Two-phase Formation of Elliptical Galaxies

Some observation of Phase II

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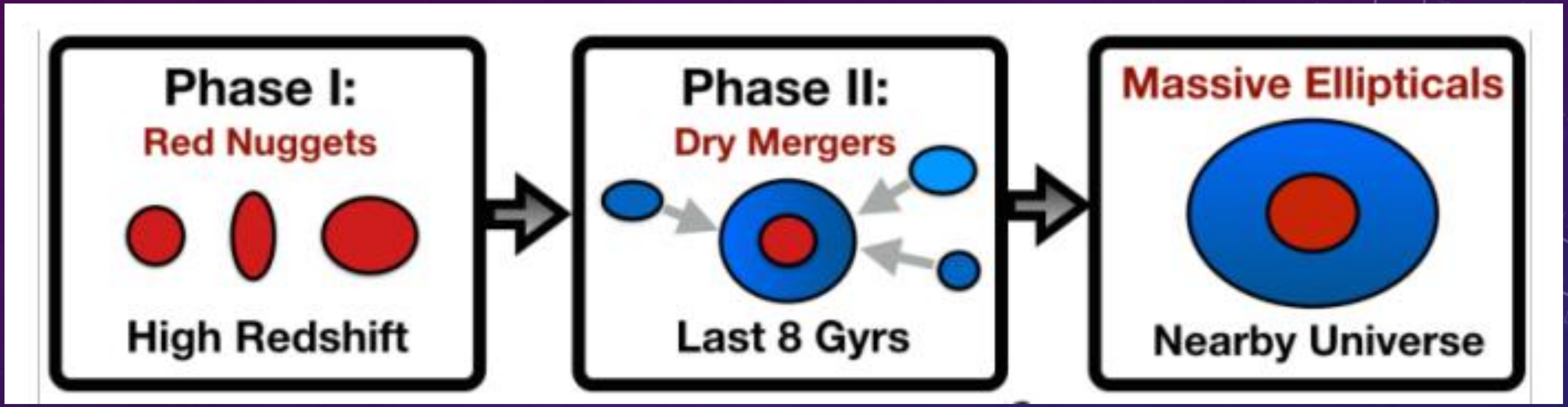
Some observation of Early Type Galaxy (ETG)

- 高红移ETG比同质量的低红移ETG更加致密 (Daddi et al. 2005; Trujillo et al. 2006)
- Z~2至今，ETG的恒星质量增长2倍，尺度增长3~5倍 (Buitrago et al. 2008; van Dokkum et al. 2010)
- Inside-out模式增长: ETG的中心部分随z变化保持不变，外层部分随着z变小而增长 (van Dokkum et al. 2010)
- 近邻ETG颜色负梯度：中心的成分更红 (Kormendy & Djorgovski 1989) => intense in-situ star formation的标志

Two-phase formation scenario



- Phase I：独立的恒星形成过程使气体全部消耗，形成早期的ETG
- Phase II：早期ETG通过并合同样没有气体的小质量ETG实现增长 (Oser et al. 2010)

- 近邻ETG包括两个成分，早期形成的核心 + 吸积卫星星系形成的外壳
- 两个成分应该具有不同的观测特点

Surface brightness profile Fitting of ETG

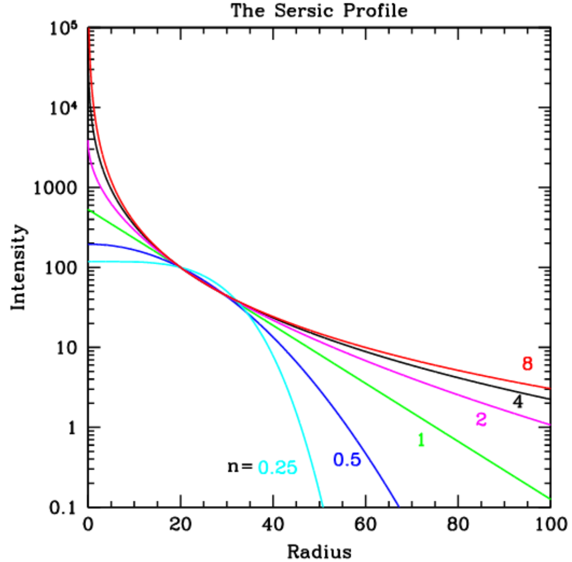
- Sersic Profile

The surface brightness profile of spheroidal galaxies is generally well fit by the Sérsic profile (Sérsic, 1968), or $R^{1/n}$ profile,[1]

