

# OBSERVATIONAL EVIDENCE OF QUASAR FEEDBACK QUENCHING STAR FORMATION AT HIGH REDSHIFT

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M2

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# QSO feedback

- AGNからのlarge scale powerful outflow
- 母銀河のガスを温めることで星形成・ブラックホール降着を抑制
- 「銀河の育ち過ぎ」を防ぐために必要（近傍での銀河質量の上限値、楕円銀河のcolorやgas欠乏とconsistent）
- 現在、多くの銀河形成モデルに取り込まれている物理素過程
- モデルでは近傍よりhigh- $z$  ( $z \sim 2$ )で最もよく効くと考えられている（ $z \sim 2$ : QSOの活動性peak、大質量銀河の星形成が減少し始める）
- 間接的な証拠（統計的）はあるがいまだに直接的な証拠（個別の銀河内におけるQSOからのoutflowとそれによる星形成の抑制）はない

今回、面分光を用いて直接的な証拠を発見した

# Observation

- ▣ Instruments: VLT-SINFONI (NIR/H,K 面分光器)
- ▣ Target: 2QZ0028-28 (QSO at  $z = 2.401$ )
- ▣ key line:  $[\text{OIII}]\lambda 5007$  (from NLR、outflowの速度mapに使用)  
 $\text{H}\alpha + [\text{NII}]\lambda 6548, 6584$  (BLRからのbroad  $\text{H}\alpha$ 以外にnarrow  $\text{H}\alpha$   
 $[\text{NII}]$ 無=>星形成由来)

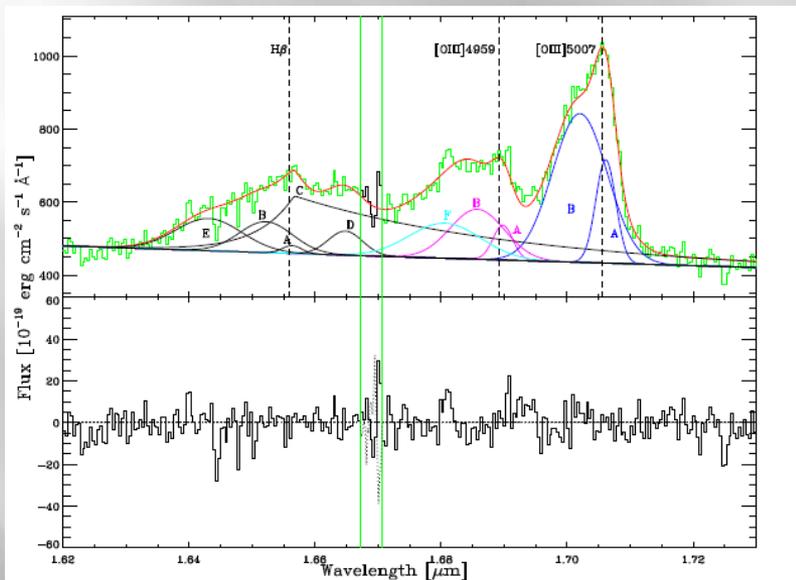


Fig. 1: Upper panel: 2QZ0028-28 H band spectrum extracted from the central 0.5 arcsec, along with the various components used for the fit (see Appendix A for details). Vertical dashed lines indicate the rest frame wavelength of each line, by taking the  $[\text{OIII}]\lambda 5007$  line peak for reference. Lower panel: Residuals of the fit. The green vertical lines enclose a the spectral zone affected by strong sky line residuals.

