The distribution of mass components in simulated disc galaxies

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ABSTRACT

Using 22 hydrodynamical simulated galaxies in a ΛCDM cosmological context we recover not only the observed baryonic Tully-Fisher relation, but also the observed "mass discrepancy–acceleration" relation, which reflects the distribution of the main components of the galaxies throughout their disks. This implies that the simulations, which span the range $52<V_{\rm flat}<222\,{\rm km\,s^{-1}}$ where $V_{\rm flat}$ is the circular velocity at the flat part of the rotation curve, and match galaxy scaling relations, are able to recover the observed relations between the distributions of stars, gas and dark matter over the radial range for which we have observational rotation curve data. Furthermore, we explicitly match the observed baryonic to halo mass relation for the first time with simulated galaxies. We discuss our results in the context of the baryon cycle that is inherent in these simulations, and with regards to the effect of baryonic processes on the distribution of dark matter.

Key words: galaxies: evolution - formation - haloes cosmology: theory - dark matter

1 INTRODUCTION

Within a ΛCDM context, the angular momentum of disc galaxies originates from tidal torques imparted by surrounding structures in the expanding Universe, prior to proto-galactic collapse (Peebles 1969; Barnes & Efstathiou 1987). Assuming that gas gains a similar

overly dense sub-structures (e.g. Navarro & Steinmetz 2000; Maller & Dekel 2002; Piontek & Steinmetz 2011).

Progress was made by implementing increasingly effective recipes for feedback from supernovae (Thacker & Couchman 2001; Stinson et al. 2006) and the inclusion of other forms of feedback from massive stars (Stinson et al. 2013; Hopkins et al. 2014). The benchmark for assessing this progress has primarily been the ability to match the Tully-Fisher relation (e.g. Governato et al. 2004; Doménech-Moral et al. 2012), with recent simulations succeeding

- 1 этап.

Момент сохраняется. Газ теряет энергию, образует вращающийся диск. Маленькие плотные диски.

- 2 этап.

Учет feedback от массивных звезд и SN. Объясняется TF и BTF, но форма V(R) не воспроизводится, появл. лок.максимум (see f.e. Brook + 2012).

- 22 модели галактик, с использованием двух независимых проектов of cosmological simulations.
- ΛCDM cosmology with WMAP parameters. Zoomed-in regions of a total cosmological volume.
- **Модели:**

A chosen region is re-simulated at a higher resolution. In this case, the re-simulation includes 40963 effective particles in a spherical

