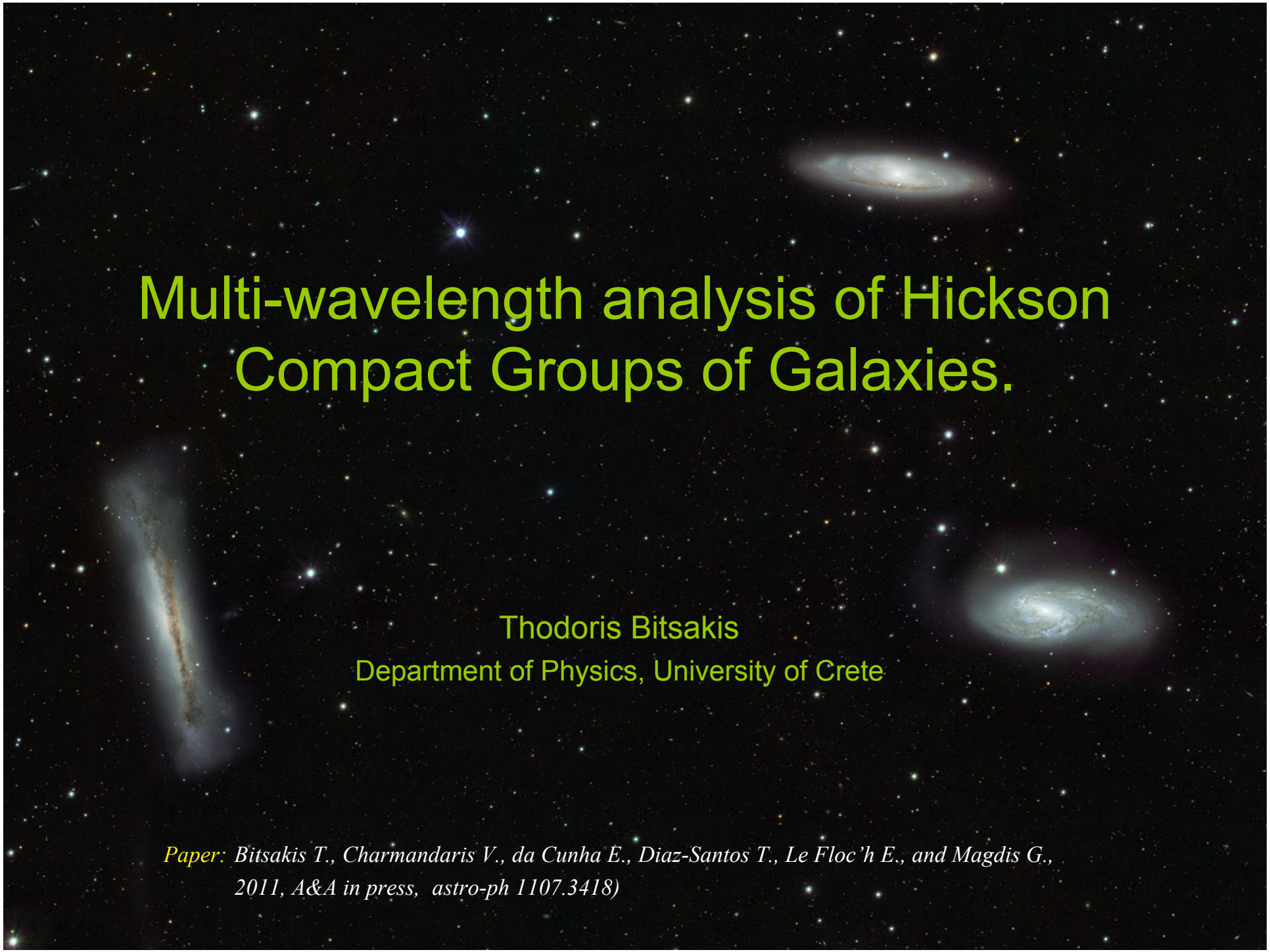

Multi-wavelength analysis of Hickson Compact Groups of Galaxies.

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Paper: *Bitsakis T., Charmandaris V., da Cunha E., Diaz-Santos T., Le Floc'h E., and Magdis G., 2011, A&A in press, astro-ph 1107.3418)*

Introduction

Galaxy structures in the Universe

- Field galaxies (Isolated galaxies, ~75% are spirals)
- Galaxy clusters (10^2-10^4 galaxies, σ_v~800-1000km/s, 25% S's)
- Galaxy groups
  - Loose groups (few galaxies, relative separations much greater than the size of the galaxies, σ_v~150km/s)
  - Compact groups (few galaxies, distances similar to the sizes of galaxies - similar to the centers of rich clusters, σ_v~250km/s)

=>Since gravity determines the morphology of a galaxy, groups are ideal to study the impact of environment in galaxy evolution

