地上と宇宙の大型望遠鏡と研究者を結集し探る
初期宇宙と天体形成

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共同利用研究課題

- 令和6年度

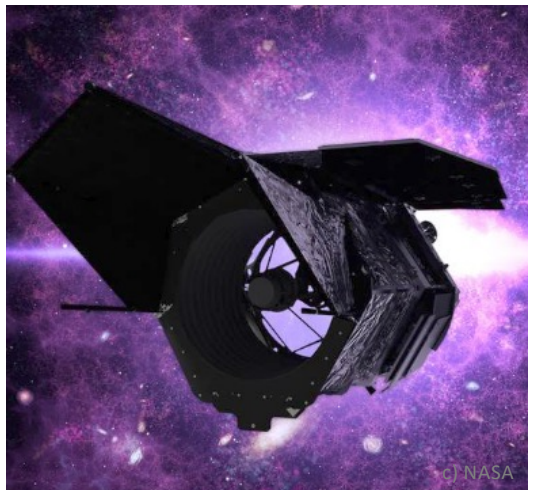
代表:大内正己

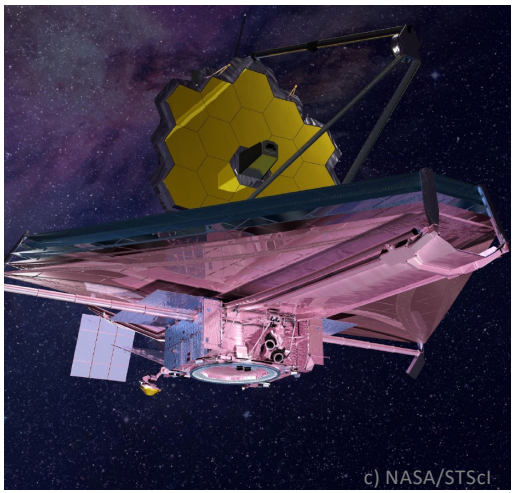
参加研究者：小野宜昭、播金優一、矢島秀伸、長峯健太郎、宮武広直他(東京大学、筑波大学、大阪大学、名古屋大学、Max Planck Institute、Copenhagen大学など)。計44名

