The Effectiveness of Utilizing Bayesian Statistics in Estimates of Galaxy Cluster Stellar Mass

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Background

- Star formation history and spectral energy distribution are inherently linked.
  - Relatively simple relationships exist between the various parameters of the star formation history
  - Current techniques for measuring stellar mass involve utilizing star formation history to infer the stellar mass based on other parameters.
  - Conroy’s annual review (2013), as well as Simha et al April 2014

Bayesian Statistics

- Bayesian Statistics vs. Sampling Theory Statistics:
  - Sampling Theory Statistics attempts to find a “best fit”, which most closely mirrors the data.
  - Bayesian statistics is defined by trying to solve for a model parameter given the data. Main objective is “Most likely fit”, given what we know.

Bayesian Statistics

- Bayes' Theorem:

$$P(\bar{\theta}|D,M) = \frac{P(D|M,\bar{\theta})P(\bar{\theta}|M)}{P(D|M)}$$

$P(\bar{\theta}|D,M)$ = Posterior

$P(D|M,\bar{\theta})$ =Likelihood

$P(\bar{\theta}|M)$ =Prior

$P(D|M)$ =Evidence

Bayesian Statistics

- "Marginalizing over the posterior distribution of D":

$$P(D|M_k) = \int P(D|M_k, \bar{\theta}_k)P(\bar{\theta}_k|M_k)\mathrm{d}\bar{\theta}_k$$

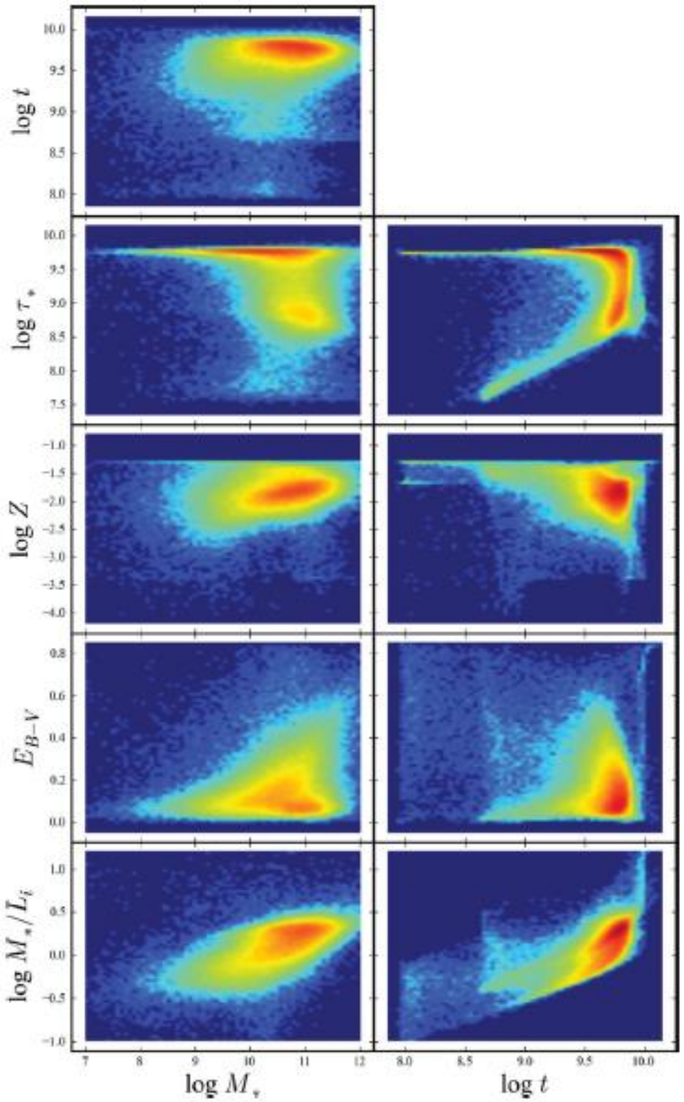
- This is not completely intuitive, but it essentially works out to be a weighted average.