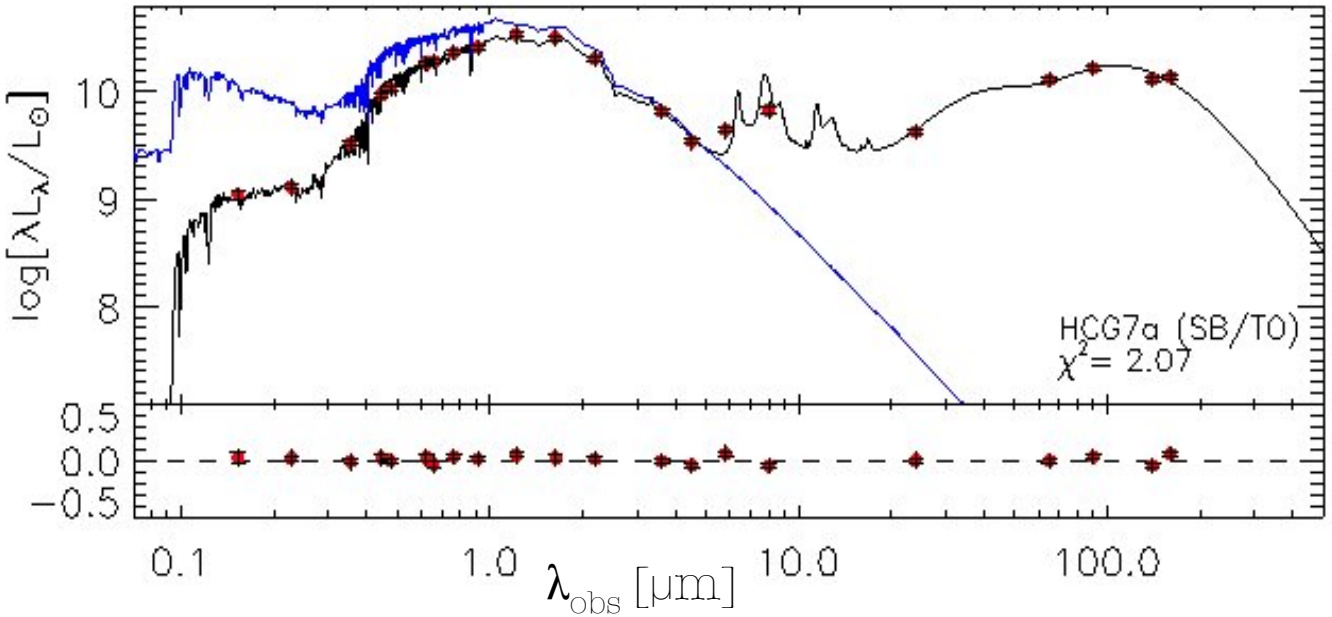
Hickson Compact Groups (100 groups, 451 galaxies)

- Systems 4 or more galaxies
- 31% E's and 43% S's (Hickson 1982)
- 43% display bridges, tails etc (Mendes de Oliveira et al. 1994)
- Indication of interactions in HI maps (Verdes-Montenegro et al. 2001)
- 40% host AGN into their nucleus (Shimada 2000; Martinez et al. 2010)

=>Strong tidal interactions occur between the group members!