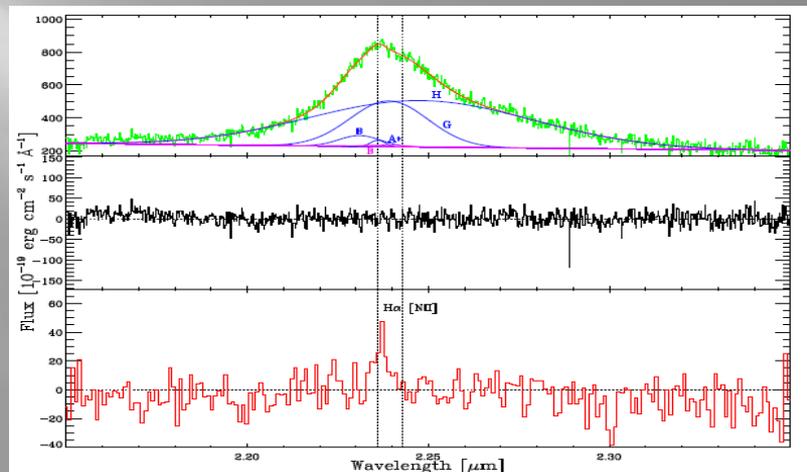


Fig. 3: Top panel: 2QZ0028-28 K-band spectrum extracted from the central arcsec, along with the various components used for the fit (blue are for  $\text{H}\alpha$  components, magenta are for  $[\text{NII}]$  lines of component B). Vertical dotted lines show the rest-frame wavelength for  $\text{H}\alpha$  and  $[\text{NII}]\lambda 6584$ , by using the same reference as in Fig. 1. Middle panel: Residuals of the fit. Bottom panel: Result of the subtraction between the spectrum extracted from the region with narrow  $\text{H}\alpha$  emission NW of the nucleus (Fig. 4) and the spectrum extracted from the region without narrow  $\text{H}\alpha$  emission, SE of the nucleus, after scaling the two spectra to match the intensity of the broad line. A clear narrow  $\text{H}\alpha$  component is detected, illustrating that the detection of this component and its distribution are not artifacts of the spectral fit.