$P(D|M, \bar{\theta})$ =Likelihood

$P(\bar{\theta}|M)$ =Prior

$P(D|M)$ =Evidence

Measuring Stellar Masses of Galaxies

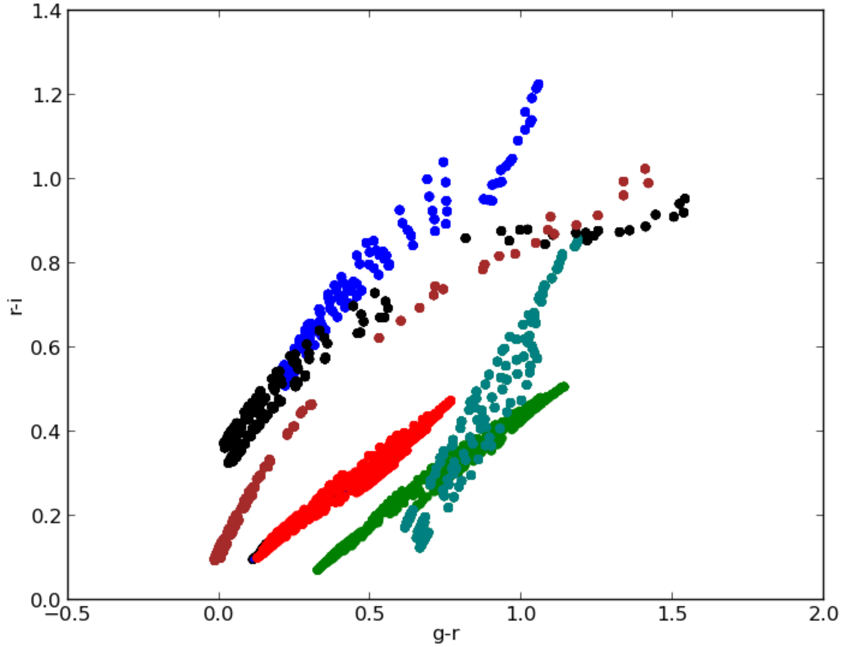


- Borrowing from Taylor et al.
- Its possible to see the ways each parameter uniquely impacts the universe of models
- Metallicity, starting time, truncation, and tau are the parameters in Simha et al

Background

- Created a universe of models based off of Conroy's FSPS and Simha et al.'s four parameter SFH model

$$\mathrm{SFR}(t) = \begin{cases} A(t-t_i)e^{-(t-t_i)/\tau} & \text{for } (t \leq t_{\text{trans}}) \\ \mathrm{SFR}(t_{\text{trans}}) + \Gamma(t - t_{\text{trans}}) & \text{for } (t > t_{\text{trans}}). \end{cases}$$



Redshift Values:
Blue = .38
Red = .447
Green = .587
Teal = .812
Dark Blue = 1.059
Black = 1.331
Brown = 1.528

Background

- Given this weighting, it is possible to compute the expected mass to light ratio, thus making it possible to compute mass.

