The Shape of Dark Matter Haloes
V. Analysis of observations of edge-on galaxies

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Accepted 2015 month xx. Received 2015 Month xx; in original form 2015 Month xx

ABSTRACT

In the previous papers in this series, we have measured the stellar and HI content in a sample of edge-on galaxies. In the present paper, we perform a simultaneous rotation curve and vertical force field gradient decomposition for five of these edge-on galaxies. The rotation curve decomposition provides a measure of the radial dark matter potential, while the vertical force field gradient provide a measure of the vertical dark matter potential. We fit dark matter halo models to these potentials. Using our HI self-absorption results, we find that a typical dark matter halo has a less dense core ($0.094 \pm 0.230\,\mathrm{M}_\odot/\mathrm{pc}^3$) compared to an optically thin HI model ($0.150 \pm 0.124\,\mathrm{M}_\odot/\mathrm{pc}^3$). The HI self-absorption dark matter halo has a longer scale length R_c of 1.42 ± 3.48 kpc, versus 1.10 ± 1.81 kpc for the optically thin HI model. The median halo shape is spherical, at $q = 1.0 \pm 0.6$ (self-absorbing HI), while it is prolate at $q = 1.5 \pm 0.6$ for the optically thin. Our best results were obtained for ESO 274-G001 and UGC 7321, for which we were able to measure the velocity dispersion in Paper III. These two galaxies have drastically different halo shapes, with one oblate and one strongly prolate. Overall, we find that the many assumptions required make this type of analysis susceptible to errors.

Key words: galaxies: haloes, galaxies: kinematics and dynamics, galaxies: photometry, galaxies: spiral, galaxies: structure

- q=c/a
- q>1- prolate
- q<1-oblate
- q=1 – spherical

Источник информации:

- stellar streams
- Grav.lensing
- Polar rings
- Modelling of HI flaring in edge-on galaxies

(vdKruit,1981,N891)

Выбраны 5 галактик типа Sd, звездные диски которых уже были профотометрированы ранее (Paper IV):

IC5249

ESO115-G021

ESO138-G014

ESO274-G001

UGC7321

Дисперсия скоростей HI – либо измерена, либо принималась 10 км/с

M/L_r- свободный параметр

$$\frac{dF_{z,\mathrm{total}}(R,z)}{dz} = \frac{dF_{z,\mathrm{gas}}(R,z)}{dz} + \frac{dF_{z,\mathrm{stellar}}(R,z)}{dz} + \frac{dF_{z,\mathrm{halo}}(R,z)}{dz}$$

$$\nabla\left(\sigma^2_{\mathrm{gas}}\,\rho_{\mathrm{gas}}\right) = \rho_{\mathrm{gas}}\nabla\Phi_{\mathrm{total}}\ .$$

- Диск: M/Lr = const
- Гало: модель Sachett

$$\rho_{\mathrm{halo}}(R,z) = \frac{\rho_{0,\mathrm{halo}}\,R_c^2}{R_c^2 + R^2 + z^2/q^2}.$$