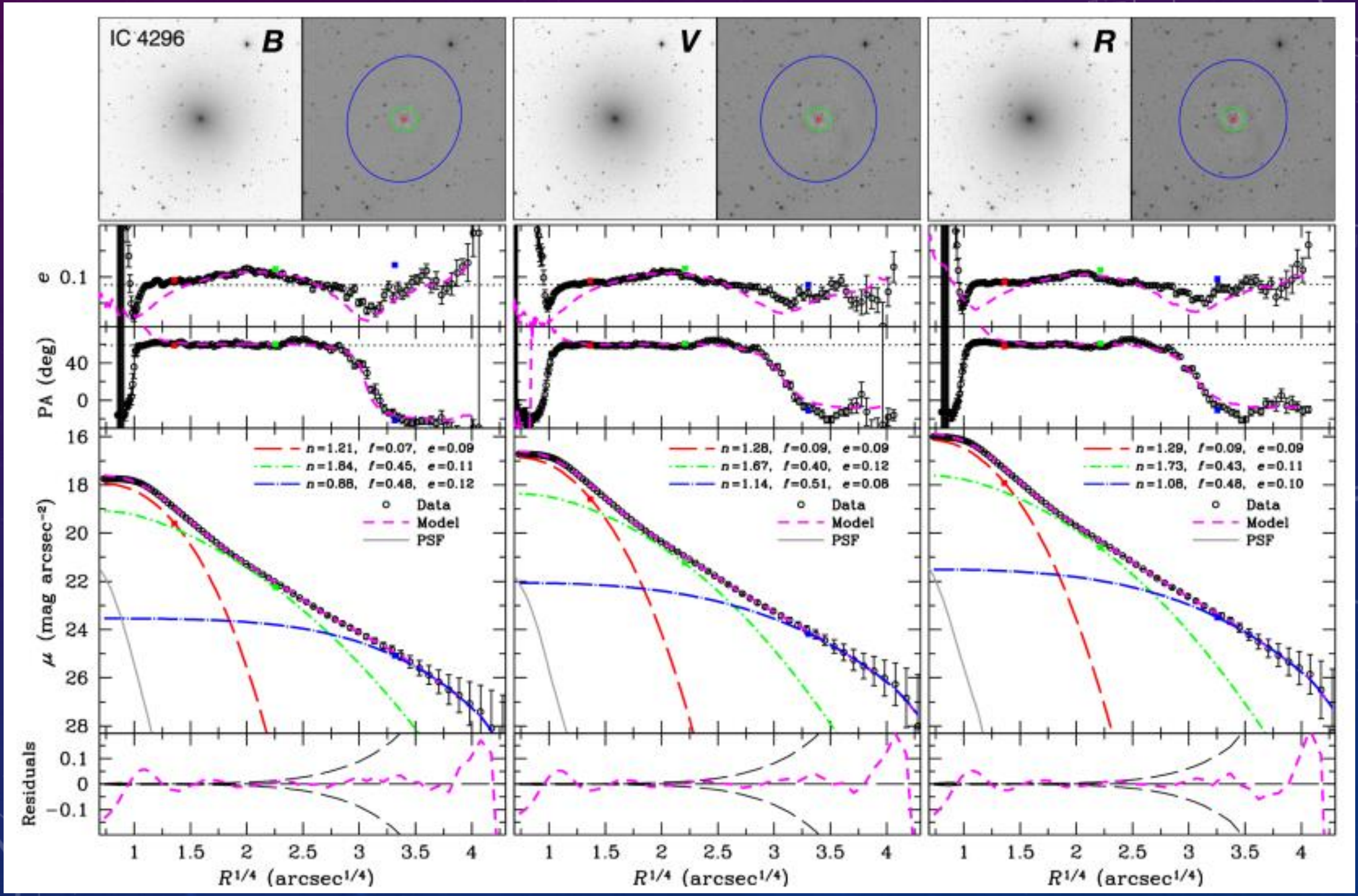
$$I(R) = I_0 \exp\left[-\beta_n \left(\frac{R}{R_e}\right)^{1/n}\right] = I_e \exp\left[-\beta_n \left\{\left(\frac{R}{R_e}\right)^{1/n} - 1\right\}\right], \tag{2.22}$$

where I_0 is the central surface brightness, n is the so-called Sérsic index which sets the concentration of the profile, R_e is the effective radius that encloses half of the total light, and $I_e = I(R_e)$.