$$P(\Delta|D) = \sum_k P(\Delta|D, M_k) P(M_k|D).$$

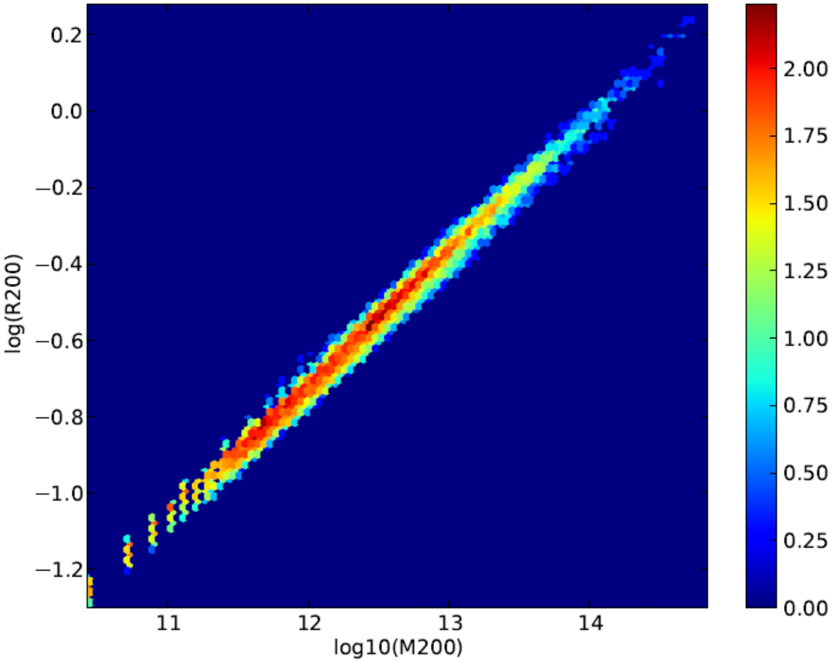
$$P(M_k|D) = \frac{P(D|M_k)P(M_k)}{\sum_k P(D|M_k)P(M_k)}$$

