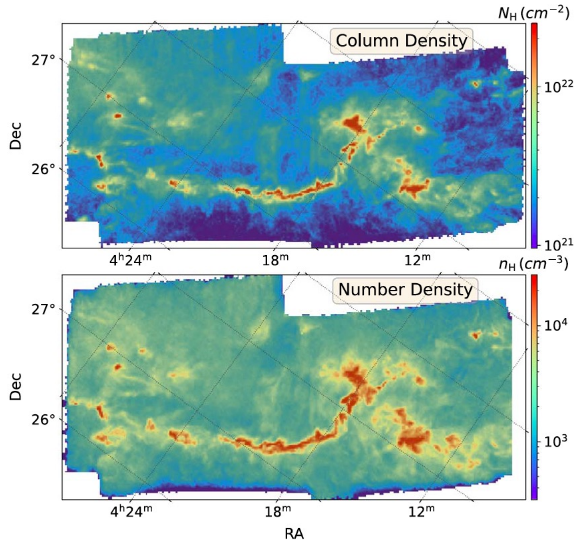


predicted

誤差

誤差分布関数

true



DCF vs Modified DCF

High-accuracy estimation of magnetic field strength in the interstellar medium from dust polarization
Raphael Skalidis and Konstantinos Tassis A&A 647, A186 (2021)

圧縮性のモード

$$\frac{1}{2}\rho\delta v^2 = \frac{\delta B B_0}{4\pi}$$

$$\delta\theta = \frac{\delta B}{B_0}$$

$$B_0 = \sqrt{2\pi\rho}\frac{\delta v}{\sqrt{\delta\theta}}$$

Modified DCF

アルフベン波のモード

$$\frac{1}{2}\rho\delta v^2 = \frac{\delta B^2}{8\pi}$$

$$\delta\theta = \frac{\delta B}{B_0}$$

$$B_0 = \sqrt{2\pi\rho}\frac{\delta v}{\delta\theta}$$

DCF

111. Star formation in cosmic-dawn galaxies

Sandro Tacchella, To be published in "Astrophysics: The James Webb Space Telescope: from first light to new world views", proceedings of the Pontifical Academy of Sciences workshop February 27-29 2024, Vatican City, E.F. van Dishoeck and G. Consolmagno (eds) arXiv:2410.04227v1

In the first two years of operation JWST has delivered key new insights into the formation and evolution of galaxies in the early Universe. By combining imaging with spectroscopy, we discovered and characterised the first generation of galaxies, probing the Universe at an age of 300 million years. While the current JWST observations confirm the overall cosmological framework and the paradigm of galaxy formation, there are also surprises, including large abundances of bright galaxies and accreting black holes in the early Universe. These observations, together with detailed measurements of the stellar populations and morphological structure, will help us to develop in the coming years a more refined understanding of the baryonic physics (including star formation and feedback processes) that leads to the formation of mature systems at later epochs, including our own Milky Way galaxy.