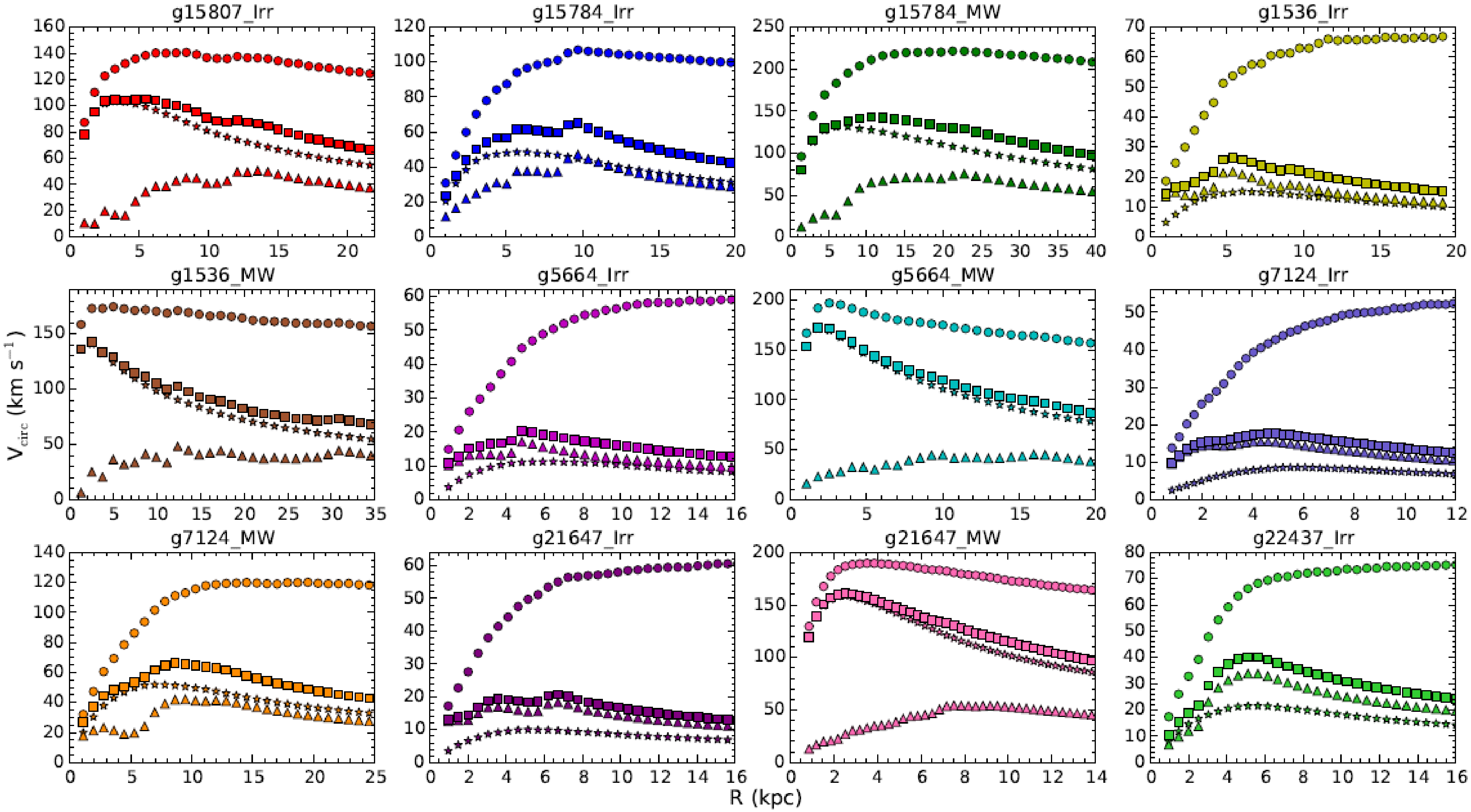


Figure 1. The circular velocity curves of the 12 MaGICC disk galaxies. Different symbols represent the velocity values due to different mass components (triangles: cold gas; stars: stars; squares: all baryons; circles: total). Simulations reproduce the variety of observed rotation curves. Furthermore, like in observations, the features present in the baryonic curves are reflected in the total one.