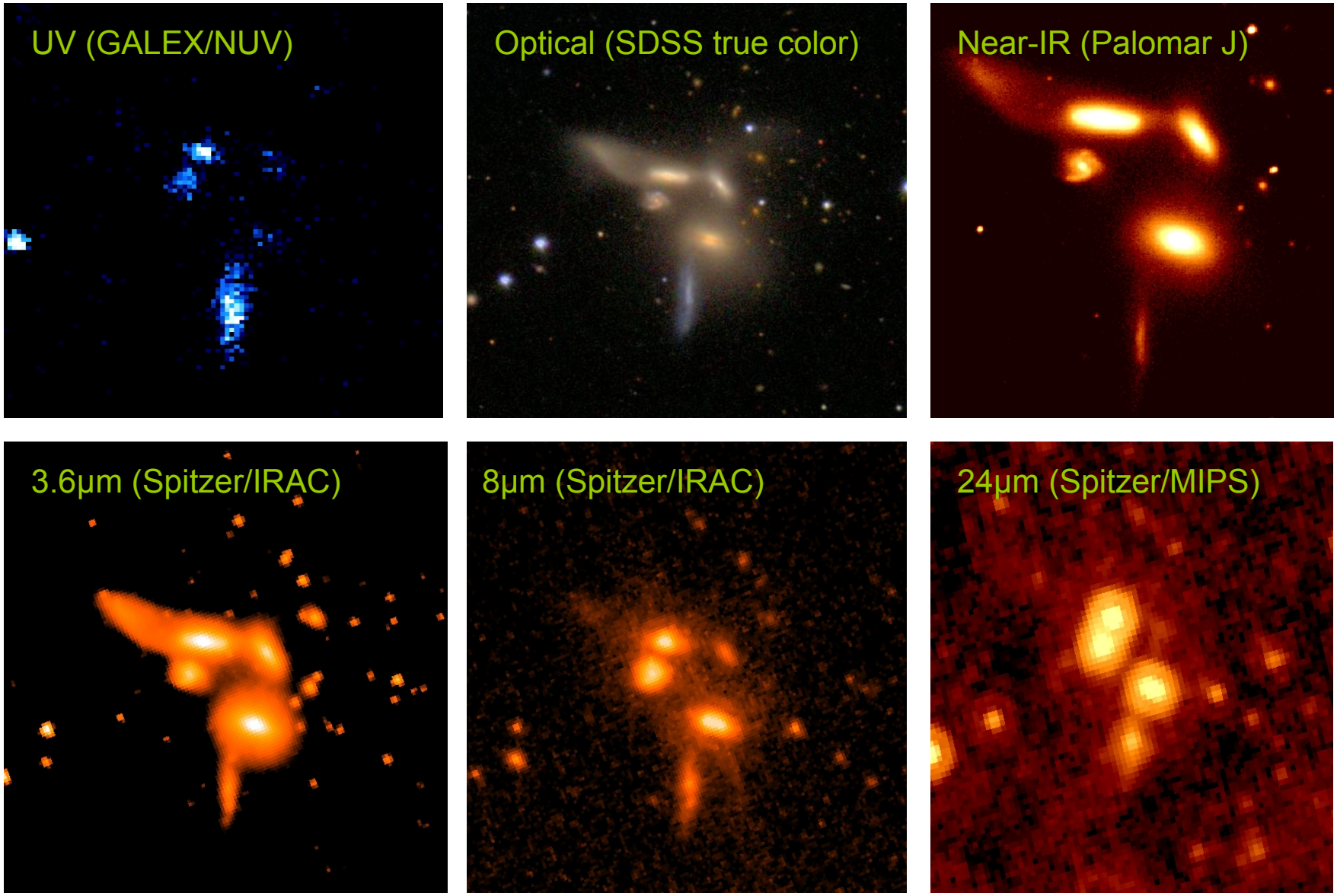
Sample Selection/SED fitting

- Sample of 32 HCGs (135 galaxies) based on availability of UV (GALEX) and mid-IR (Spitzer) maps.
- Collected a complete multi-wavelength dataset: GALEX FUV/NUV, B, R, SDSS(ugriz), JHKs, Spitzer IRAC (3.6, 4.5, 5.8 & 8.0μm) /MIPS (24μm), IRAS 60/100μm, Akari FIS (65, 90, 140 & 160μm)



- We use the theoretical model of da Cunha et al. (2008) to fit the observed SEDs of the galaxies => UV and IR data are essential!
- Using the model we estimate: $M_{stellar}$, SFRs, sSFRs, L_{IR}, A_v