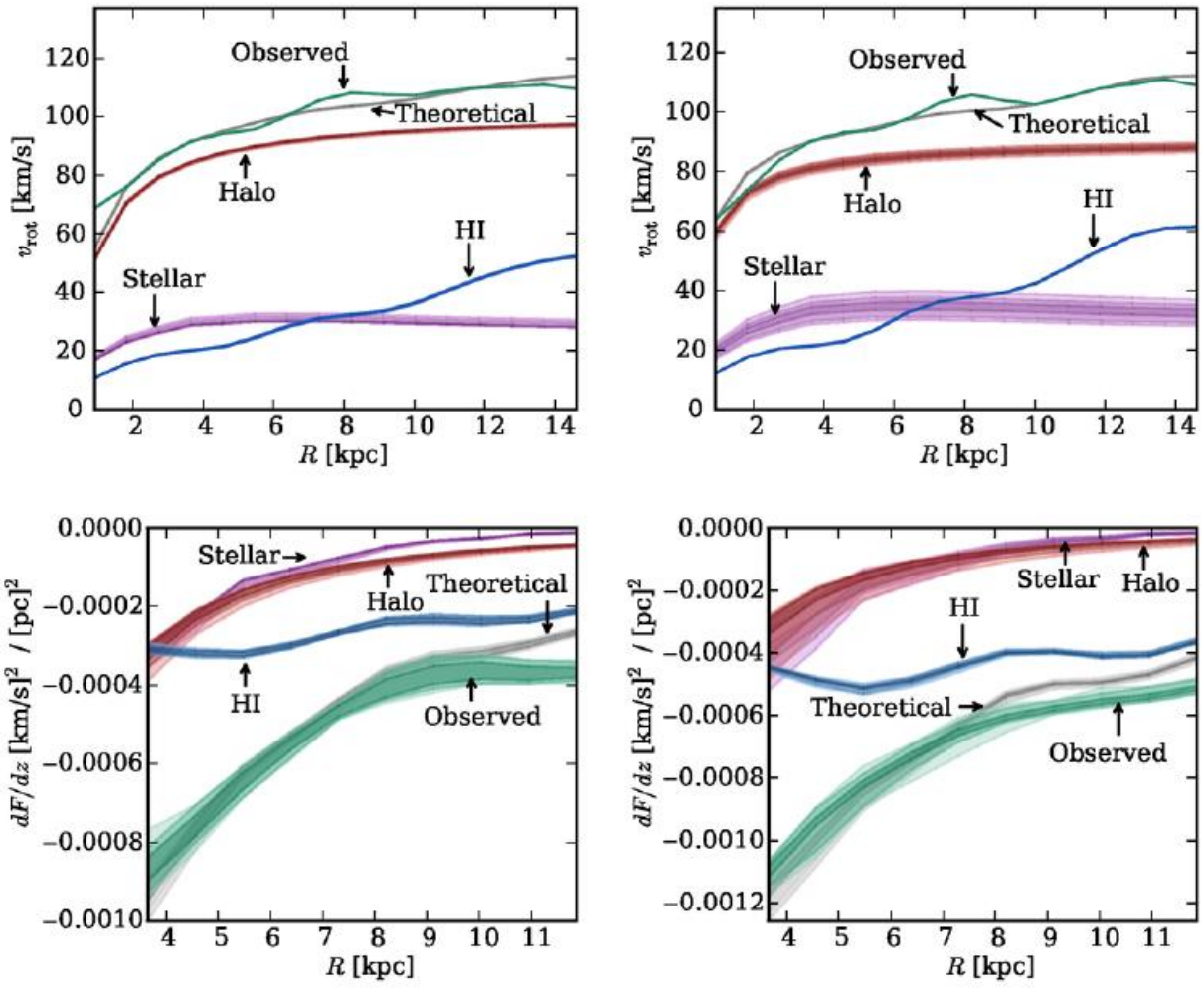
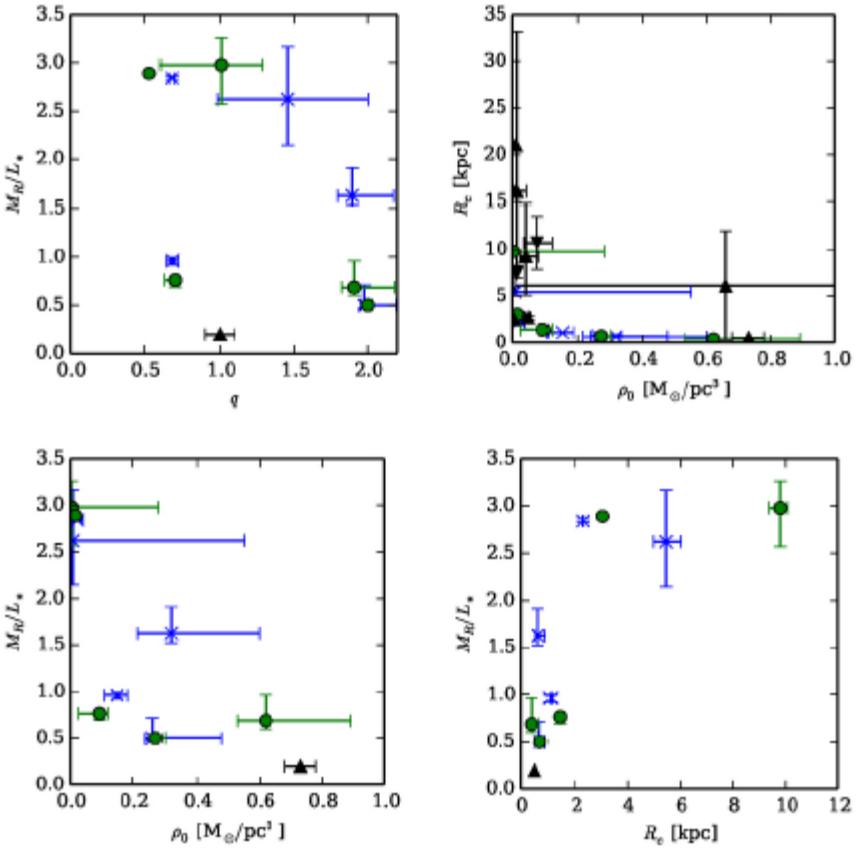