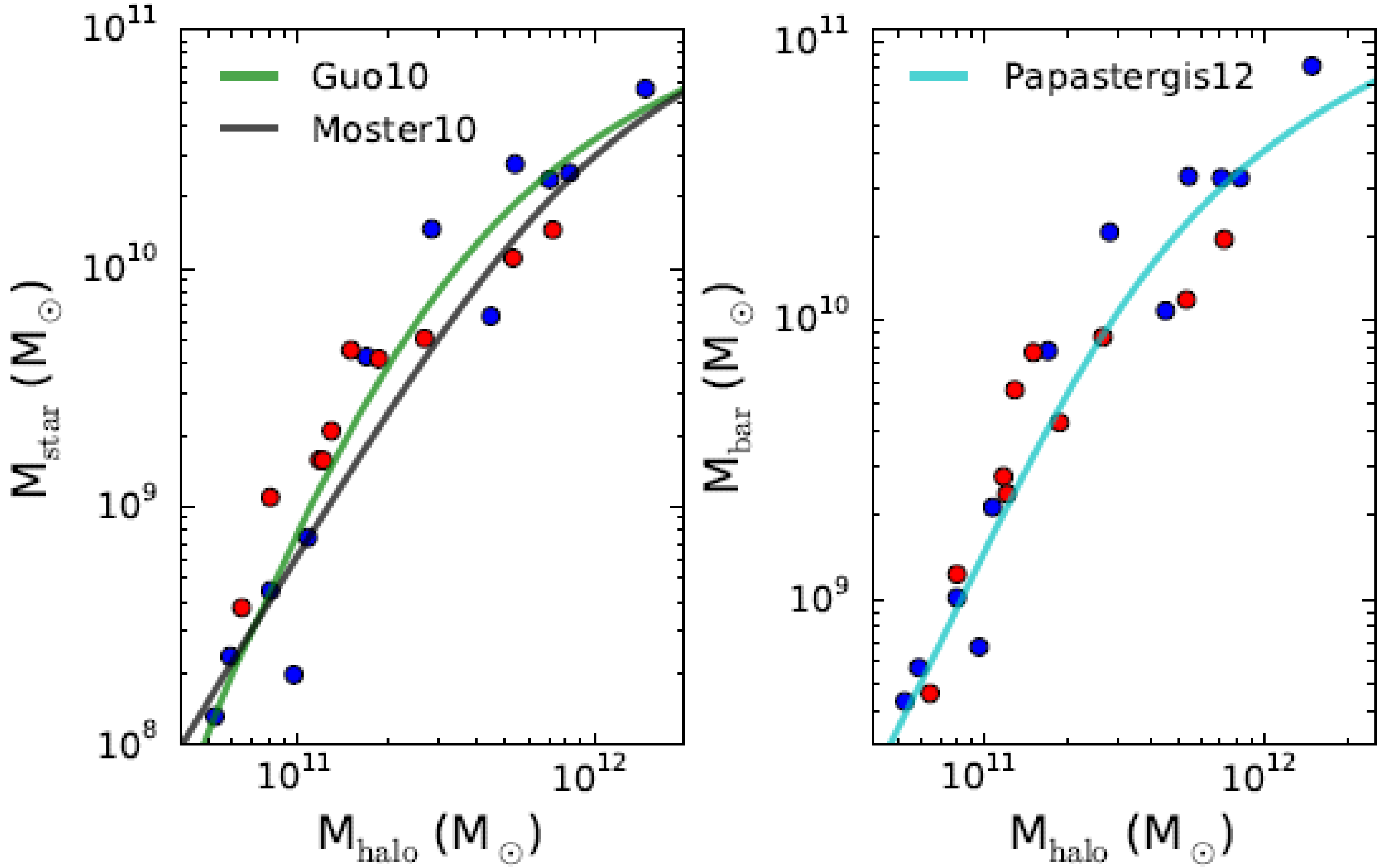


Figure 3. The stellar-to-halo mass (left panel) and baryon-to-halo mass (right panel) relations, with MaGICC galaxies in blue and CLUES galaxies in red. Also shown are the empirical stellar-halo mass relations from Guo et al. 2010 (green line) and Moster et al. 2010 (black line), and the baryon-to-halo mass relation from Papastergis 2012 (cyan line).