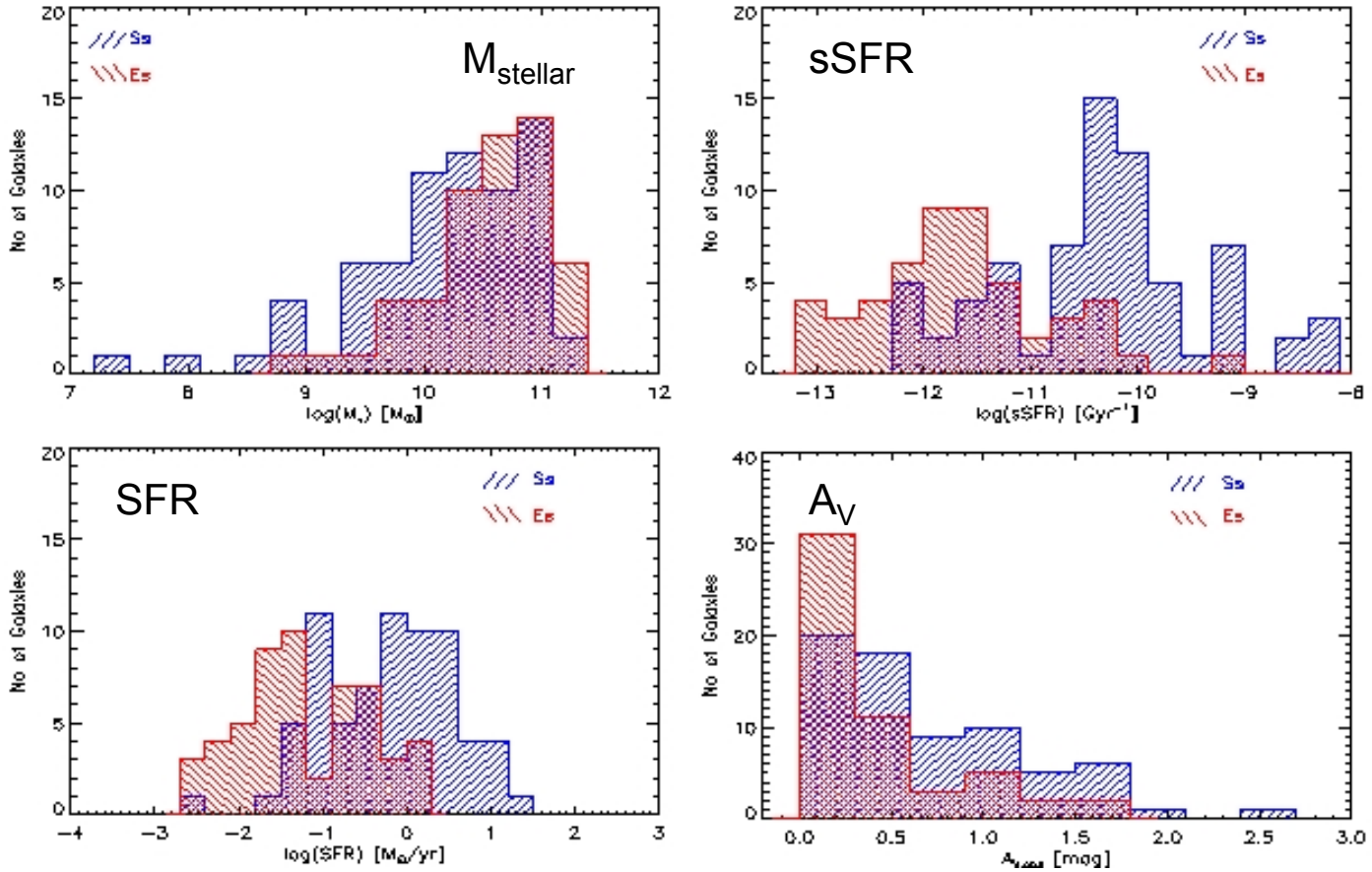
An example of datasets: HCG79



Comparison Samples

- Isolated Field Galaxies
  - SINGS (75 field galaxies cover a wide range in Hubble type and luminosities it only contain 4 early-type galaxies)
  - 9 isolated field elliptical galaxies of Temi et al. (2004)
  - LVL (258 galaxies within a distance of 11Mpc)
- Interacting pairs
  - 26 nearby early-stage interacting pairs (Smith et al. 2007)
- Field and Group-Cluster galaxies
  - 1994 field and group/cluster galaxies selected by cross-correlating SDSS with GALEX catalogues (Haines et al. 2008)

The Physical Properties of HCG galaxies



- Late-type galaxies (S) have stellar masses ($M_{stellar}$) similar to early-type (E) systems
- 8 early-type galaxies display high SFRs, and few late-types have low SFRs
- Some S's with very low sSFRs, and 8 early-types with sSFRs comparable to E's
- Identify 8 early-type galaxies with high extinction (A_V > 1mag)

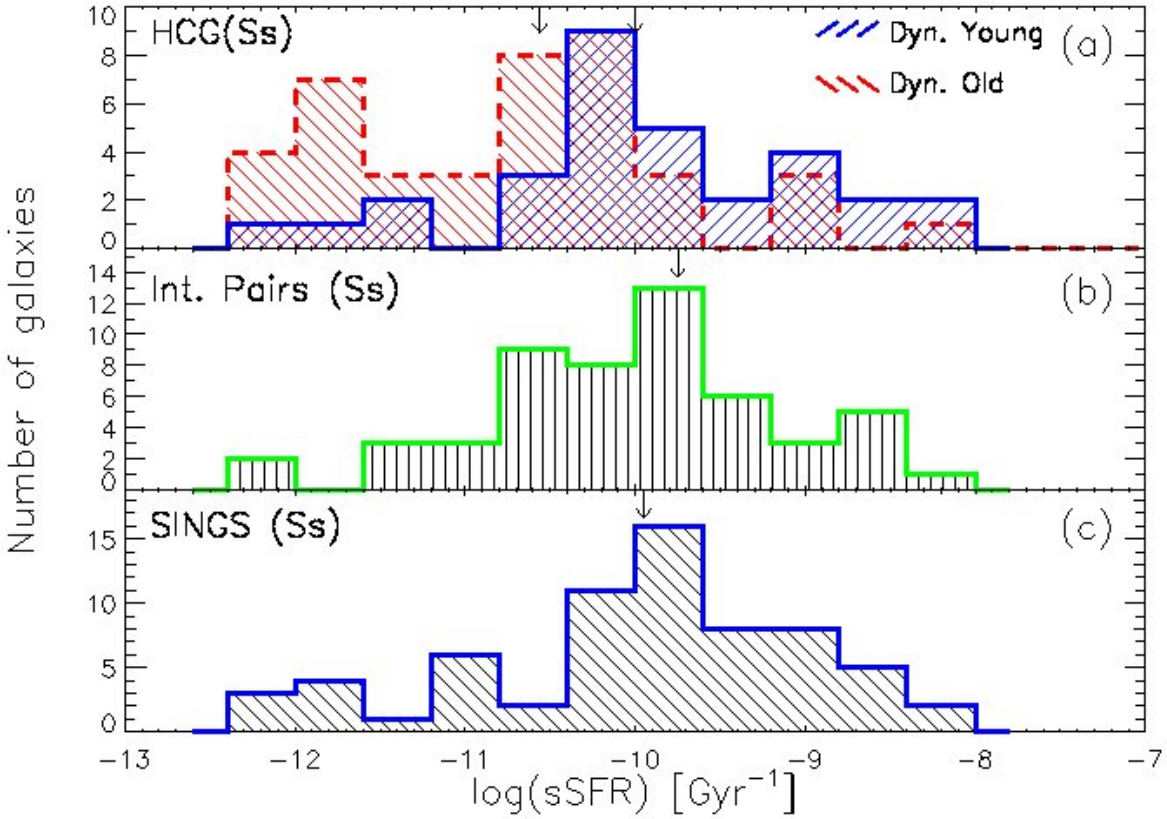
Evolutionary state of the groups

- Verdes-Montenegro et al. (2001) classified the groups based on their spatial distribution of their atomic hydrogen (HI) gas content
  - Phase 1: The HI is located in the galaxy disks
  - Phase 2: 40-70% is in the disks and the rest has been stripped out
  - Phase 3: Almost all the HI gas has been stripped out of galaxies

