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PRESENTACIÓN ORAL

Major and minor mergers: global star formation efficiency

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Abstract. We study galaxy pair samples selected from the Sloan Digital Sky Survey (SDSS-DR7) and we perform an analysis of minor and major mergers with the aim of investigating the dependence of galaxy properties on interactions. We build a galaxy pair catalog requiring $r_p < 25$ kpc h^{-1} and $\Delta V < 350$ km s^{-1} within redshift $z < 0.1$. By visual inspection of SDSS images we removed false identifications and we classify the interactions into three categories: pairs undergoing merging, M; pairs with evident tidal features, T; and non disturbed, N. We also divide the pair sample into minor and major interactions according to the luminosity ratio of the galaxy members. We conclude that the characteristics of the interactions and the ratio of luminosity galaxy pair members involved in a merger are important parameters in setting galaxy properties.

Resumen. Se realizó un análisis de interacciones mayores y menores seleccionadas a partir del catálogo espectroscópico Sloan Digital Sky Survey (SDSS-DR7). Se construyó una muestra de galaxias en pares cercanos aplicando el límite de separaciones proyectadas, $r_p < 25$ kpc h^{-1} y velocidades radiales relativas, $\Delta V < 350$ km s^{-1} dentro de un redshift $z < 0.1$. Mediante inspección visual se removieron falsas identificaciones y se cuantificó la intensidad de la interacción. Además, se dividió la muestra de galaxias en interacciones mayores y menores de acuerdo a la razón de luminosidad de sus galaxias miembro. A partir de este análisis concluimos que la intensidad de las interacciones y la razón de luminosidad de las galaxias involucradas en una fusión son parámetros importantes en establecer las propiedades de las galaxias.

1. Introduction

According to hierarchical structure formation models, galaxy-galaxy interactions play a critical role in the formation and evolution of galaxies as discussed by Woods et al. 2007 and references there in. Simulations show that galaxies grow by accreting other galaxies, mostly minor companions. Although collision of comparable galaxies are expected to be the most damaging, encounters between galaxies and minor companions should be the most common type of interaction because of the greater fractional abundance of low luminosity galaxies. Numerical simulations show that in major interactions there is an important redistribution of mass and a strong gravitational tidal torque causing gas angular momentum to be transferred outwards before the final merger. In minor interactions the tidal action from the less massive companions can induce a non-axisymmetric structure in the disk of the main galaxy (Hernquist & Mihos 1995). The star formation activity in minor interactions depend on structural and orbital parameters. In this work we focus on a statistical analysis of close galaxy pairs and following Alonso et al. (2007) these pairs were classified according to the level of morphological disturbance associated to the interaction. In an attempt to explore the physical mechanisms that may affect the star formation activity and galaxy colors. We use K-corrections of the publicly available code described in Blanton & Roweis (2007) (`k-correct_v4.2`) as a calibration for our k-corrected magnitudes.

2. The Sample

We build a Galaxy Pair Catalog (GPC) from the SDSS-DR7, following our previous works (Alonso et al. 2007), requiring members to have relative projected separations, $r_p < 25\,\mathrm{kpc\,h^{-1}}$ and relative radial velocities, $\Delta V < 350\,\mathrm{km\,s^{-1}}$ within redshifts $z < 0.1$. We classified all galaxies in the pair catalog taking into account the eye-ball detection of features characteristics of interactions, using the photometric SDSS-DR7. We defined two categories: *Disturbed* and *Non disturbed* pairs. *Disturbed* pairs are sub-classified as merging (M, pairs with evidence of an ongoing merging process) and tidal (T, pairs with signs of tidal interactions but not necessarily merging). *Non disturbed* (N) pairs showing no evidence of distorted morphologies (see Fig. 1). We find that about 10 % of galaxy pairs are classified as M, 30 % as T and 60 % as N, these percentages do not depend on redshift.

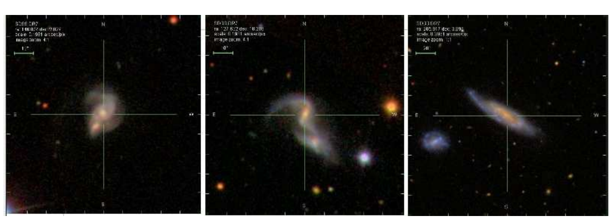

Figure 1. Examples of galaxy pair images with different classification: M (left panel), z=0.060; T (medium panel), z=0.027 and N, z=0.023(right panel); the scale, size in arcsec and the N-E direction can be seen in Figure.

3. Major and minor interactions

For the present analysis we have divided our sample in major and minor interaction pairs according to the luminosity ratio of the galaxy members (Fig. 2, *left*), the usually adopted criterion for the classification into major or minor interaction. In Fig. 2 (*left*, *a*) we show the distribution of the L_2/L_1 ratio, and the adopted threshold $L_2/L_1 = 0.33$ which gives 877 minor and 1082 major interactions.