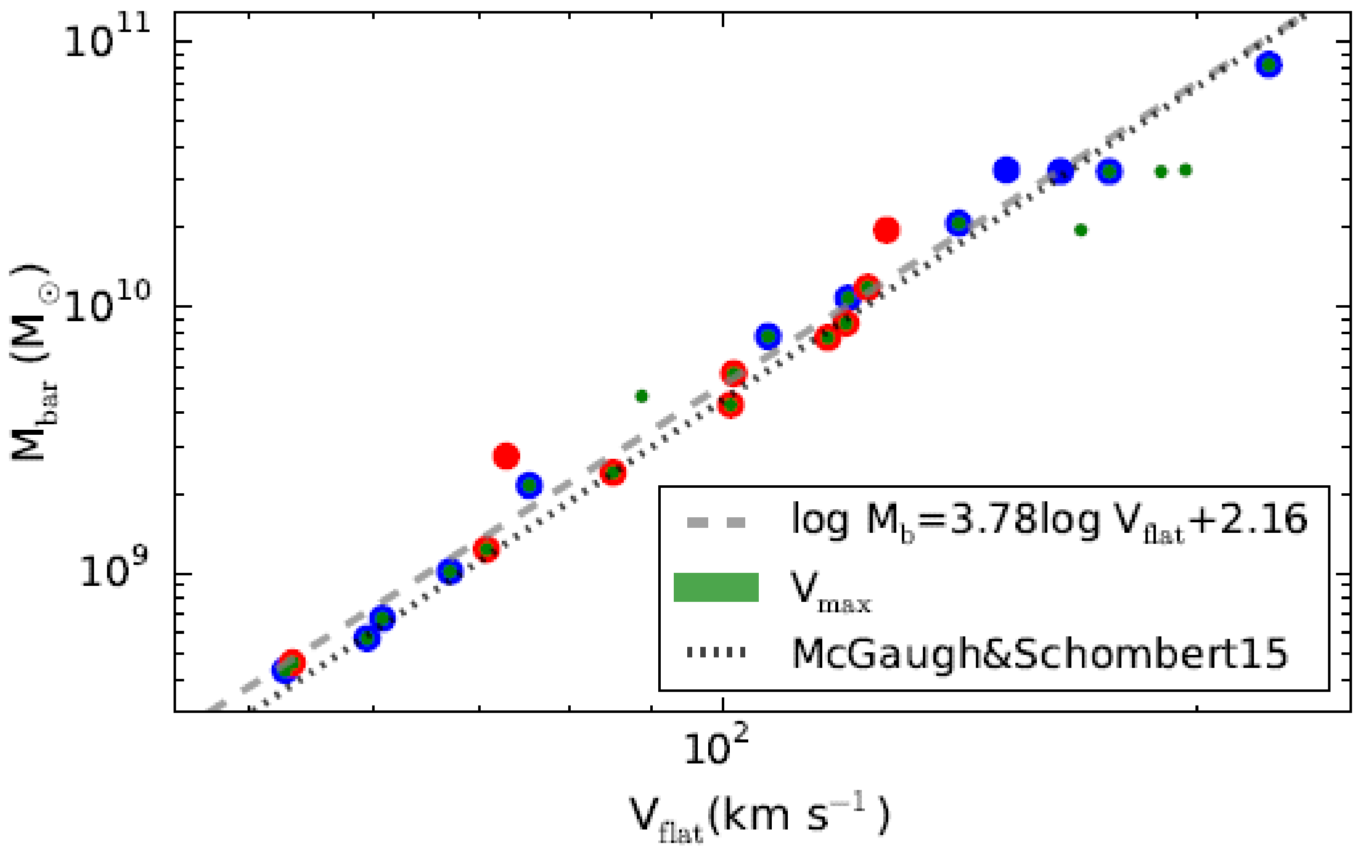


Figure 4. The baryonic Tully-Fisher relation: total baryonic mass M_{bar} (stars + cold gas) plotted against rotation velocity V_{flat}. Blue points are from the MagiCC suite while the red points are the galaxies from the CLUES simulation. The dashed line shows the linear fit to the simulated data, with slope=3.78. The small green points show V_{max} rather than V_{flat}, which results in a slightly flatter relation, with slope=3.49 (see text for details). The dotted line is the observational relation using measurements in the V band given in McGaugh & Schombert 2015 with slope=3.92.

