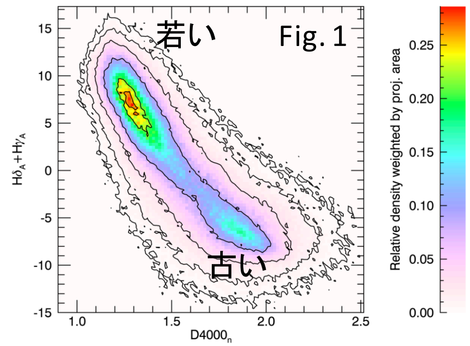
# Resolving the age bimodality of galaxy stellar populations on kpc scales　　Zibetti et al. MNRAS accepted


**ABSTRACT**

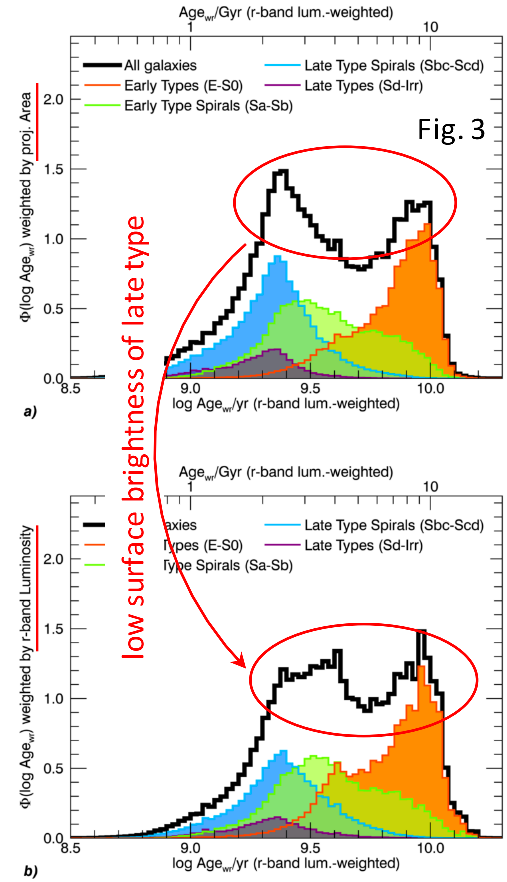
Galaxies in the local Universe are known to follow bimodal distributions in the global stellar populations properties. We analyze the distribution of the local average stellar-population ages of 654 053 sub-galactic regions resolved on ∼ 1-kpc scales in a volume-corrected sample of 394 galaxies, drawn from the CALIFA-DR3 integral-field-spectroscopy survey and complemented by SDSS imaging. We find a bimodal local-age distribution, with an old and a young peak primarily due to regions in early-type galaxies and star-forming regions of spirals, respectively. Within spiral galaxies, the older ages of bulges and inter-arm regions relative to spiral arms support an internal age bimodality. Although regions of higher stellar-mass surface-density, $\mu_*$, are typically older, $\mu_*$ alone does not determine the stellar population age and a bimodal distribution is found at any fixed $\mu_*$. We identify an "old ridge" of regions of age ∼ 9 Gyr, independent of $\mu_*$, and a "young sequence" of regions with age increasing with $\mu_*$ from 1–1.5 Gyr to 4–5 Gyr. We interpret the former as regions containing only old stars, and the latter as regions where the relative contamination of old stellar populations by young stars decreases as $\mu_*$ increases. The reason why this bimodal age distribution is not inconsistent with the unimodal shape of the cosmic-averaged star-formation history is that *i*) the dominating contribution by young stars biases the age low with respect to the average epoch of star formation, and *ii*) the use of a single average age per region is unable to represent the full time-extent of the star-formation history of "young-sequence" regions.



**Key words:** galaxies:stellar content – galaxies: structure – galaxies:statistics

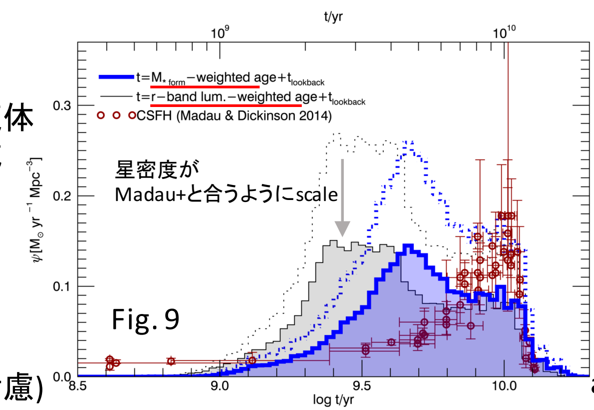




空間分解しても、bimodalityあり
✓ SFMSとred sequence




## sample

- CALIFA(fiber IFU, 3400-7150A)で観測されたz=0.005-0.03の394天体
- smoothingをかけて広い範囲(>1 $R_{eff}$?)で各spaxelのSN>10を達成
  - 657,423 spaxel
  - 有効空間分解能 : 2.57"、平均1kpc
  - SDSS画像も同じ空間分解能へsmoothing




- SED fitting
  - Zibetti+09のspectral library (Chabrier IMF, BC03, AGBを考慮)
  - $SFR(t) = \frac{t}{\tau}\exp\left(-\frac{t^2}{\tau^2}\right) + \delta(t)$ : random burst
  - $Z(M(t)) = Z_{final} - (Z_{final} - Z_0)\left(1 - \frac{M(t)}{M_{final}}\right)^{\alpha}$ , $\alpha > 0$

age分布のpeakは
- late-type : log(age)=9.4
- early-type: log(age)=10.0
- early-type spiral : log(age) =9.6, 9.8の2つ
  - armとbulge/inter arm

mass-weighted age

$$\mathrm{Age}_{\mathrm{M_*\text{-}w.}} = \frac{\int_{t=0}^{t_0} dt\ (t_0 - t)\ \mathrm{SFR}(t)}{\int_{t=0}^{t_0} dt\ \mathrm{SFR}(t)} = \frac{\int_{t=0}^{t_0} dt\ (t_0 - t)\ \mathrm{SFR}(t)}{\mathrm{M}_{*\ \mathrm{formed,tot}}}$$

単位時間あたりの、新たに誕生した全ての星のluminosity

light-weighted age (r-band)

$$\mathrm{Age}_{\mathrm{l.\text{-}w.}} = \frac{\int_{t=0}^{t_0} dt\ (t_0 - t)\ \mathrm{SFR}(t)\ \mathscr{L}'(t)}{\int_{t=0}^{t_0} dt\ \mathrm{SFR}(t)\ \mathscr{L}'(t)}$$

$$\mathscr{L}'(t) = \int_{Z_{*\,\mathrm{min}}}^{Z_{*\,\mathrm{max}}} dZ_* \int_{\tau_{\mathrm{eff,min}}}^{\tau_{\mathrm{eff,max}}} d\tau_{\mathrm{eff}}\ f(t, \tau_{\mathrm{eff}}, Z_*)\ \mathscr{L}(t_0 - t, Z_*(t))\ e^{-\tau_{\mathrm{eff}}(t, Z_*)} \quad (6)$$

単位時間あたりの、新たに誕生した星の単位質量あたりのluminosity

t = age + lookback time : z=0でのage
age bin以内の時間で星形成が完結すると仮定
Hαなどで直接測定したCSFHと大きく異なる → 上の仮定は間違い
- 若い/古い領域への古い/若い成分のコンタミが原因
- ageがmixされて極端に若い/古いageは得られなくなる
- SFHが完全にわかれば解消できる