- 盘星系，n=1；椭圆星系，n=4
- 随着测光精度的提高，de Vaucouleurs ¼ law不适用
- 对椭圆星系，2.5 < n < 10 (e.g. Kormendy et al. 2009)

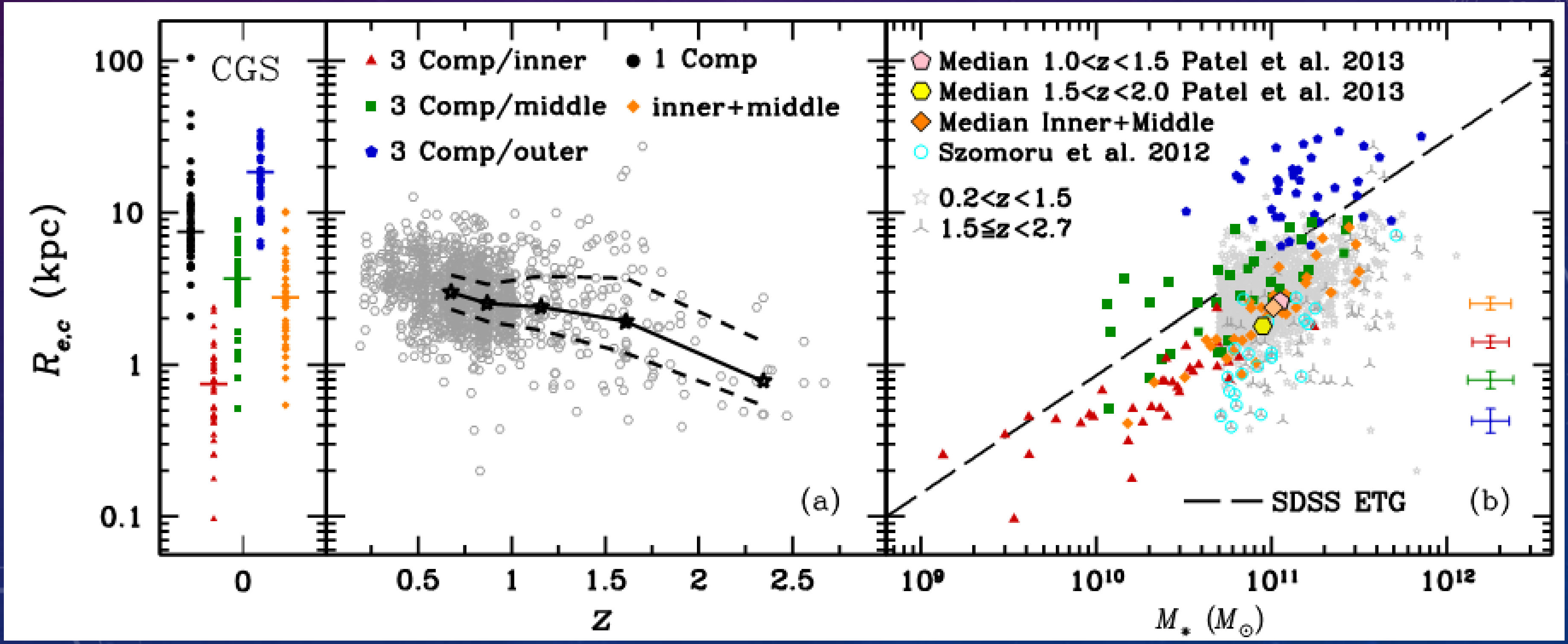


Multi-component Fitting of ETG