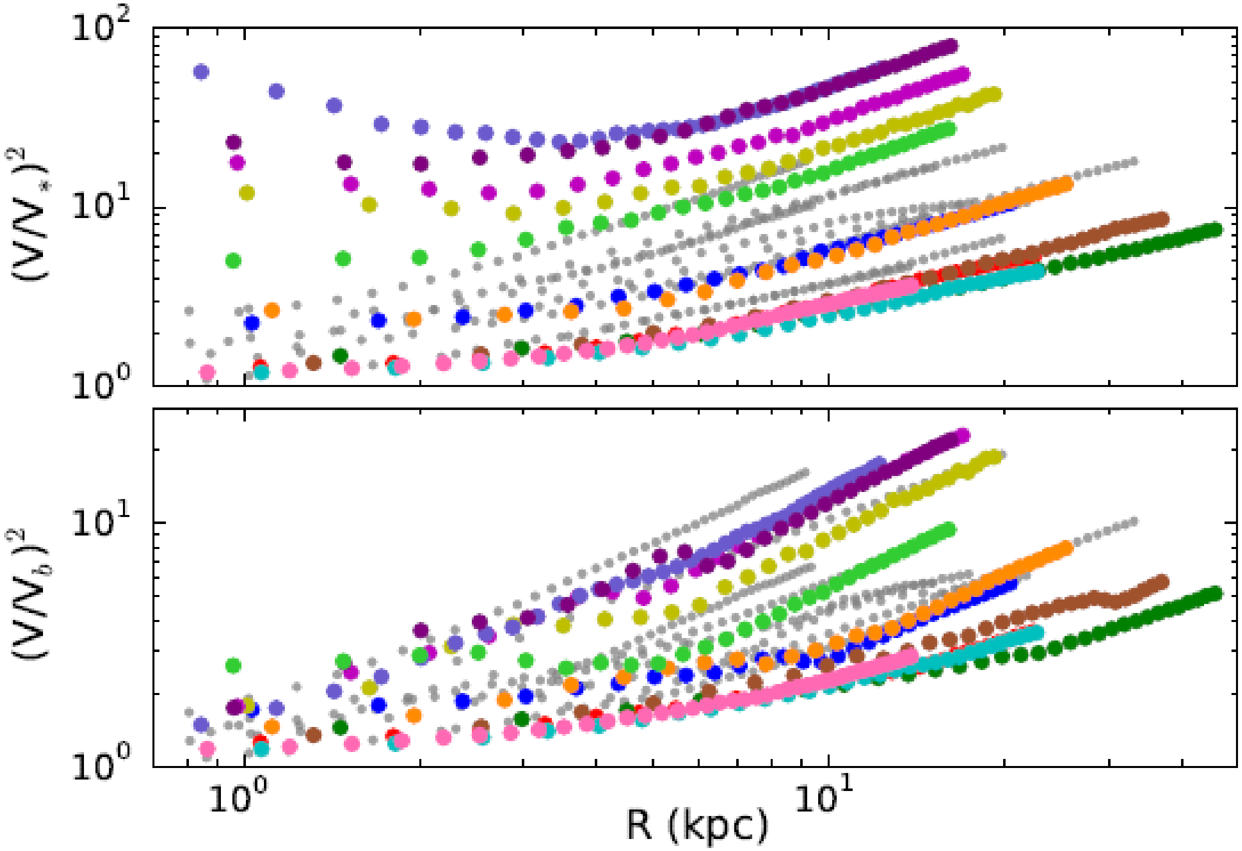
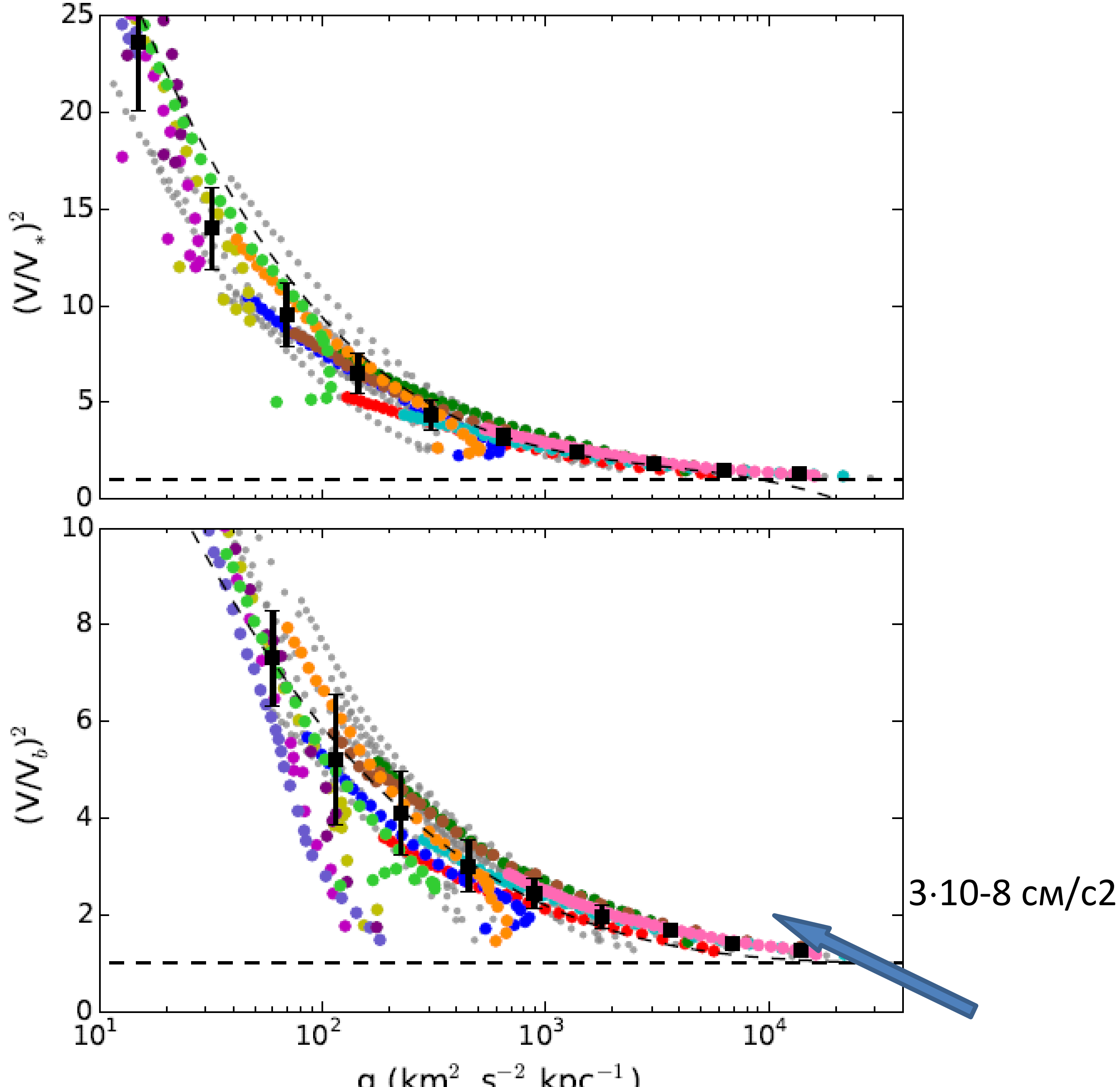


Figure 5. Mass discrepancy versus radius (stars, top panel; all baryons, lower panel). Data points for each MaGICC galaxy are represented in a different color according to figure 1. Data points for all CLUES galaxies are small dots in gray color (as in figure 2). As occurs with observed galaxies, the lower the surface brightness of the galaxy the higher the mass discrepancy encountered: mass discrepancy does not hold a correlation with radius. Smaller values of D are found when all baryons are taken into account as expected.



25
20
15
10
5
0
$(V/V_*)^2$
10
8
6
4
2
0
$(V/V_b)^2$
10^1
10^2
10^3
10^4
g (km^2 s^{-2} kpc^{-1})
3·10-8 см/с2

ИТОГ

Our study shows that the distribution of mass within disc galaxies with a wide range of masses and rotational velocities can now also be well reproduced within a CDM universe.