- We classify the groups as dynamically “young” if at least 75% of their galaxies are late-types, and as dynamically “old” if the fraction of their spiral galaxies is less than this (Bitsakis et al. 2010)
  - In dynamically “young” the nearest neighbor is at 37kpc and while in “old” groups the nearest neighbor is closer (26kpc)
  - Dynamically “young” groups have σ_V~132km/s while “old” have σ_V~408km/s

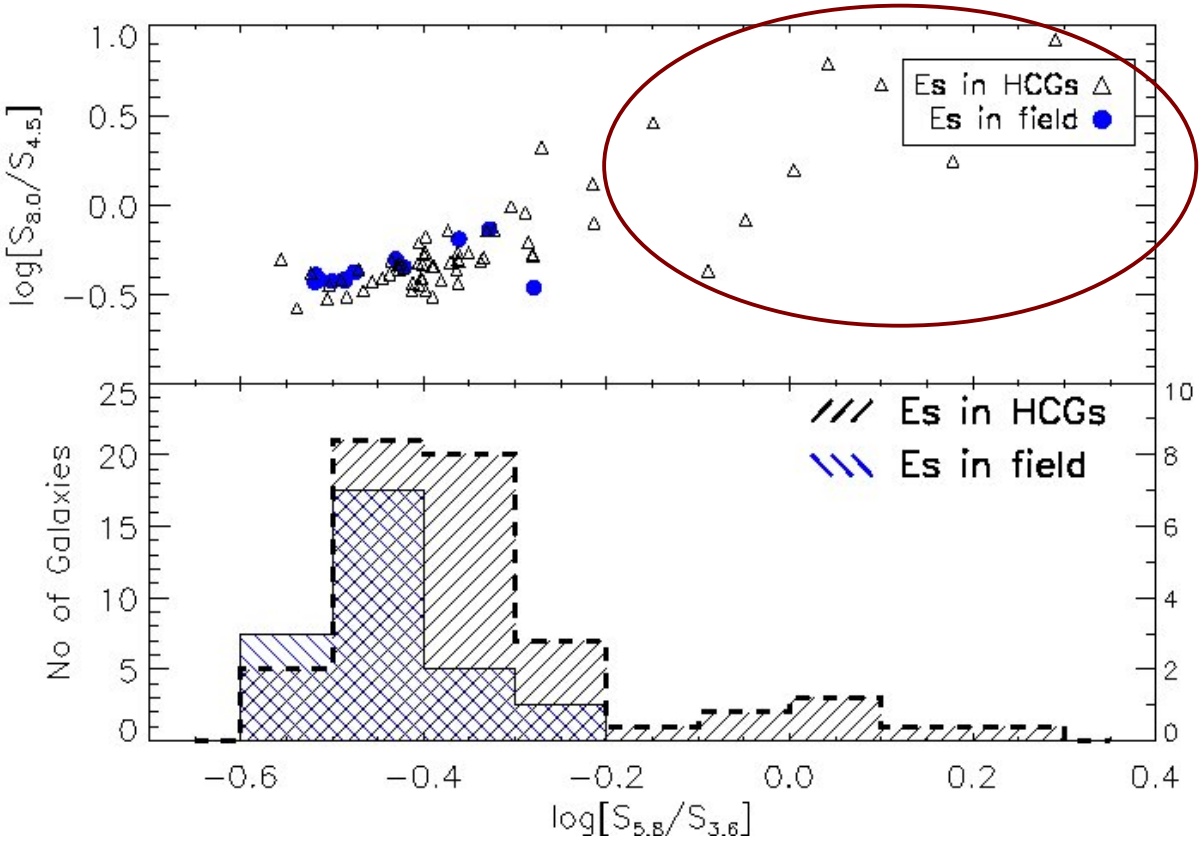
- There is a global agreement between the two methods for 12 out of 14 groups we have in common

HCG late-type galaxies



- The sSFRs of late-type galaxies in dynamically “young” HCGs are similar to interacting pair and field galaxies
- The sSFRs of late-type galaxies in dynamically “old” groups are 3 times lower =>They had increased their stellar mass