柏大型計算機システム、会議室など

予算:物件費5万円(レンタルサーバー等、オンライン共同研究対応)
　　旅費10万円→年度途中で枯渇

大型望遠鏡による観測研究
（初期宇宙と天体）





- すばる（HSC→PFS等)、Roman宇宙望遠鏡、などによる大規模計画
- ALMA電波干渉計
- JWST宇宙望遠鏡

論文（令和6年度中）

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- Fujimoto,"JWST and ALMA Multiple-line Study in and around a Galaxy at z = 8.496: Optical to Far-Infrared Line Ratios and the Onset of an Outflow Promoting Ionizing Photon Escape",The Astrophysical Journal,964,2024
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- Liang,"Cosmic Himalayas: The Highest Quasar Density Peak Identified in a 10,000 deg^2 Sky with Spatial Discrepancies between Galaxies, Quasars, and IGM HI",arXiv e-prints,2024
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- Hatano,"EMPRESS. XIV. Strong High-ionization Lines of Young Galaxies at z = 0{¥textendash}8: Ionizing Spectra Consistent with the Intermediate-mass Black Holes with M_BH~10^3-10^6 Mo",The Astrophysical Journal,966,2024
- Nakane,"Lya Emission at z = 7-13: Clear Evolution of Lya Equivalent Width Indicating a Late Cosmic Reionization History",The Astrophysical Journal,967,2024
- Gimenez-Arteaga,"Outshining in the spatially resolved analysis of a strongly lensed galaxy at z = 6.072 with JWST NIRCam",Astronomy and Astrophysics,686,2024
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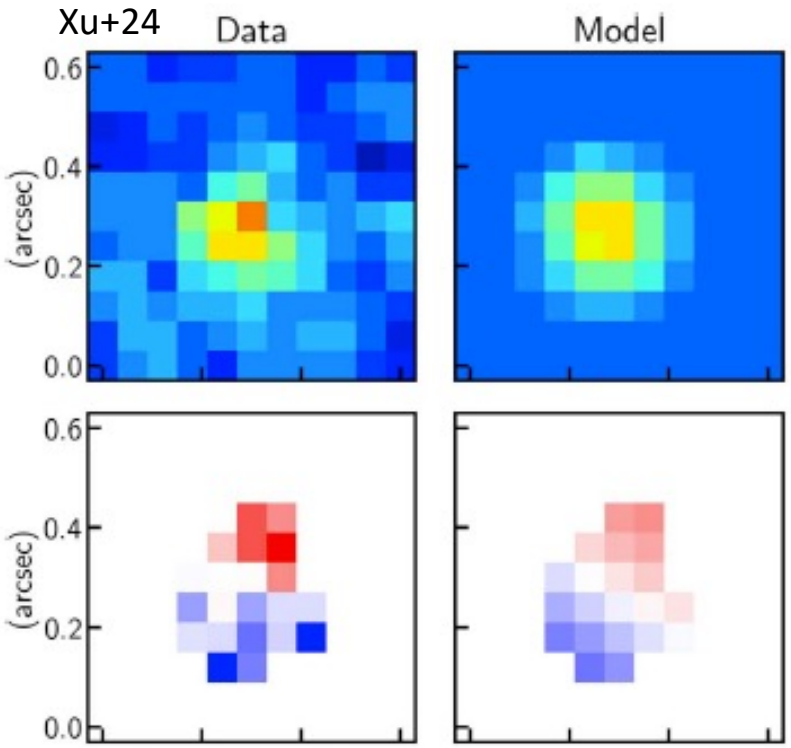
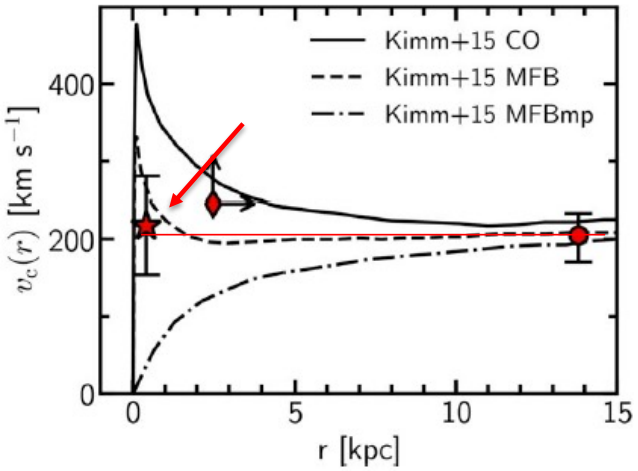
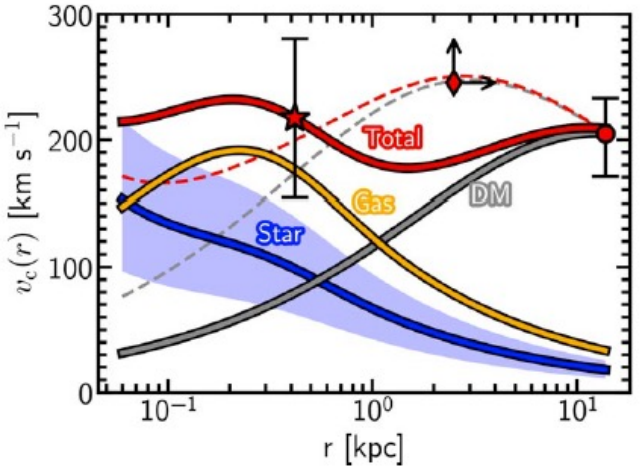
- Harikane,"JWST, ALMA, and Keck Spectroscopic Constraints on the UV Luminosity Functions at z~7-14: Clumpiness and Compactness of the Brightest Galaxies in the Early Universe",arXiv e-prints,2024
- Zhang,"Statistics for Galaxy Outflows at z~6-9 with Imaging and Spectroscopic Signatures Identified with JWST/NIRCam and NIRSpec Data",The Astrophysical Journal,970,2024
- Umeda,"JWST Measurements of Neutral Hydrogen Fractions and Ionized Bubble Sizes at z = 7-12 Obtained with Lya Damping Wing Absorptions in 27 Bright Continuum Galaxies",The Astrophysical Journal,971,2024
