WORK IN PROGRESS

Effects of collisions and interactions on star formation in galaxy pairs in the field.

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Abstract. By using cosmological simulations, we studied the effects of galaxy interactions on the star formation activity in the local Universe. We selected galaxy pairs from the 3D galaxy distribution according to a proximity criterion. The 2D galaxy catalog was constructed by projecting the 3D total galaxy distribution and then selecting projected galaxy pairs. The analysis of the 3D galaxy pair catalog showed that an enhancement of the star formation activity can be statistically correlated with proximity. The projected galaxy pairs exhibited a similar trend with projected distances and relative radial velocities. However, the star formation enhancement signal is diminished with respect to that of the 3D galaxy pair catalog owing to projection effects and spurious galaxy pairs. Overall, we found that hierarchical scenarios reproduced the observational dependence of star formation activity in pairs on orbital parameters and environment. We also found that geometrical effects due to projection modify the trends more severely than those introduced by spurious pairs.

Resumen. Usando simulaciones cosmológicas, estudiamos el efecto que producen las interacciones entre galaxias sobre la actividad de formación estelar en regiones de baja densidad para el Universo Local (z ¡ 0.1). A partir de un análisis estadístico, concluimos que los encuentros cercanos a bajas velocidades relativas producen un significante aumento de la actividad de formación estelar respecto de la mostrada por las galaxias aisladas de campo. Para comparar nuestros resultados con las observaciones, construimos a partir del catálogo tridimensional de pares de galaxias, un catálogo bidimensional emulando los datos observacionales. Los resultados hallados a partir de los catálogos simulados 2D y 3D, muestran que las tendencias encontradas entre la actividad de formación estelar y la proximidad a una galaxia vecina con baja velocidad relativa, coinciden con los resultados observacionales. Finalmente, a partir del catálogo proyectado, podemos determinar cual es el efecto producido por los pares espurios, introducidos en la proyección, sobre los resultados.

1. Introduction

Observations in the local Universe as well as at high redshift show that galaxy interactions can trigger star formation activity independently of environment (García Lambas et al. 2003; Alonso et al. 2004). A possible theoretical ex-

planation to this fact is associated to the dynamical stability of the systems. Numerical simulations showed that interactions between systems without bulge or with a small one can develop tidal instabilities which produce gas inflows into the central region of the systems, triggering starbursts (e.g. Barnes & Hernquist 1996; Tissera 2000).

Barton et al (2000) analyzed a sample of about 250 pairs of galaxies determining that interactions could be correlated with an enhancement of star formation activity. From 2dFGRS survey (Colles et al 2001), García Lambas et al. (2003) and Alonso et al. (2004) built up catalogs of galaxy pairs in different environment, selecting them by applying both velocity ($\Delta V \leq 350$ km s^{-1}) and projected ($r_p \leq 100$ kpc) separation criteria. These authors found a clear correlation between interactions and the star formation activity.

In this work we intend to test if hierarchical scenarios for galaxy formation can reproduce these observations and how projection effects might distort the real signals.

2. Galaxy pairs in numerical simulations: Analysis and Results

We analyze numerical simulations consistent with the *concordance* Cold Dark Matter model: $\Omega_m = 0.3$, $\Lambda = 0.7$ and $H_0 = 70 \mathrm{kms}^{-1}\mathrm{Mpc}^{-1}$ which includes star formation and chemical enrichment. In order to identify galactic systems from the simulations, we proceeded following steps. First, we identified the virialized structures by using the percolation method developed by Davis et al (1985), called *friends-of-friend* (fof), which selected structures contained within a density contour defined by a *linking length* parameter. After this process, we defined spherical regions of 0.5 Mpc of radio centered at each virialized system. Finally, within each of these regions, the substructure was identified by using a smaller *linking length* parameter. This procedure allowed us to select systems from 5×10^8 to $10^{13} \mathrm{M_o doth}^{-1}$ total mass.

After the identification of galactic systems from the simulations, we analyzed the physical and chemical properties of the gas and stellar components in each galactic object by calculating averages over the particles within the radius that encloses 83% of the baryonic mass of the systems. The star formation activity is quantified by the estimation of the birth rate parameter: $b = sfr/ <sfr>$, defined as the ratio between the present star formation rate and its mean value over whole history of the galaxy (Kennicutt et al. 1998).

The 3D galaxy pair catalog was constructed by selecting galaxies closer than $r \approx 200$ kpc. Following García Lambas et al. (2003) a control sample was also defined by galaxies without a close companion. The comparison between the star formation activity in both catalogs unveils the effects of having a close neighbour.

The projection of the galactic systems onto randomly chosen directions allowed us to mimic observations and to construct a 2D galaxy pair sample by applying the same observational criteria chosen by García Lambas et al. (2003). We required galaxies to be closer in projected distance ($r_p < 100$ kpc) and relative velocity ($\Delta V < 350 \mathrm{km/s}$ in order to be included in the 2D galaxy pair catalog. A corresponding control sample was also defined for the projected pair catalog.

In the 3D galaxy pair catalog, we found a clear trend for an enhancement of the star formation activity for close pairs with respect to galaxies without a close companion. We estimated a relative distance threshold of $\approx 50 \text{kpch}^{-1}$ for the star formation activity to be statistically important. A weak trend for lower velocity encounters to trigger stronger star formation activity was also detected.

The 2D simulated galaxy-pair catalog showed comparable trends for the star formation activity to be enhanced for small relative projected distances and relative radial velocities. We also obtained similar dependence of the star formation activity in pairs on environment.

The 2D catalogs not only allowed us to compare the simulations with observations in a more reliable fashion, but also to evaluate the effects introduced by spurious pairs and projection. We found that many galaxies in the 2D catalog appear as pairs when in fact their 3D relative separation is larger than the cut-off value adopted as criteria to define pairs. These spurious systems, with arbitrary values of star formation rate, produced a distortion in the observed trends between star formation activity and the orbital parameters. As expected the effects of spurious is more important for larger projected separations. We estimated that $\sim 29\%$ of pairs within $r_p \leq 100 \text{kpch}^{-1}$ are spurious while this contamination diminishes to 16% within $r_p \leq 35 \text{kpch}^{-1}$. Nevertheless, as discussed by Perez et al. (2005), the projection of galaxies itself introduces the largest effects since the elimination of spurious pairs does not allow the recovering of the original signal.

3.   Conclusions.

Comparing the results from 3D and 2D simulated galaxy pair catalogs, we conclude that:

- there is a correlation between the star formation activity of a galaxy and the 3D distance to its closest neighbor, which have to be, on averaged, at $r < 50 \text{kpc/h}$ to show important star formation enhancement with respect to isolated systems.

- the properties of galaxy pairs in the 2D simulated catalog reproduced the observations trends with orbital parameters and environment obtained from García Lambas et al. (2003).

- spurious pairs in the 2D galaxy pair catalog are more imporant at larger separation and their effects are less severe than those introduced by the projection of the 3D galaxy distribution itself.

4.   Acknowledgments

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