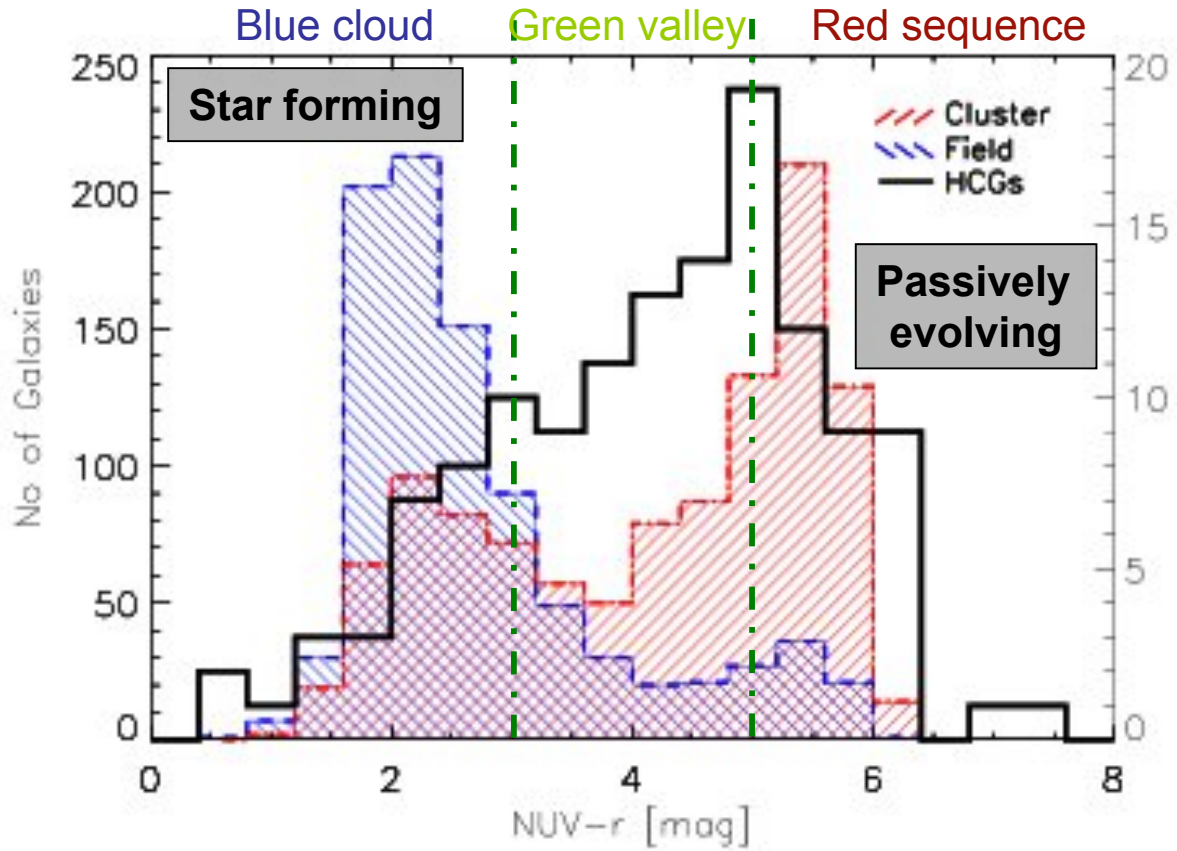
HCG early-type galaxies



- 75% of HCG early-type galaxies display similar mid-IR colors to the field ellipticals (Temi et al. 2004)
- 8 early-type galaxies with mid-IR colors similar to those of late-type galaxies - checking their radial profiles

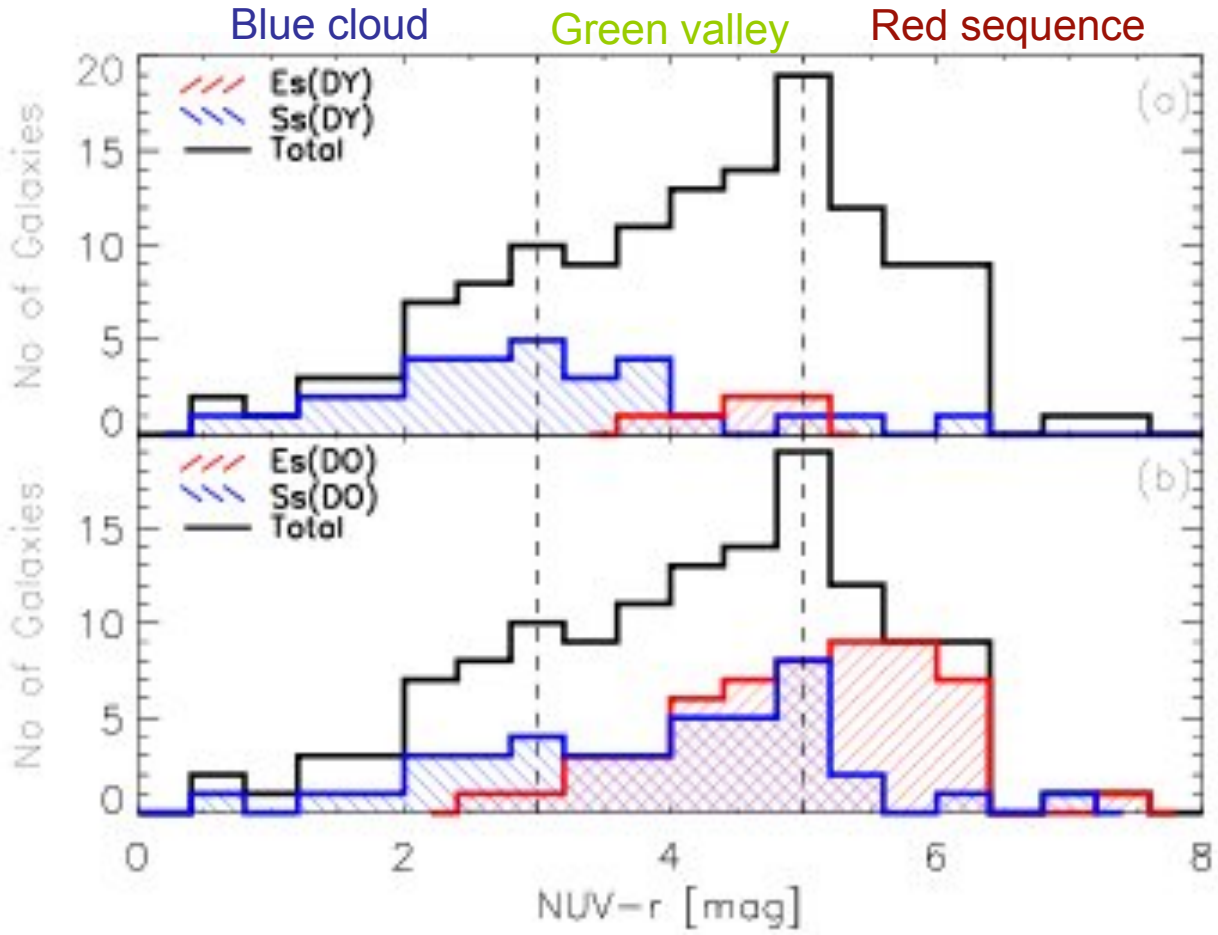
  => we suggest that 7 of them are misclassified spirals