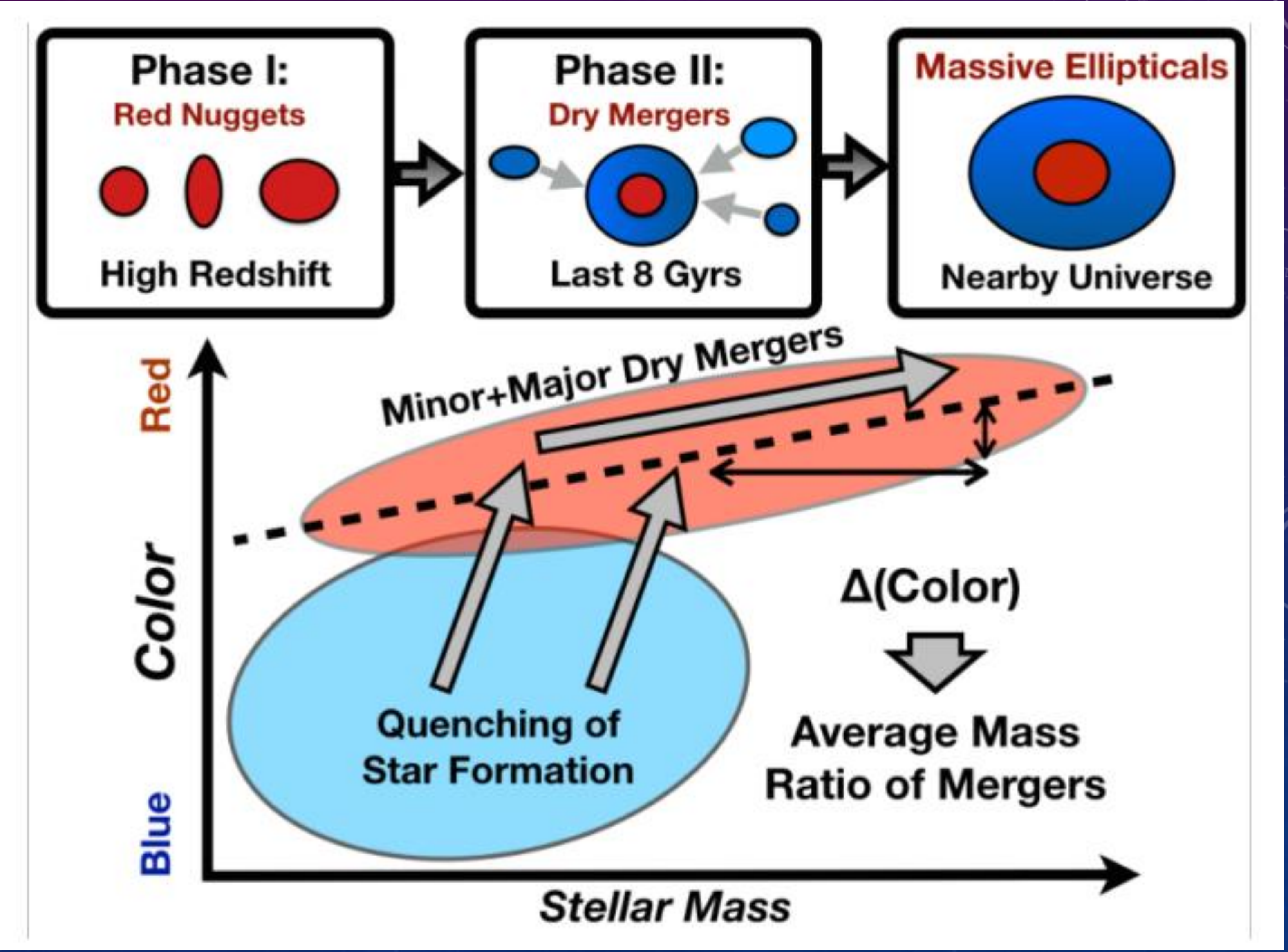


Stellar mass – size relation

- 在M-R图上，Inner+middle component 和 z~1 的ETG具有相同的位置
- Inner+middle是高红移ETG的遗迹
- Outer可能是之后dry minor merge的结果