- Yanagisawa,"Balmer Decrement Anomalies in Galaxies at z~6 Found by JWST Observations: Density-bounded Nebulae or Excited H I Clouds?",The Astrophysical Journal,974,2024
- Yanagisawa,"Strong He I Emission Lines in High N/O Galaxies at z~6 Identified in JWST Spectra: High He/H Abundance Ratios or High Electron Densities?",The Astrophysical Journal,974,2024
- Zhu,"The Physical Origin of Extreme Emission Line Galaxies at High redshifts: Strong [OIII] Emission Lines Produced by Obscured AGNs",arXiv e-prints,2024
- Xu,"Dynamics of a Galaxy at z > 10 Explored by JWST Integral Field Spectroscopy: Hints of Rotating Disk Suggesting Weak Feedback",The Astrophysical Journal,976,2024
- Kusakabe,"The MUSE eXtremely Deep Field: Detections of circumgalactic Si II* emission at z>~2",Astronomy and Astrophysics,691,2024
- Nakane,"Low [O/Fe] Ratio in a Luminous Galaxy at the Early Cosmic Epoch (z > 10): Signature of Short Delay Time or Bright Hypernovae/Pair-instability Supernovae?",The Astrophysical Journal,976,2024
- Umeda,"SILVERRUSH. XIV. Lya Luminosity Functions and Angular Correlation Functions from ~20,000 Lya Emitters at z~2.2-7.3 from upto 24 deg^2 HSC-SSP and CHORUS Surveys: Linking the Post-Reionization Epoch to the Heart of Reionization",arXiv e-prints,2024
- Yanagisawa,"A Galaxy with an Extremely Blue UV Slope beta=-3 at z=9.25 Identified by JWST Spectroscopy: Evidence for a Weak Nebular Continuum and Efficient Ionizing Photon Escape?",arXiv e-prints,2024
- Fujimoto,"ALMA Lensing Cluster Survey: Deep 1.2 mm Number Counts and Infrared Luminosity Functions at z ≃ 1-8",The Astrophysical Journal Supplement Series,275,2024
- Nakajima,"EMPRESS. X. Spatially resolved mass-metallicity relation in extremely metal-poor galaxies: evidence of episodic star-formation fueled by a metal-poor gas infall",arXiv e-prints,2024
- Kageura,"Census of Lya Emission from ~600 Galaxies at z=5-14: Evolution of the Lya Luminosity Function and a Late Sharp Cosmic Reionization",arXiv e-prints,2025