UV-optical colors I (comparison sample)



- Compare our HCG sample (black histogram) with a field and a cluster galaxy samples from Haines et al. (2008)
- Field galaxies are mostly star-forming (>60%), while cluster galaxies are mostly passively evolving (>50%)
- HCGs are mostly passively evolving. Most galaxies within “green valley”

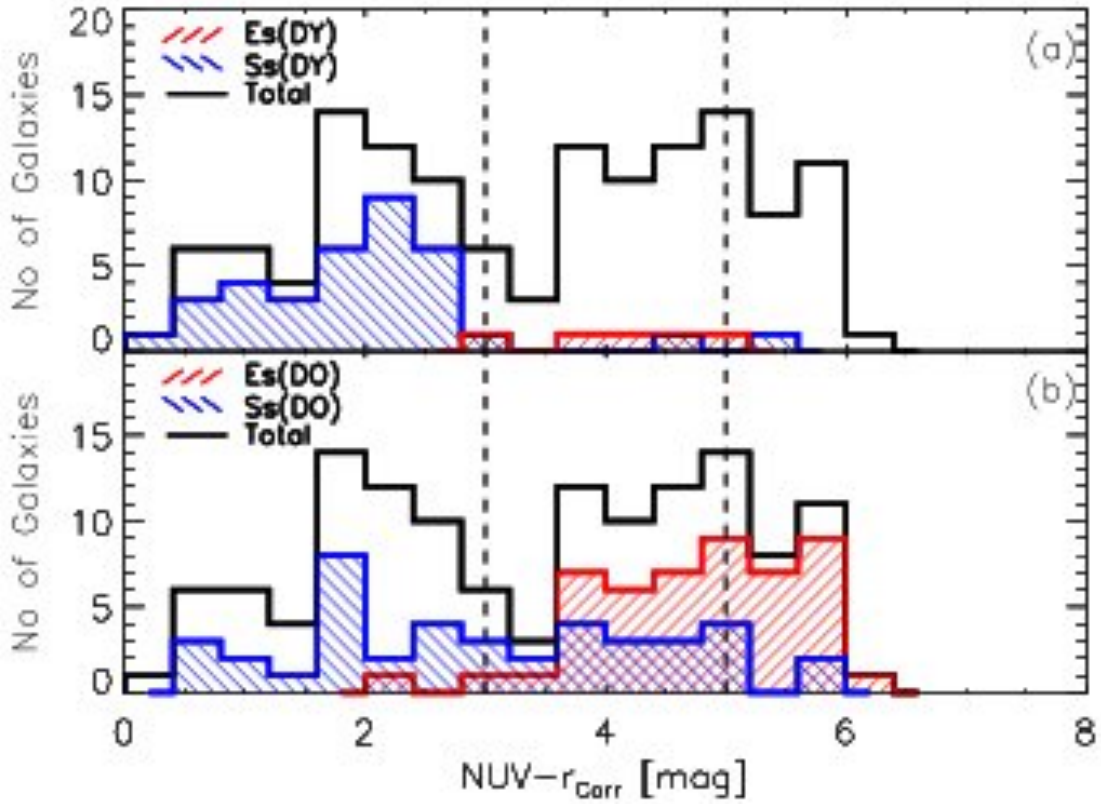
UV-optical colors II (observed)



• In dynamically “young” groups, 40% of late-type galaxies are within the “green valley” probably because of dust extinction