A simple model for star formation in dark matter haloes

SFR of a dark matter halo of mass M_h at redshift z

$$\mathrm{SFR}(M_h, z) = \varepsilon(M_h) f_b \frac{dM_h}{dt},$$

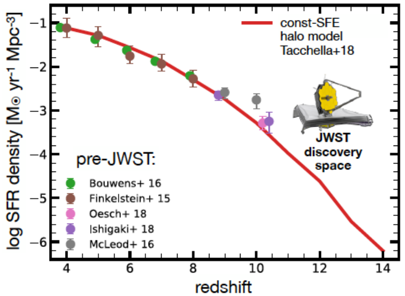
constant SFE model

star formation efficiency

dark matter accretion rate λCDMモデル

cosmic barion fraction

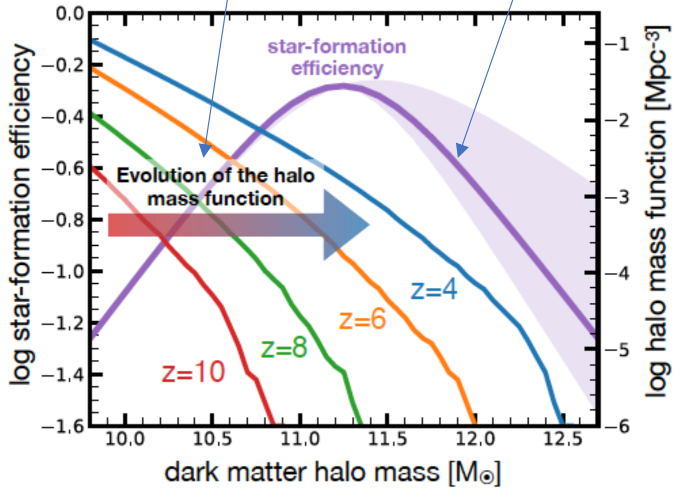
様々の関係を説明可能
cosmic SFR density
galaxy stellar mass function
star forming main-sequence
mass metallicity relation



Dark matterのモデルはバリオン過程と縮退している

SFRのz=14~4立ち上がりはハローの質量関数の立ち上がりの反映

想定されるzによらないε(Mh)の形



JWST: a new era of discoveries

JWSTで$z \simeq 10$-20の銀河を見る

NIRCam and NIRSpec

カメラ　　　R>1000スペクトル

Finding and characterising the first galaxies

HubbleとSpitzerは$z>9$の候補

JWST　NIRCamで発見、分光z_{spec}=13.2, 12.63

Hubbleの候補、分光z_{spec}=11.58, 10.38

SFR~1$M_{\odot}$/yr、R~100pc➔ ΣSFR~$10^2 M_{\odot} yr^{-1} kpc^{-2}$

JADES-GS-z14-0, $z_{spec}=14.21^{+0.08}_{-0.20}$、ALMAで [OIII]88$\mu$m, Z~0.1$Z_{\odot}$

$z_{spec}=13.90\pm0.17$

UV光度関数の明るい側の激しい進化は見られないようだ。z=14~12で2.5倍、const. SFEモデルと相違

Understanding early UV-bright galaxies

There is a higher abundance of bright galaxies at high redshifts than expected from theoretical models pre-JWST, including the constant-SFE model.

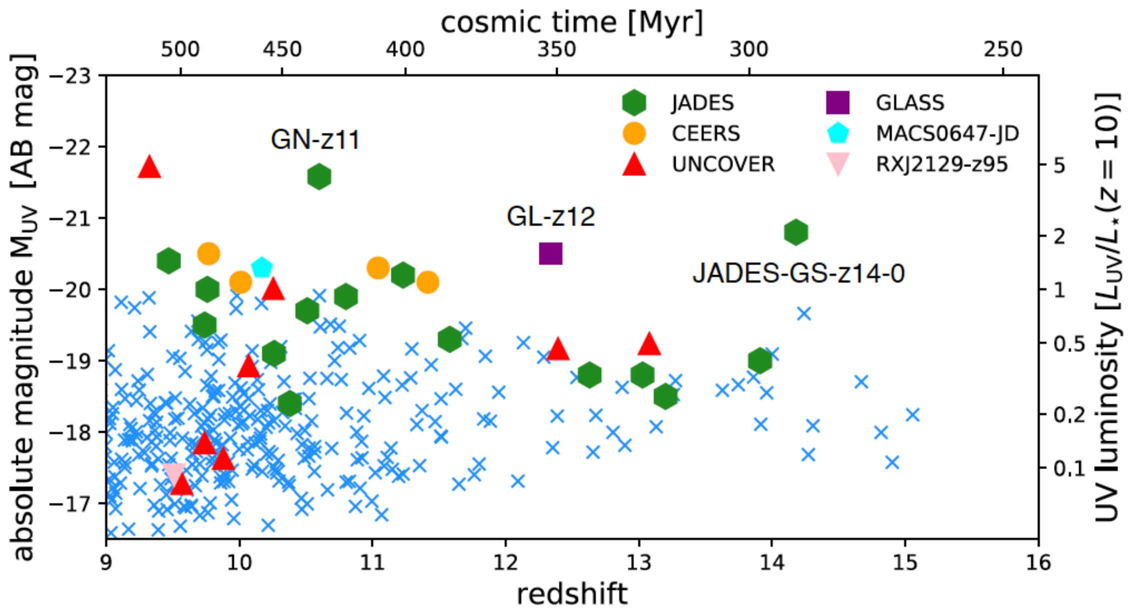
So why is there an over-abundance of UV-bright galaxies at z>10?