など。→ このうちXu et al. (2024) とUmeda et al. (2024)の結果を紹介

中心部まで平坦な銀河回転曲線

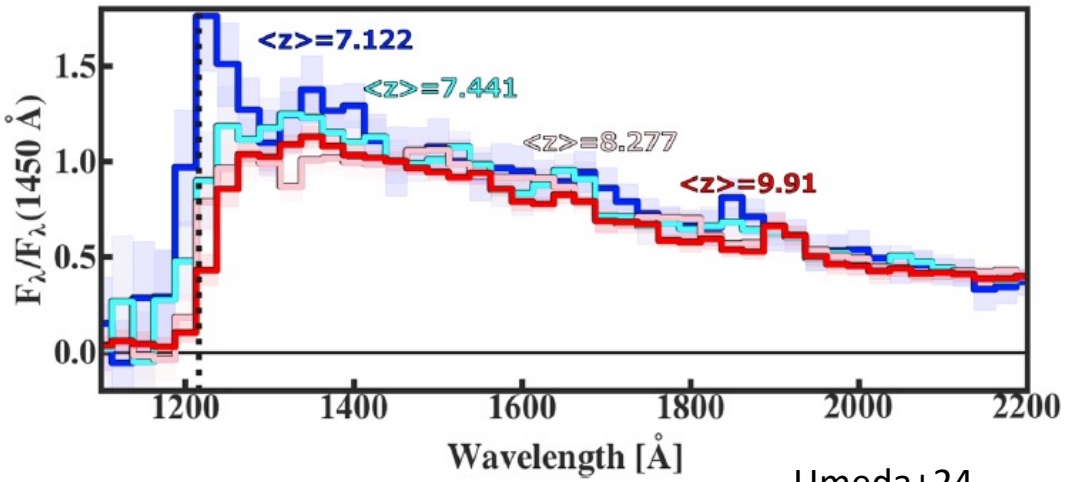




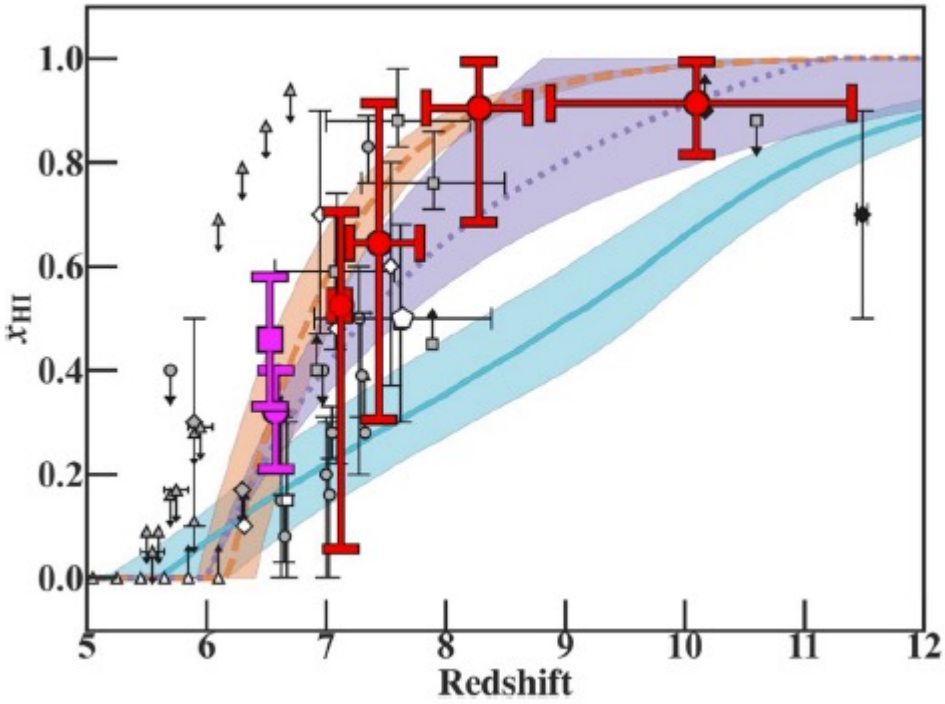


- 赤方偏移11 (宇宙年齢 400 Myr) の時代の高光度銀河GN-z11のJWST観測データを精査
  - 有意な速度勾配の検出(CIII]輝線) → V_{rot}=200km/s at ~0.4 kpc (V_{cir} at ~10kpcと同程度)
- 銀河中心付近での高速度の回転？
  - 暗黒物質では説明できないほど高密度。力学質量は10^9Mo (cf. BH質量10^6Mo)
  - バリオンが中心に集中する構造(弱いFeedbackの証拠？)

