Spatially-unresolved SED fitting can underestimate galaxy masses: a solution to the missing mass problem

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We perform spatially-resolved, pixel-by-pixel SED fitting on galaxies up to $z \sim 2.5$ in the Hubble Extreme Deep Field (XDF). Comparing stellar mass estimates from spatially resolved and spatially unresolved photometry we find that unresolved masses can be systematically underestimated by factors of up to 5. The ratio of the unresolved to resolved mass measurement depends on the galaxy's specific star formation rate (sSFR): at low sSFRs the bias is small, but above sSFR $\sim 10^{-9.5}$ yr^{-1} the discrepancy increases rapidly such that galaxies with sSFRs $\sim 10^{-8}$ yr^{-1} have unresolved mass estimates of only one half to one fifth of the resolved value. This result indicates that stellar masses estimated from spatially-unresolved datasets need to be systematically corrected, in some cases by large amounts, and we provide an analytic prescription for applying this correction. We show that correcting stellar mass measurements for this bias changes the normalization and slope of the star-forming main sequence and reduces its intrinsic width; most dramatically, correcting for the mass bias increases the stellar mass density of the Universe at high redshift and can resolve the long-standing discrepancy between the directly-measured cosmic star formation rate density at $z \gtrsim 1$ and that inferred from stellar mass densities ("the missing mass problem").

空間分解の度合いによって銀河の星質量推定は影響されるか？

- HSTデータを用いて、pixel-by-pixelでSED fittingして、星質量を算出。
- それを銀河全体でのSED fittingから求めた星質量と比較。
- →銀河全体で求めた星質量は空間分解して積算した値よりも小さめに出る。
  - 特にhigh sSFR銀河で。→ high-zで顕著になる。

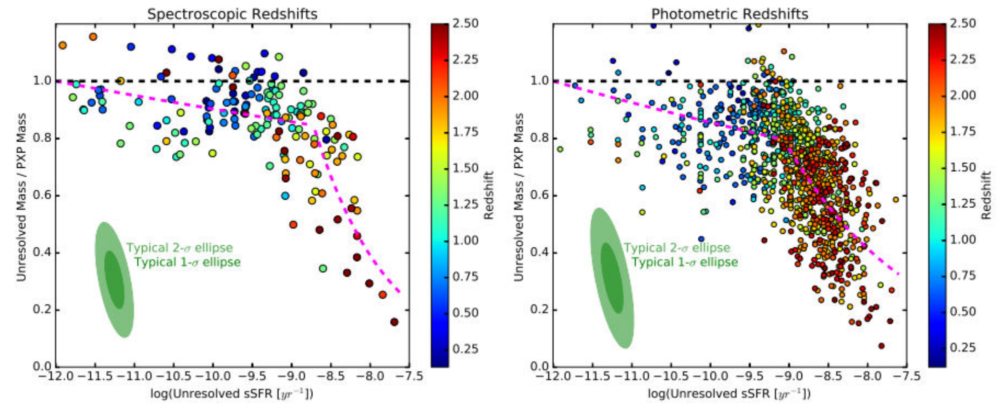

Figure 2. Ratio of the median unresolved mass estimate and the median pixel-by-pixel mass estimate as a function of specific star formation rate for galaxies in the XDF with spectroscopic redshifts (left) and photometric redshifts (right). Points are colored based on their redshift. The horizontal black dashed line shows where the two mass estimates are equal. The magenta dashed line shows a broken power law fit to the data to demonstrate the two regime behavior.

