1. Introduction

- M51 is a system consisting of two interacting galaxies: NGC 5194 (grand design spiral Sbc) & NGC 5195 (SB0), located at D=8.4±0.6 Mpc (Feldmeier et al. 1997).
- Observed by Hubble Heritage program (PI: S.Y. Beckwith) and released to the public in May 2005 (Mutchler et al. 2005).
- ACS/WFC in F435W (B), F555W (V), F814W (I), F658N (H) bands.

2. Star Cluster Survey

- Detection and photometry with SExtractor.
- Star cluster selection and classification using the structural parameter of SExtractor and visual inspection.
- A 'clean' sample of about 3,600 star clusters with V<23 mag, including ~2,200 Class 1 clusters (circular shape without neighbor) and ~1,400 Class 2 clusters (non-circular shape and/or with neighbors).

3. Star Cluster Spatial Distribution

- Most star clusters in M51 are bluer than (B-V)=0.5, and (V-I)=0.8 and are mostly distributed along the distinguishable spiral structures of M51.
- Class 2 star clusters appear to be more tightly bound along the spiral arms, compared with Class 1 clusters.
- However, spatial distribution also depends on the color of star clusters: blue clusters with (B-V)<0.5 appear mostly associated with spiral arms while red clusters with (B-V)>0.5 appear more widely scattered.

4. Compact Clusters vs. Faint Fuzzy Clusters

- At least more than two components in the size distribution: one with Reff ~ 3pc and the other with Reff ~ 7pc.
- Faint Fuzzy clusters are found to distribute around NGC 5195 (Hwang & Lee 2006; HL06).
- Spatial distribution of faint fuzzy clusters is different from that of compact red clusters (Fig. 4).
- It seems that faint fuzzy clusters are not distributed in random but rather in a certain direction.
- Different spatial distribution and size implies different origin of FF clusters than other typical compact red clusters.

5. Star Cluster Age & Mass Distribution

- Used ACS/WFC BVI(H) + WFC2 U(F336W) band data.
- We have derived age and mass of about 2,600 star clusters with SED fitting using the Bruzual & Charlot (2003) model.
- Fig. 2: 2D contour map of Class 1 and Class 2 star clusters (Fig. 3 of HL08).
- Fig. 3: The effective radius Reff distribution of all star clusters with Log(M/M⊙) > 4.5 (left panel) and clusters with Log(M/M⊙) < 4.5 (right panel). Black solid line shows the theoretical data while red dashed line shows the extrapolated data from the best fit mass distribution in the corresponding age bin.

6. Evolution of Cluster Formation Rate

- Cluster formation rate reveals significant increase around 250 Myrs.
- However, the theoretical models of M51 system (Toomre & Toomre 1972; Salo & Laurikainen 2000; Durrel et al. 2003) expect the passage of NGC5195 to have taken place at about 300-500 Myrs ago.
- The theoretically expected interaction epoch is roughly consistent with the epoch of cluster formation rate increase.

7. Next Step – Spectroscopy Campaign

- Very important role of ground-based telescopes.
- Major purposes of this 'proposed' campaign:
  - To determine the kinematical properties of star clusters in M51.
  - To separate the halo population from the disk population of clusters.
  - To compare the kinematical properties of Faint Fuzzy clusters with Compact Red Clusters.
  - To determine the age and metallicity of star clusters.
  - To reconstruct the star cluster formation history in the context of the dynamical evolution of M51.
  - To test theoretical models for dynamical evolution of M51 – single passage model or multiple passage model.

8. Tentative Proposed Setup

- For Subaru/FGB/IFS: A combination of 3000 grating and L600 filter to cover 3500 – 6000 Å with 4800 sec accumulated exposure time, which returns 1.34 A/pixel spectra for V<22 mag clusters.
- For Gemini/GMOS: R600 or R660 grating with 7200 sec accumulated exposure, which returns 0.45 – 0.47 A/pixel spectra for V<22 mag clusters.

9. Summary

- We have detected and visually classified about 3,600 star clusters with V<23 in the entire HST/ACS field of M51.
- Most star clusters are bluer than (B-V)=0.5 and (V-I)=1.0 but some clusters are as red as (V-I)=1.0.
- Some of these red clusters are faint fuzzy clusters mostly around NGC 5195.
- Faint fuzzy clusters display a different spatial distribution than compact red clusters, implying different origin.
- Cluster age distribution shows two peaks at about 100 Myrs and 250 Myrs. And the cluster formation rate appears to be increased around 250 Myrs, which is roughly coincide with the dynamical encounter epoch of NGC 5195 and NGC 5194 expected by the theoretical models.

10. References

- Mutchler et al. 2005, BAAS, 27, 3
- Mutchler et al. 2005, BAAS, 27, 3