遅い宇宙再電離

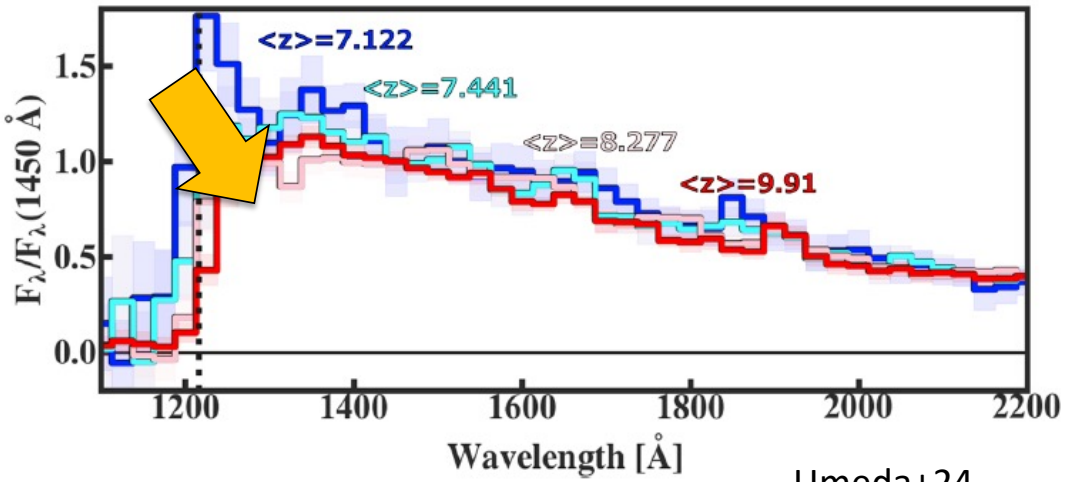


Umeda+24



- JWST観測：平均銀河スペクトル
  - 高赤方偏移(z)ほど強いLyα減衰翼吸収(1216A)→宇宙再電離
  - 宇宙再電離史（X_{HI}の進化)の初期(z>8)を初めて示す→全容が分かるように
  - z~8-10で高い中性水素割合X_{HI}の（90%程度)：z~8-10宇宙再電離初期
    - 宇宙再電離は遅い時代(z~6-8)に起こった→遅い宇宙再電離

遅い宇宙再電離



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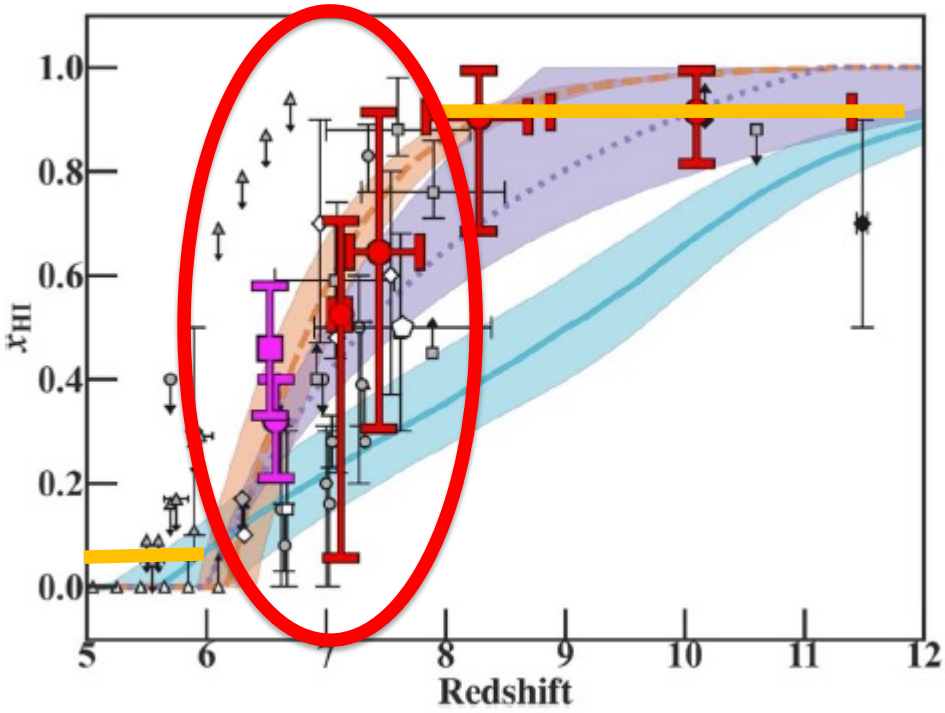

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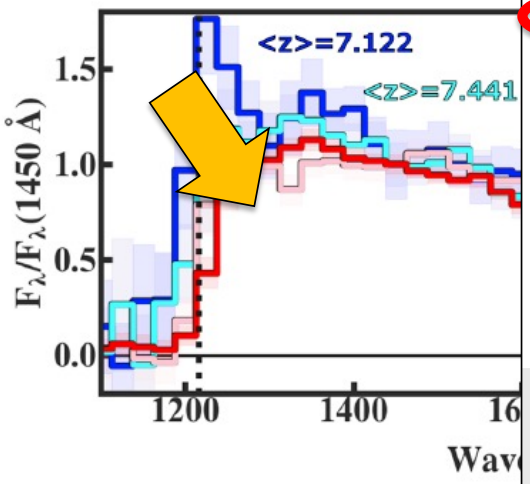
2024年出版の宇宙物理全論文(34,514編) のうちtop 0.2%