# Results(1)[OIII] velocity map

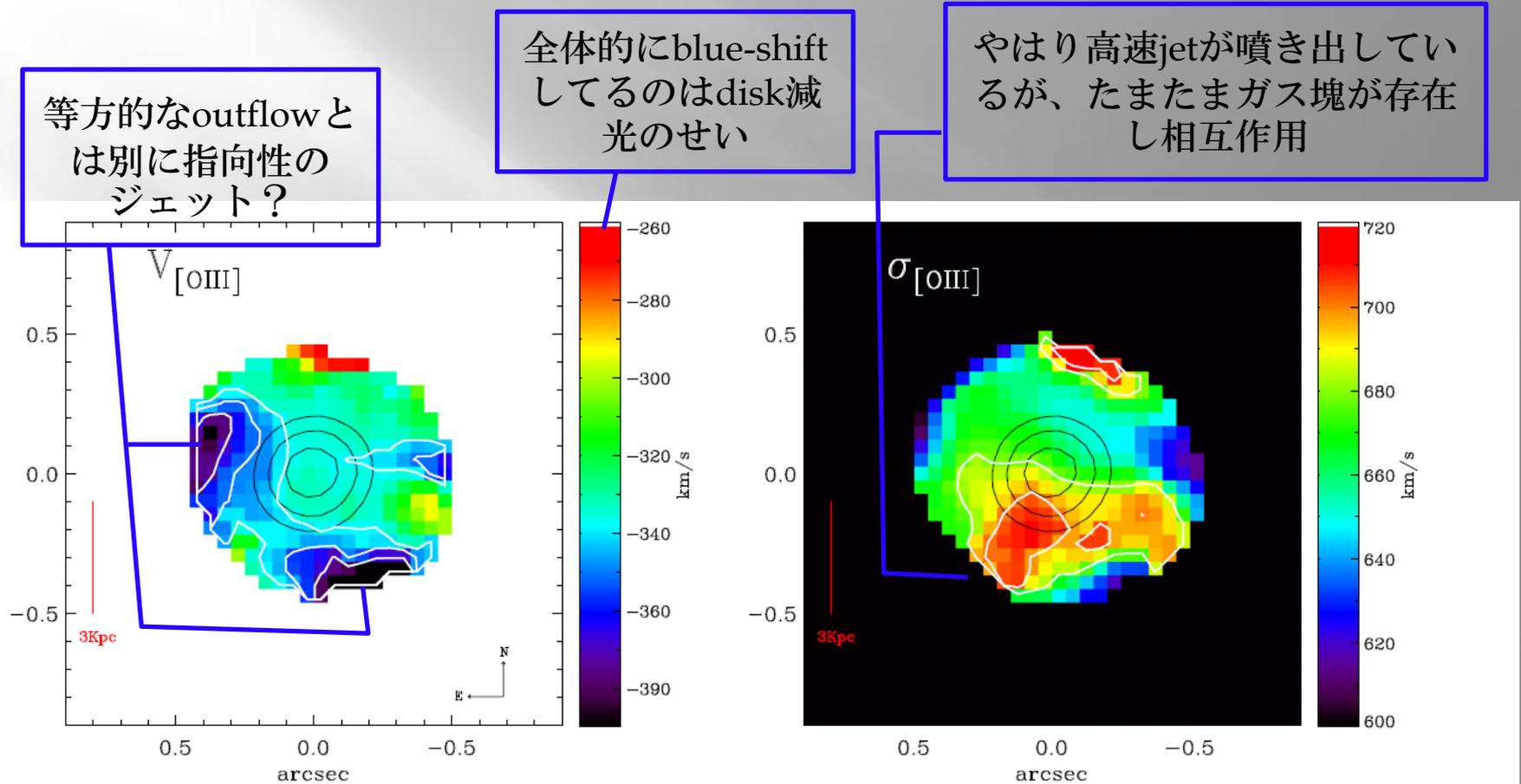


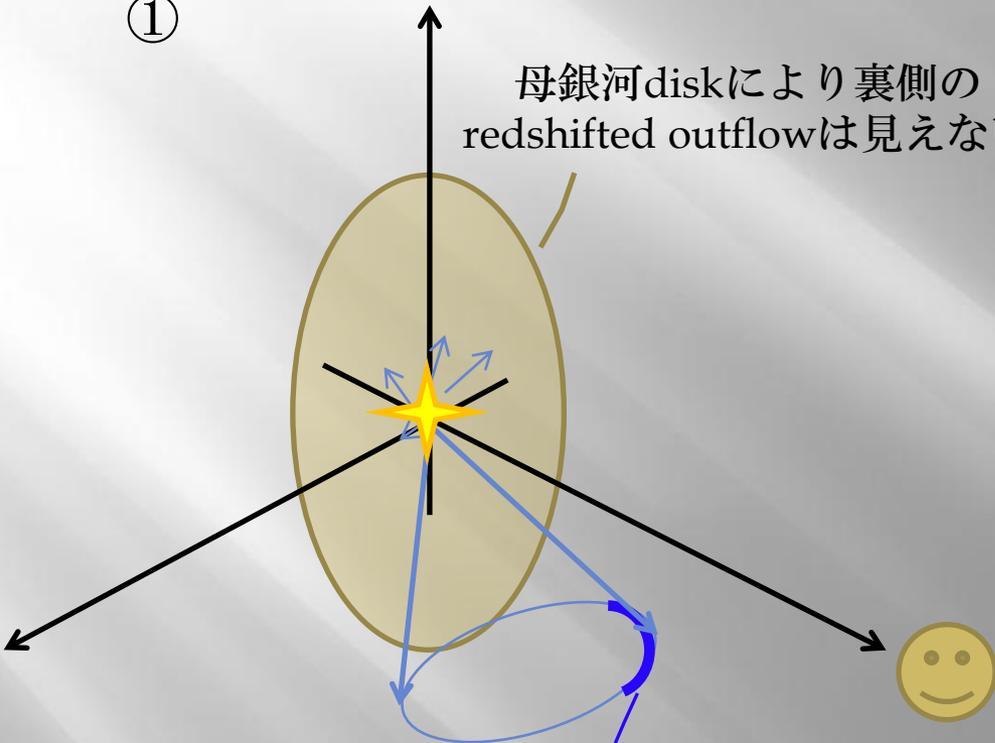
Fig. 2: Left panel: Velocity field (first moment map) of the [OIII] $\lambda$ 5007 line, showing the prominent excess of blueshifted gas with a bow-like morphology SE of the nucleus. White contours are at 330, 360, and 390 km/s. Right panel: Velocity dispersion (second moment map) of the [OIII] $\lambda$ 5007 line, showing the excess of dispersion in the SE region. White contours are at 680 and 700 km/s. In both maps the black contours trace the continuum.

