

H α emission in the outskirts of galaxies at $z=0.4$

Rhythm SHIMAKAWA^{1,*†}, Masayuki TANAKA¹, Satoshi KIKUTA² and Masao HAYASHI¹

Abstract

This paper reports detections of H α emission and stellar continuum out to approximately 30 physical kpc, and H α directionality in the outskirts of H α -emitting galaxies (H α emitters) at $z = 0.4$. This research adopts narrow-band selected H α emitters at $z = 0.4$ from the emission-line object catalog by Hayashi et al. (2020), which is based on data in the Deep and Ultradeep layers of the Hyper Suprime-Cam Subaru Strategic Program. Deep narrow- and broad-band images of 8625 H α emitters across 16.8 deg² enable us to construct deep composite emission-line and continuum images. The stacked images show diffuse H α emission (down to $\sim 5 \times 10^{-20}$ erg s⁻¹ cm⁻² arcsec⁻²) and stellar continuum (down to $\sim 5 \times 10^{-22}$ erg s⁻¹ cm⁻² Å⁻¹ arcsec⁻²), extending beyond 10 kpc at stellar masses $> 10^9 M_{\odot}$, parts of which may originate from stellar halos. Those radial profiles are broadly consistent with each other. In addition, we obtain a dependence of the H α emission on the position angle because relatively higher H α equivalent width has been detected along the minor-axis towards galaxy disks. While the H α directionality could be attributed to biconical outflows, further research with hydrodynamic simulations is highly demanded to pin down the exact cause.

$z=0.4$ 銀河外縁部でのH α 輝線を初めて検出。

- 銀河外縁部はmerger history等の階層的構造形成の情報を残していると考えられ、outer diskやstellar haloの観測が多くなされてきた。
- 近傍ではSDSS fiberデータによって $r=100$ kpcに渡るH α 輝線が検出されているが、遠方ではまだ例が無い。
- HSC-SSP NB921のflux excessデータから $z=0.4$ H α (+[NII]) 輝線天体を選択し、stackingによりH α 画像とcontinuum画像を作成。
- $r>30$ kpcまで広がる成分を初めて検出。
 - 物理的起源の解明には多色データの情報やシミュレーションとの比較が必要。

Fig2: H α とcontinuumのradial profile. Mediumとhigh mass sampleではbulge + disk成分だけでは説明できないH α とstellar continuumが同じように外側まで広がっているのを ($z=0.4$ で) 初めて確認。

→outer diskやhaloの星 (hot young starsとold stars) によるものか?

Power law slopeは近傍銀河よりもflatterだがS/N的に議論は難しい。(haloは30kpcを境にしたbroken power lawだという研究もある。)

Fig 3: SFR(H α) radial profile. 下段は全成分に対するpower law成分の寄与。外側ほどpower law成分が卓越している。

Fig 4: PAを揃えてstackingした画像でのH α radial profile。極軸方向に大きなH α を確認。Outflowによるものかもしれないが、haloの寄与も考える。

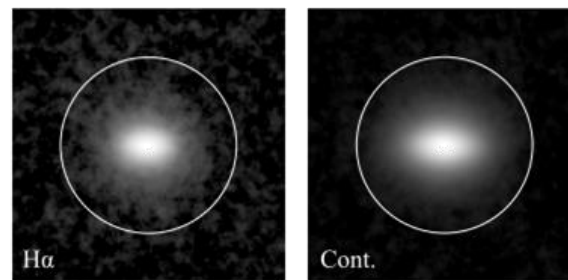


Fig. 5. The left and right panels show the composite H α (+[NII]) and continuum images of shape-aligned H α emitters (see section 4). The white circles depict the radius of 30 ph-kpc. Here they are stretched to a logarithmic scale to improve visibility.