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JWST Measurements of Neutral Hydrogen Fractions and Ionized Bubble Sizes at z = 7–12 Obtained with Lyα Damping Wing Absorptions in 27 Bright Continuum Galaxies

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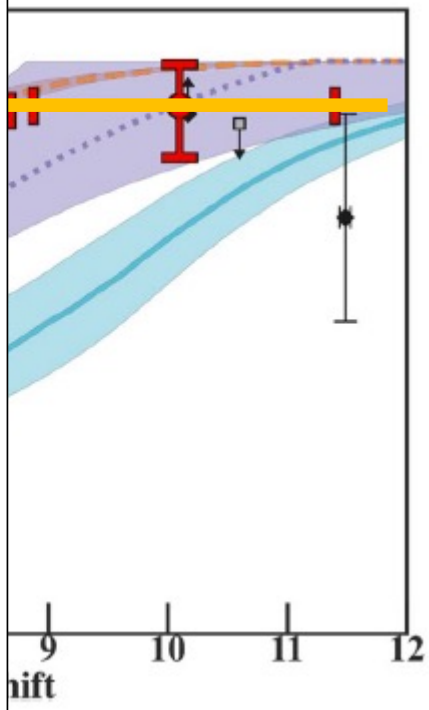
Umeda, Hiroya ; Ouchi, Masami ; Nakajima, Kimihiko ; Harikane, Yuichi ; Ono, Yoshiaki ; Xu, Yi ; Isobe, Yuki ; Zhang, Yechi

We present volume-averaged neutral hydrogen fractions $x_{H\,I}$ and ionized bubble radii R_b measured with Lyα damping wing absorption of galaxies at the epoch of reionization. We combine JWST/NIRSpec spectra taken by the CEERS, GO-1433, DDT-2750, and JADES programs and obtain a sample containing 27 bright UV-continuum (M_{UV} < -18.5 mag) galaxies at 7 < z < 12. We construct four composite spectra binned by redshift and find the clear evolution of the softening break toward high redshift at rest-frame 1216 Å, suggesting an increase of Lyα damping wing absorption. We estimate Lyα damping wing absorption in the galaxy spectra with realistic templates including Lyα emission and circumgalactic medium absorptions. Assuming the standard inside-out reionization picture having an ionized bubble with radius R_b around a galaxy embedded in the intergalactic medium with $x_{H\,I}$, we obtain $x_{H\,I}$ (R_b) values generally increasing (decreasing) from xHI=0.53-0.47+0.18 to 0.92-0.10+0.08 (logRb=1.67-0.16+0.14 to -0.69-0.24+0.89 comoving Mpc) at redshift 7.12-0.08+0.06 to 9.91-1.15+1.49 . The redshift evolution of $x_{H\,I}$ indicates a moderately late reionization history consistent with the one previously suggested from the electron scattering of cosmic microwave background and the evolution of UV luminosity function with an escape fraction f_{esc} ~ 0.2. Our R_b measurements suggest that bubble sizes could be up to a few dex larger than the cosmic average values estimated by analytic calculations for a given $x_{H\,I}$, while our R_b measurements are roughly comparable with the values for merged ionized bubbles around bright galaxies predicted by recent numerical simulations.



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まとめ

初期宇宙と天体形成
- すばる（HSC→PFS等)、ALMA, Roman, JWST宇宙望遠鏡などの大型望遠鏡と多数の研究者

１）中心部まで平坦な銀河回転曲線
- 赤方偏移11の銀河:有意な速度勾配
- 暗黒物質やBHでは説明できない
- バリオンが中心に集中する構造(弱いFeedbackの証拠？)

２）遅い宇宙再電離史
- 銀河平均スペクトルに強いLyα減衰翼吸収→z~8-10で高いX_{HI}（~90%)
- 宇宙再電離史（X_{HI}の進化)の全容を初めて示す
- 宇宙再電離はz~6-8に起こった（遅い再電離史）