# Results(1)[OIII] velocity map

- QSO driven outflow 3次元的にはこんなイメージか？  
*'bow-like, suggestive of the envelope of a strong conical outflow'*

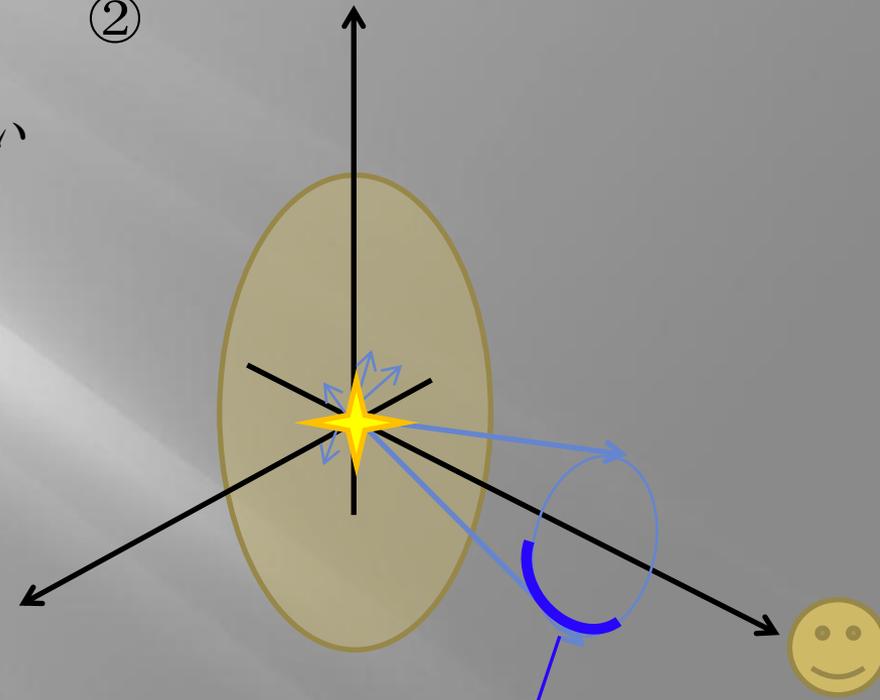
①

母銀河diskにより裏側の  
redshifted outflowは見えない



ここが一番blueshiftして見えてる  
(コーン軸は観測者方向からSE方向にズレてる)

②



$\frac{1}{4}$ コーン状のoutflow (コーン軸は観測者方向)

# Results(2) narrow H $\alpha$ Intensity map

[OIII] velocity mapでQSO drivenなoutflowジェットが噴き出している領域、特にジェットとgasが相互作用していると考えられる領域で星形成が確かに抑制されている