For comparison, we also construct a control sample for the pair catalog, defined by galaxies without a close companion within the adopted separation and velocity thresholds. By using a Monte Carlo algorithm, for each galaxy pair, we selected two other galaxies without a companion within $r_p < 100\,\mathrm{kpc\,h^{-1}}$ and relative radial velocities, $\Delta V < 350\,\mathrm{km\,s^{-1}}$. Moreover, these galaxies were also required to match the observed redshift, luminosity and local density environment, Σ_5, distributions of the corresponding pair sample, to represent a robust control sample (Perez et al. 2009) (see Fig. 2 *right*).

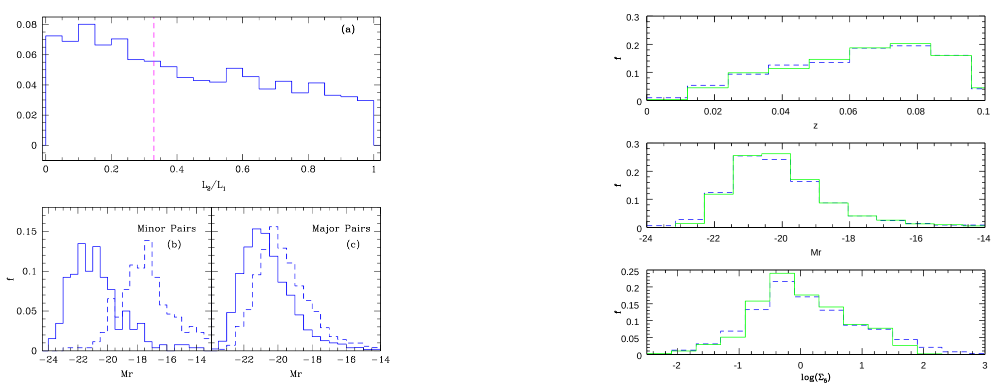

Figure 2. Left: (*a*) Distribution of the luminosity ratios of galaxies in the pair sample. (*b*) and (*c*) show the M_r distributions of the most luminous (solid lines) and less luminous (dashed lines) galaxy member in minor and major pair subsamples, respectively. Right: Distribution of z, M_r and $\log(\Sigma_5)$ in pair galaxies (dashed lines) and in the control sample (solid lines)

3.1. Global star formation efficiency in major and minor interactions

Since interacting galaxies may finally end in a single system, in this subsection we analyze the efficiency of interactions to trigger the formation of stars in the pair considered as a whole. For this aim, we compute the sum of the stellar masses and the sum of the star formation rates for the two members of a given pair using the data given in Brinchman et al (2004). Fig. 3 (*left*) shows the behavior of the total star formation rate ($SFR_1 + SFR_2$) as a function of the total stellar mass ($M_1^* + M_2^*$). In a similar way, we performed an analysis computing the global index colors as a function of a total stellar mass. The results are displayed in Fig. 3 (*right*).

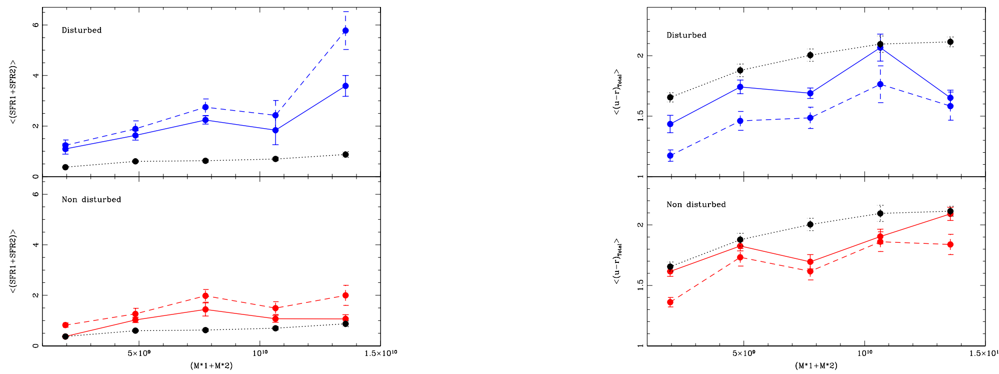

Figure 3. Total star formation rate $< SFR_1 + SFR_2 >$ and Total $< (u - r) >$ as a function of total stellar mass $M_1^* + M_2^*$ for major (dashed) and minor (solid) interactions classified as Disturbed (M and T) and non-disturbed (N) (upper and lower panels, respectively). Dotted lines represent the control sample within uncertainties derived through the bootstrap re-sampling technique.

4. Conclusions

We have performed a statistical analysis of 1959 galaxy pairs ($r_p < 25$ kpc h^{-1} and $\Delta V < 350$ km s^{-1}) within $z < 0.1$ selected from SDSS-DR7 and we have carried out an eye-ball classification of images according to the evidence of interaction through distorted morphologies and tidal features.

We can summarize the main results in the following conclusions.

- We classified 10% of the total pair sample as merging, 30% with tidal features, and 60% as non disturbed.
- We have also performed an analysis of the pairs considered as a single system. We find that at a given total stellar mass, major interactions are more efficient in forming new stars in comparison to minor pairs (by a factor ≈ 2). Nevertheless, in both, minor and major interactions, disturbed pairs (M and T systems) have a significantly higher total star formation rate than non-disturbed galaxies. In a similar way, at a given total stellar mass, disturbed pairs show blue global color with respect to non-disturbed systems.

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