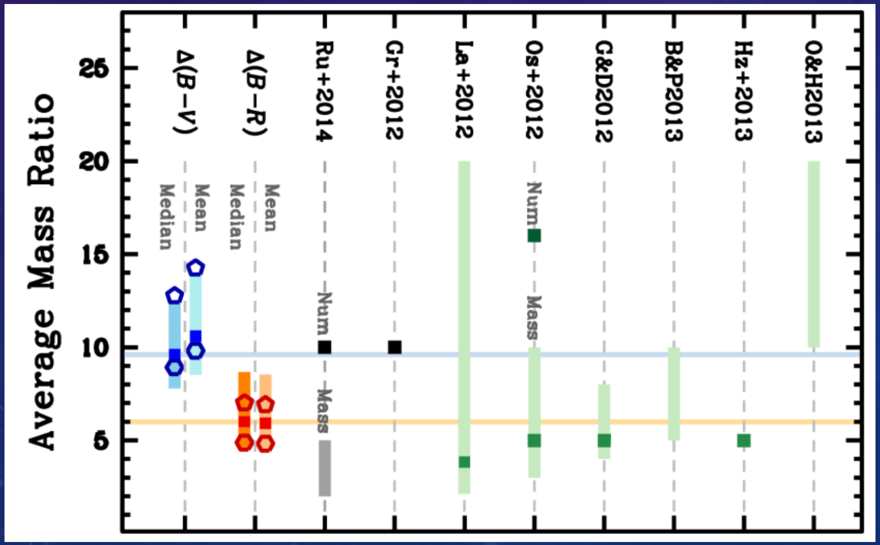
Stellar mass – color relation => Mass ratio of mergers

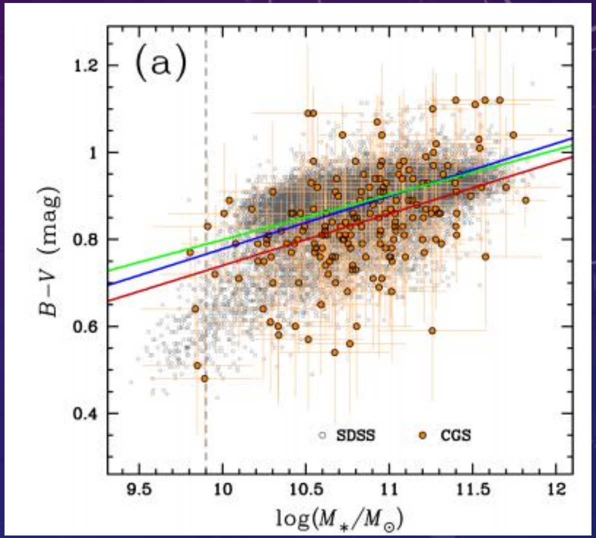


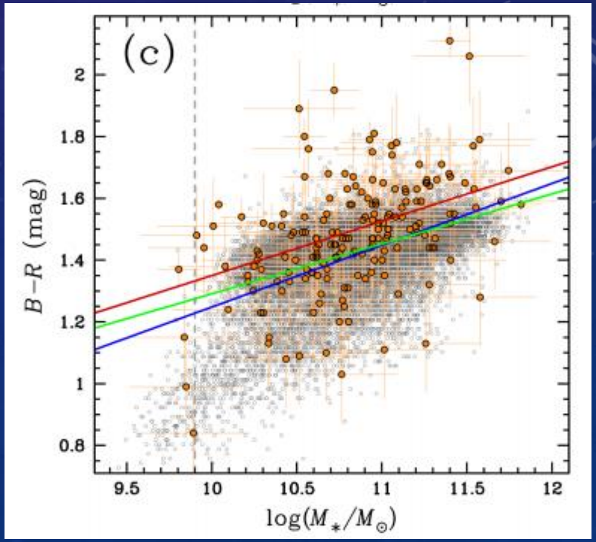
Stellar mass – color relation => Mass ratio of mergers

- 两条假设
  - Two-phase formation scenario
    - 并合过程是dry minor mege
    - 并合前，所有星系停止恒星形成
  - Stellar mass – color relation

$$\langle \text{Mass Ratio} \rangle = M_{*,\text{core}} / \langle M_{*,\text{sat}} \rangle = 10^{(\langle \text{Color}_{\text{inner}} \rangle - \langle \text{Color}_{\text{outer}} \rangle)/\beta},$$







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