H α 、continuumそれぞれを3成分でprofile fitting.
 - bulge成分: gaussian
 - disk成分: exponential
 - halo成分: power law

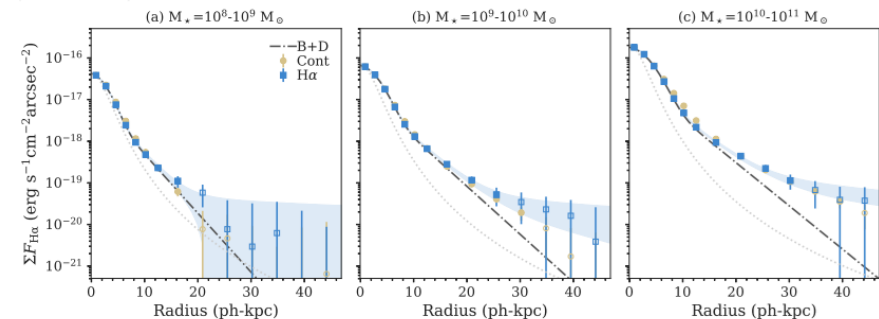


Fig. 2. Radial profiles of surface brightness of H α line emission (blue squares) and normalized stellar continuum (yellow circles) for H α emitters at $z = 0.4$. Less than 2σ detections are represented by the open symbols. The error-bars depict 1σ errors and the light-blue regions are 1σ errors of the curve fitting (see text). From the left to right, figures depict radial profiles for H α emitters with stellar masses of (a) 10^{8-9} , (b) 10^{9-10} , and (c) $10^{10-11} M_{\odot}$, respectively. The dotted curves indicate scaled radial profiles of the composite PSF (fitted by a Moffat distribution). The dot-dashed curves are the best-fit Gaussian+exponential radial profiles, which are expected to trace bulge+disk components of the H α emitters.

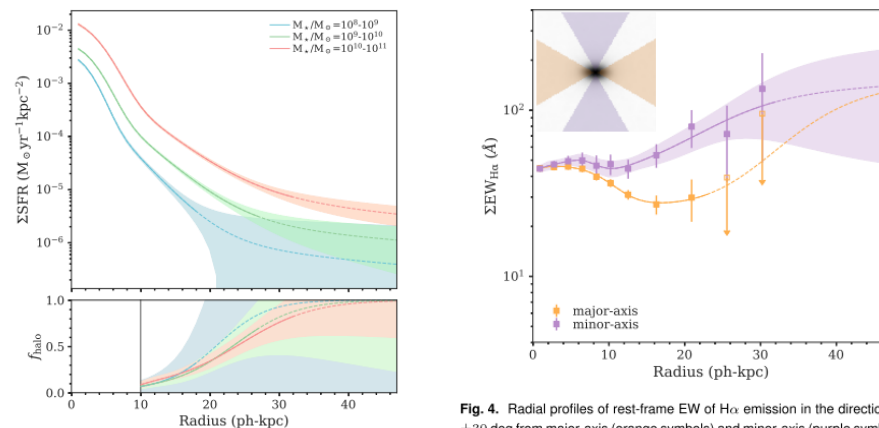


Fig. 3. (Top panel) Radial profiles of surface SFR densities of H α emitters in three stellar mass bins as in figure 1 and table 1 (blue: 10^{8-9} , green 10^{9-10} , and red: $10^{10-11} M_{\odot}$, respectively). (Bottom panel) Fractions of power law components to the best-fitted profiles (f_{halo}) in respective stellar mass bins at $r > 10$ ph-kpc. Non detection regions with $< 2\sigma$ are extrapolated by the best-fitted curves (dashed curves).

Fig. 4. Radial profiles of rest-frame EW of H α emission in the directions of ± 30 deg from major-axis (orange symbols) and minor-axis (purple symbols), respectively. An image illustration of the areas used in the stacking analysis is denoted at the upper left corner. The error-bars and color-filled regions represent 1σ errors. The open symbols indicate 2σ upper limits. The dashed curves depict extrapolated lines of the best-fitted models. The gray region indicates the standard deviations of non-aligned EW $_{\text{H}\alpha}$ profile based on 100 composite images with random rotation.