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SUPERNOVA FEEDBACK AND THE BEND OF THE TULLY-FISHER RELATION

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RESUMEN

Estudiamos el origen de la relación de Tully-Fisher analizando simulaciones hidrodinámicas en un universo ΛCDM. Encontramos que las galaxias más pequeñas exhiben masas estelares menores que aquellas predichas por el ajuste lineal de las galaxias más masivas, en consistencia con las observaciones. En este modelo, estas tendencias son generadas por la acción más eficiente de la retroalimentación al medio por supernovas en la regulación de la formación estelar de las galaxias más pequeñas. Sin introducir parámetros dependientes de escala, el modelo predice un cambio de pendiente en la relación de Tully-Fisher para una velocidad característica de ∼100 km s^{-1}, en acuerdo con resultados observacionales y teóricos previos.

ABSTRACT

We have studied the origin of the Tully-Fisher relation by analysing hydrodynamical simulations in a ΛCDM universe. We found that smaller galaxies exhibit lower stellar masses than those predicted by the linear fit to high mass galaxies (fast rotators), consistently with observations. In this model, these trends are generated by the more efficient action of supernova feedback in the regulation of the star formation in smaller galaxies. Without introducing scale-dependent parameters, the model predicts that the Tully-Fisher relation bends at a characteristic velocity of ∼100 km s^{-1}, in agreement with previous observational and theoretical findings.

Key Words: cosmology: theory — galaxies: evolution — galaxies: formation

1. INTRODUCTION

The Tully-Fisher relation is very important for constraining galaxy formation models because it links two fundamental properties of galaxies such as the stellar (sTFR) or baryonic (bTFR) mass and the depth of the potential well.

In particular, there are observational evidences that the sTFR does not follow a linear trend for the whole range of observed rotation velocities. According to the results of McGaugh et al. (2000), the sTFR bends at ∼90 km s^{-1} in such a way that smaller galaxies have lower stellar masses than those derived from the extrapolation of the linear fit to fast rotators. Moreover, McGaugh et al. (2010) have reported that there is also a bend in the bTFR but at a lower rotation velocity (∼20 km s^{-1}).

2. SIMULATIONS

In this work, we studied the role of Supernova (SN) feedback on the shape of the sTFR and bTFR by analysing hydrodynamical simulations in a ΛCDM universe[4]. A version of the chemical code GADGET-3 including treatments for metal-dependent radiative cooling, stochastic star formation and SN feedback (Scannapieco et al. 2006) was employed. The simulated volume corresponds to a cubic box of a comoving 10 Mpc h^{-1} side length. The simulation has a mass resolution of $6 \times 10^6\ M_\odot\ h^{-1}$ and $9 \times 10^5\ M_\odot\ h^{-1}$ for the dark and gas phase, respectively.

Simulated disc-like galaxies were identified following the methods describe by De Rossi et al. (2010). The mean properties of galactic systems were estimated at the baryonic radius $R_{\rm bar}$, defined as the one which encloses 83 per cent of the baryonic mass of the systems. We found that the tangential velocity of these systems constitutes a good representation of their potential well so that, for the sake of simplicity, we used the circular velocity estimated at $R_{\rm bar}$ as the kinematical indicator for our study.

3. RESULTS AND DISCUSSION

The massive-end of the simulated sTFR can be fitted by a power-law of the form $\log(M_*/M_\odot\ h^{-1}) = (3.68 \pm 0.09) \times \log(V/100\ \text{km s}^{-1}) + (9.42 \pm 0.26)$,

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[4]$\Omega_{\rm m} = 0.3$, $\Omega_\Lambda = 0.7$, $\Omega_{\rm b} = 0.04$ and $\rm H_0 = 100\ \it h^{-1}$ km s^{-1} Mpc^{-1} with $h = 0.7$