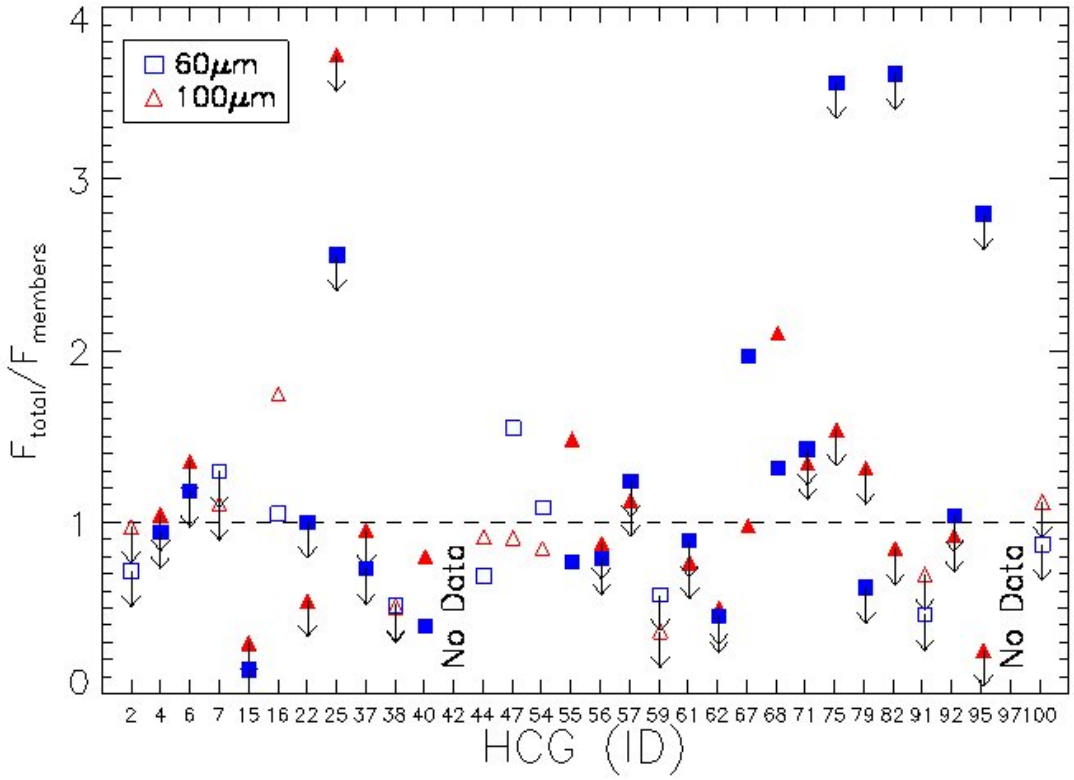
• In dynamically “old” groups, 65% of late-type galaxies are located within the “green valley”, because of dust extinction and/or old stellar population for the S’s, and gas accretion from other group members for E’s

UV-optical colors III (extinction corrected)



- In dynamically “young” groups the late-type galaxies are in the “blue cloud” as in the field, and early-type galaxies move to “redder” colors
- In dynamically “old” groups the late-type galaxies which have lower sSFRs have also redder colors since they contain old stellar populations, 25% of E’s move to “bluer” colors because of star formation due to gas accretion from group members and merging of dwarf companions

Diffuse Cold Dust in the IGM



- We use the model SEDs to calculate the "synthetic" IRAS 60/100μm flux densities of each group member and divide the observed values of the group with the sum of the flux densities of all group members
- It is plausible that there is diffuse cold dust in the intragroup medium (especially in dynamically "old" groups). High angular resolution observations in the far-IR are needed (Herschel Space Telescope)

Conclusions

- The classification of the evolutionary state of HCGs according to the fraction of late-type members appears to be physical and in agreement with previous classifications
- In dynamically “young” groups the late-type galaxies have similar SF properties and colors with field and early stage interacting pair spirals.
- In dynamically “old” groups the late-type galaxies display lower sSFRs and redder NUV-r colors since multiple past interactions increased their stellar mass and reduced their SFR by stripping gas out of their disks. On the other hand, 25% of the early-type galaxies in these groups display bluer colors and enhanced SFRs possibly due to gas accretion from other group members as well as merging of dwarf companions

The group environment affects the evolution of the galaxies.

- Early on, the influence of the close companions to group galaxies is similar to the one of galaxy pairs as well as galaxies in the field.
- However, as the time progresses, the effects of tidal interactions and merging have as a result to increase the fraction of E’s and build up the stellar mass of the remaining S’s.

Future Perspectives

- We will propose for Herschel observations
- These observations will help us to:
  - better constrain the far-IR SEDs and parameters of these galaxies.
  - confirm the existence of the diffuse cold dust in the intragroup medium, and characterize its structure and composition

- We use the sample of compact groups described in McConnachie et al. (2009), which contains ~4400 groups (~9700 galaxies)
- For 3800 of these galaxies, we obtained GALEX, SDSS, 2MASS, and WISE data
- This sample will help us to better characterize the nature of compact groups