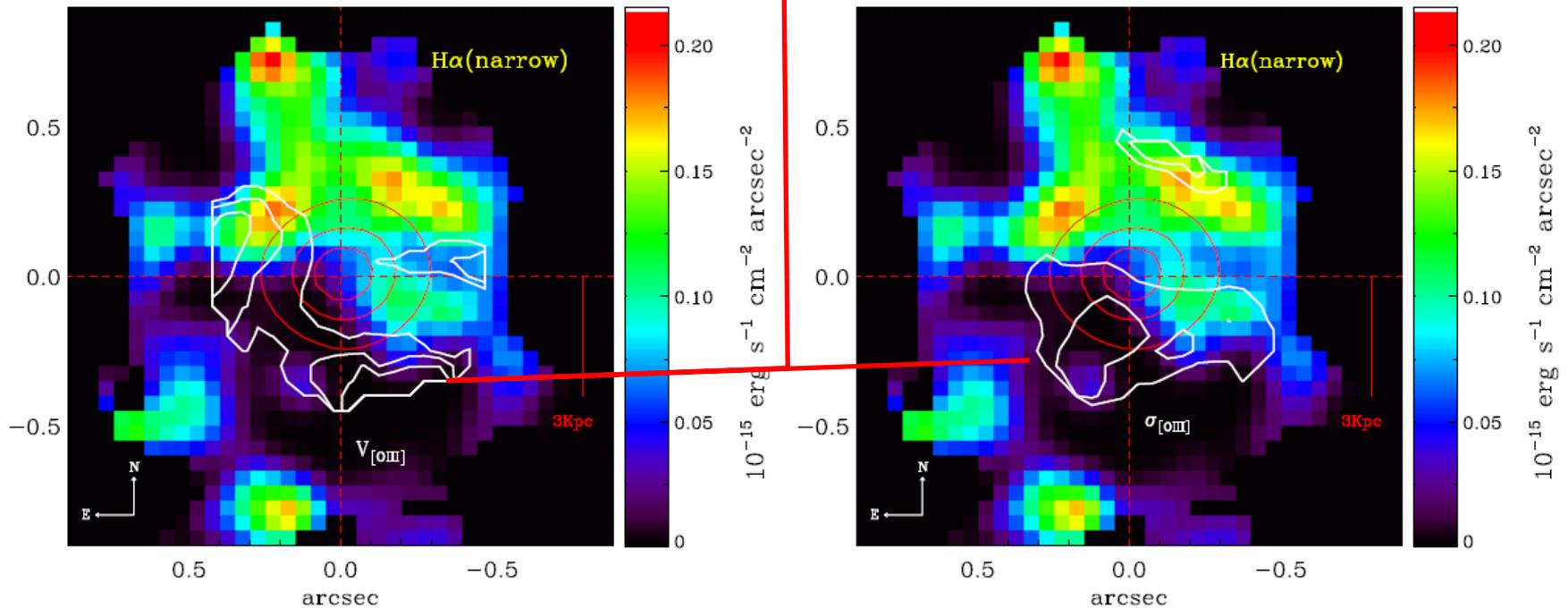


Fig. 4: Map of the narrow component of H $\alpha$  with contours tracing the [OIII] velocity shift (left panel) and velocity dispersion (right panel), as in Fig. 2. Star formation, traced by H $\alpha$ , is heavily suppressed in the SE region where the strongest outflow is traced by [OIII].

# Conclusion

- ▣ 面分光データのフィッティングから、QSOのNLR由来の[OIII]5007とdiskの星形成由来のnarrow H $\alpha$ を検出
- ▣ [OIII]速度map => QSO driven outflowを空間分解  
：S、E方向に指向性のジェット
- ▣ [OIII]速度分散map => disk rotationでなく outflow  
SE方向でジェットとdisk gasが強く相互作用
- ▣ narrow H $\alpha$ 強度map (= 銀河内の星形成空間map)  
=> outflowが強い（少なくとも中心から噴き出した時は）領域、特にgasと相互作用しているだろうSE方向で星形成が明らかに抑制
- ▣ 既存の銀河形成モデルで重要な物理プロセスであるAGNフィードバックをよく支持する初の直接的な観測証拠の一つ