Outshining：
低分解能やbinningにより低質量星の寄与が埋もれて、SED fittingがOB型星 (小M/L) に偏ってしまう効果。

空間分解の有無によるMsの比較。
High sSFRで違いが顕著。

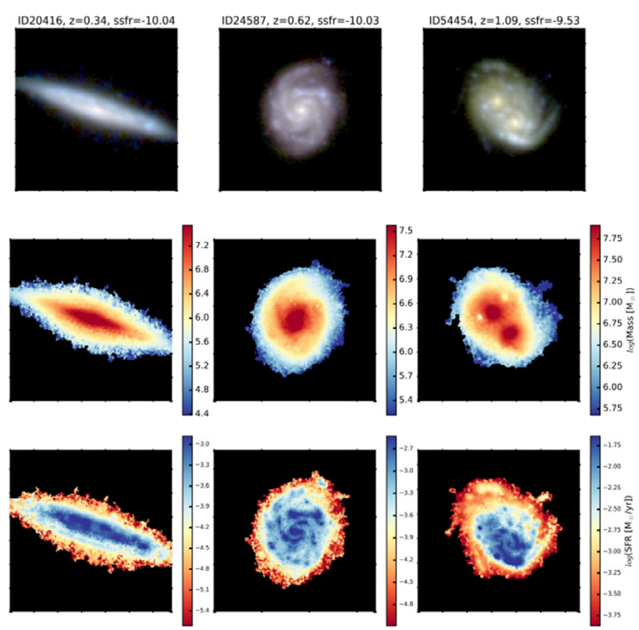

Figure 1. Two-dimensional maps of three representative XDF galaxies created using our model SED template set. From top to bottom we show false-color images in approximately rest-frame *ugr*, logarithmic stellar mass maps, and logarithmic SFR maps. The galaxies have, from left to right, RA = {53.1712061°, 53.1699419°, 53.14785833°}, Dec = {−27.81471020°, −27.7710194°, −27.77403611°}, z_{spec} = {0.337, 0.622, 1.088}, and $\log(M_*/M_\odot)$ = {10.3, 10.7, 10.9} where the mass measurement is the median pixel-by-pixel mass from our final catalog.

Spatially-resolved Ms and SFR distribution

Fig2の違いを補正した場合の、
銀河全体でのMain sequence。

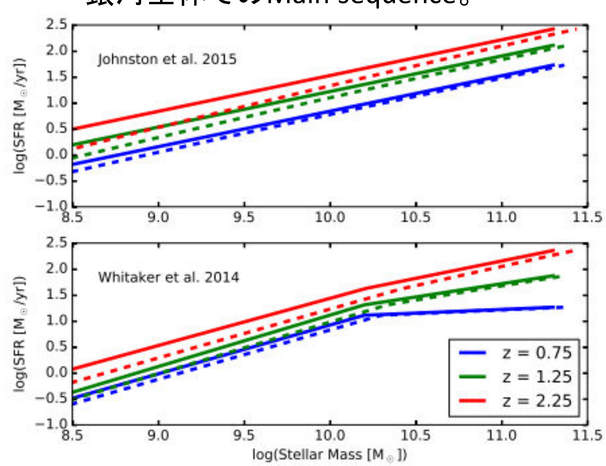

Figure 10. Corrections to previously published star-forming main sequence relations at various redshifts made using our piecewise fit to the XDF (z_s + z_p) galaxies. The top panel shows relations from Johnston et al. (2015) and the bottom panel those of Whitaker et al. (2014). The solid lines show the original relationships, and the dashed lines the corrections based on this work. The blue, green, and red colors show redshift 0.75, 1.25, and 2.25 respectively.

補正を加えると、星形成率密度進化
ともよく合うようになる。

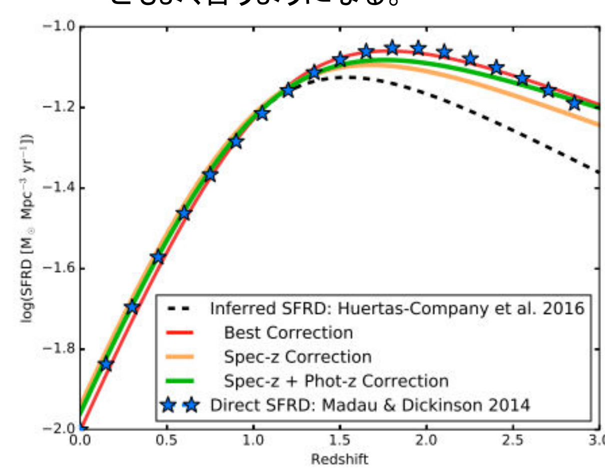

Figure 12. Corrections to the observed cosmic star-formation history. The dashed black line shows the SFRD curve inferred from the observed stellar mass density (we show the results of Huertas-Company et al. (2016)), and the solid colored lines the corrected values based on our work. The corrections bring the inferred SFRD into much better agreement with the direct observations of the SFRD compiled by Madau & Dickinson (2014), shown as the blue stars