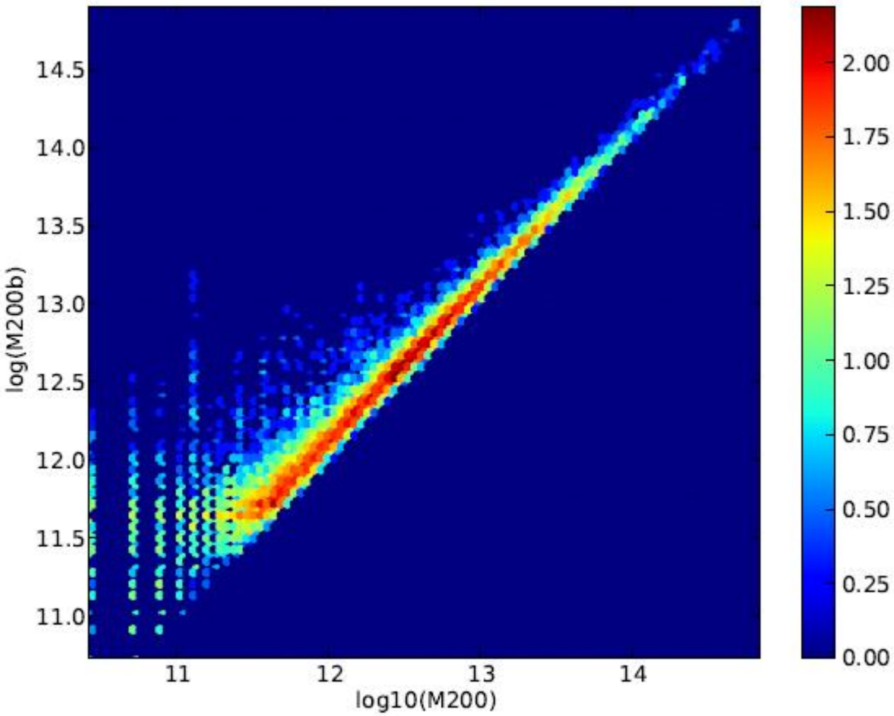
$P(\bar{\theta}|D, M)$ = Posterior

$P(\bar{\theta}|M)$ =Prior

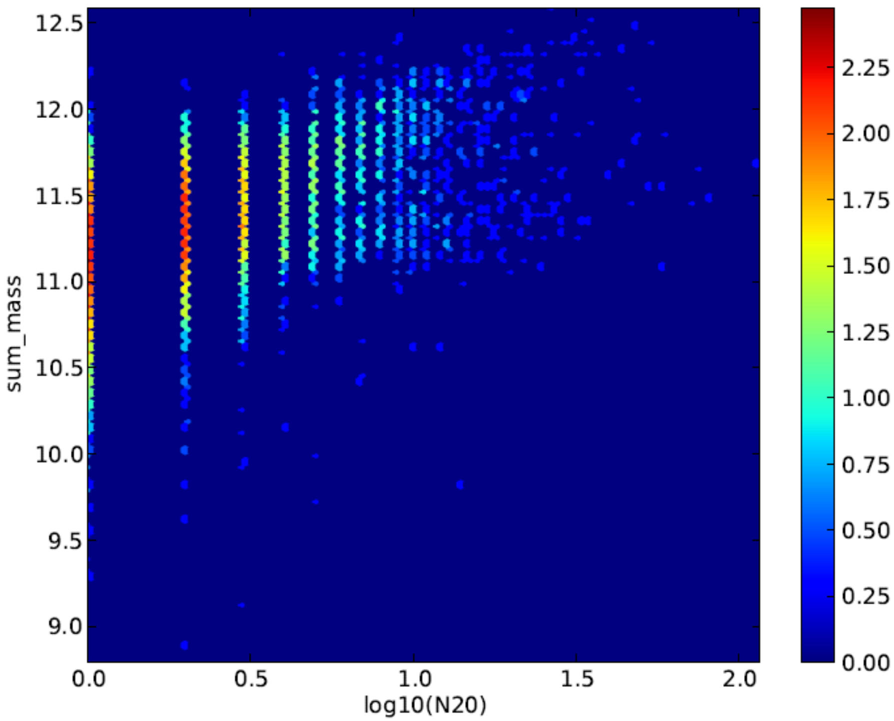
$P(D|M)$ =Evidence

Results – BCC Simulations

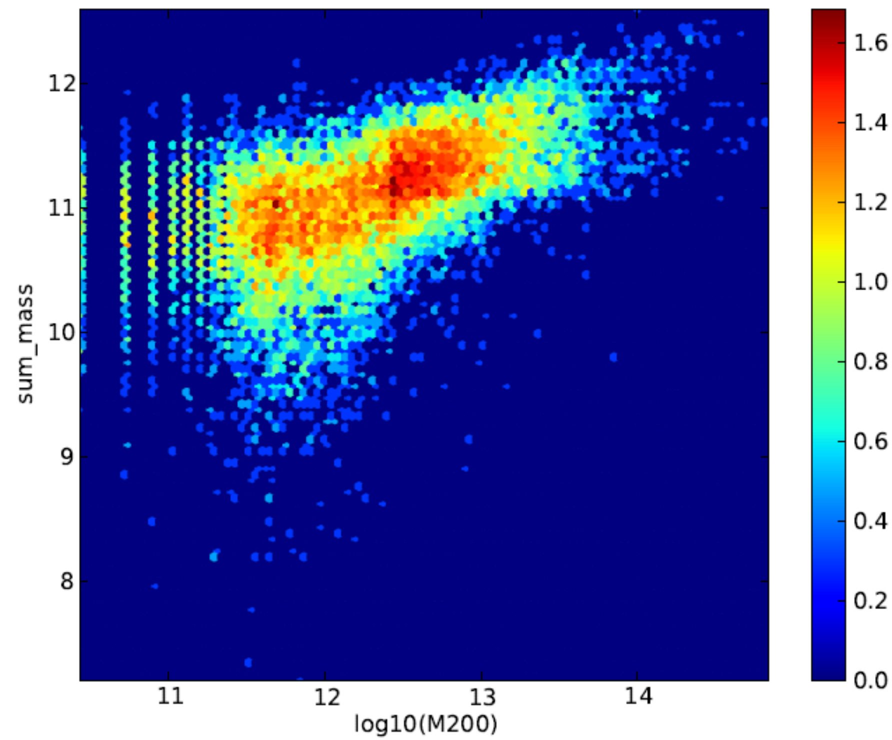




Results



12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
sum_mass
0.0
0.5
1.0
1.5
2.0
log10(N20)
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00



12
11
10
9
8
sum_mass
11
12
13
14
log10(M200)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0

Conclusions & Future Avenues

- We appear to have a reliable method of computing stellar mass.
- Going Forward:
  - Gaussian noise has been added to the data files, in an attempt to test the robustness of the estimation technique.
  - Split clusters into central and satellite galaxies and examine how each contribute as a function of cluster mass.

Questions?