Figure 5. Rotation curve and vertical force gradient decomposition of ESO 138-G014. The left side panels show the results for the optically thin HI models, while the right side panels show the results for the self-absorption at $T_{\rm spin} = 100\,{\rm K}$ results.



Name	HI model	ρ_0 [$M_\odot$/pc^3]	R_c [kpc]	q	M_*/L_R
IC 5249	SA	$0.004^{+0.003}_{-0.001}$	$9.79^{+0.21}_{-2.06}$	$1.0^{+0.4}_{-0.3}$	$2.98^{+0.02}_{-1.17}$
IC 5249	OT	$0.007^{+0.005}_{-0.001}$	$5.45^{+0.21}_{-0.52}$	$1.5^{+0.5}_{-0.5}$	$2.62^{+0.38}_{-1.19}$
ESO 115-G021	SA	$0.015^{+0.001}_{-0.001}$	$3.02^{+0.03}_{-0.08}$	$0.5^{+0.1}_{-0.1}$	$2.89^{+0.11}_{-0.44}$
ESO 115-G021	OT	$0.022^{+0.004}_{-0.001}$	$2.30^{+0.10}_{-0.15}$	$0.7^{+0.1}_{-0.1}$	$2.84^{+0.16}_{-1.15}$
ESO 138-G014	SA	$0.620^{+0.009}_{-0.007}$	$0.41^{+0.02}_{-0.01}$	$1.9^{+0.1}_{-0.3}$	$0.69^{+0.04}_{-0.06}$
ESO 138-G014	OT	$0.261^{+0.002}_{-0.003}$	$0.70^{+0.02}_{-0.01}$	$2.0^{+0.1}_{-0.2}$	$0.50^{+0.02}_{-0.01}$
ESO 274-G001	SA	$0.094^{+0.009}_{-0.019}$	$1.42^{+0.09}_{-0.03}$	$0.7^{+0.1}_{-0.1}$	$0.76^{+0.57}_{-0.26}$
ESO 274-G001	OT	$0.150^{+0.020}_{-0.022}$	$1.10^{+0.04}_{-0.03}$	$0.7^{+0.1}_{-0.1}$	$0.96^{+0.46}_{-0.42}$
UGC 7321	SA	$0.270^{+0.001}_{-0.001}$	$0.72^{+0.01}_{-0.01}$	$2.0^{+0.1}_{-0.1}$	$0.50^{+0.02}_{-0.01}$
UGC 7321	OT	$0.318^{+0.064}_{-0.042}$	$0.64^{+0.03}_{-0.02}$	$1.9^{+0.1}_{-0.3}$	$1.63^{+0.48}_{-0.66}$

Table 1. Measured parameters for the various haloes. OT denotes the optically thin HI models, while SA denotes the self-absorbing HI

Выводы

- Учет HI self-absorption приводит к менее плотному и более протяженному галою
- Среднее q=1.0\pm0.6, а без учета – 1.5\pm0.6.
- Галактики с измеренной дисперсией скоростей HI:
- ESO274-G001 q = 0.7\pm0.1
- UGC7321 q = 2.0\pm0.1

Проблемная галактика – HI halo.