（宇宙論）λCDMからの変更？揺らぎスペクトルの変更、。。。

（銀河形成）SFE↑z↑feedback-free starburst(high ρ、low Z)

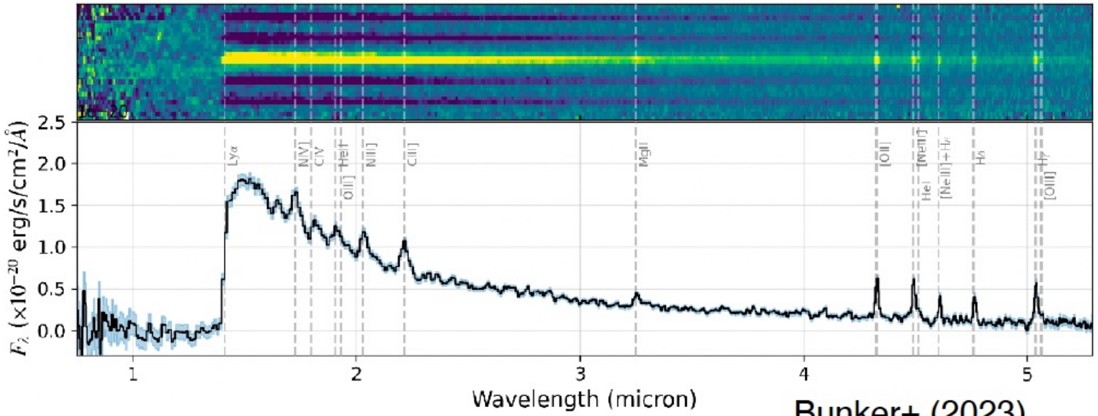
burstiness 時間変化する星形成率

（輻射輸送）zero dust attenuation at high redshift、よりtop-heavyなIMF, 恒星以外の天体の寄与（Massive BH）



GN-z11

Broad-line Regionのスペクトルに酷似



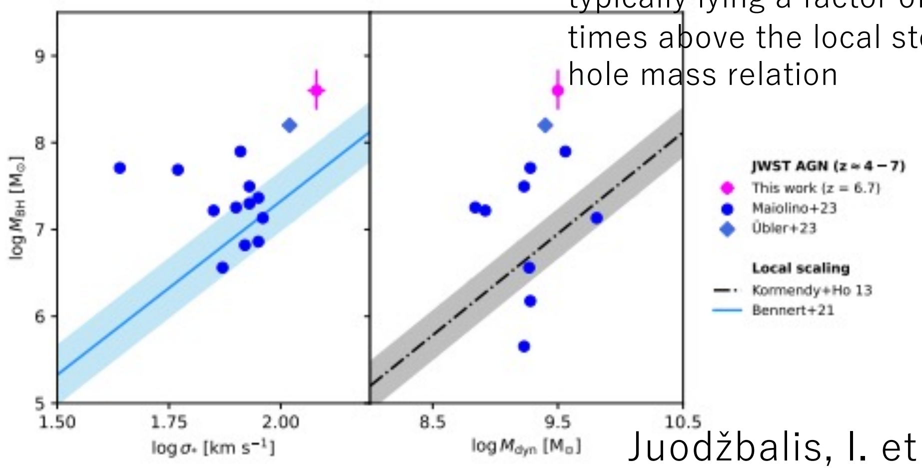
Bunker+ (2023)

the highest-redshift known AGN (z_{spec}=10.60)

galaxy: R~200pc, M*~$10^{8.9}M_\odot$、

BH: M_{BH}~$10^6 M_\odot$ 、 dM_{BH}/dt~$5L_{Edd}$

typically lying a factor of 10－100 times above the local stellar-to-black hole mass relation



Juodžbalis, I. et al.2024