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От Сильченко О.К.

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PROBING THE HOT X-RAY CORONA AROUND THE MASSIVE SPIRAL GALAXY, NGC 6753, USING DEEP XMM-NEWTON OBSERVATIONS

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ABSTRACT

X-ray emitting gaseous coronae around massive galaxies are a basic prediction of galaxy formation models. Although the coronae around spiral galaxies offer a fundamental test of these models, observational constraints on their characteristics are still scarce. While the presence of extended hot coronae has been established around a handful of massive spiral galaxies, the short X-ray observations only allowed to measure the basic characteristics of the coronae. In this work, we utilize deep *XMM-Newton* observations of NGC 6753 to explore its extended X-ray corona in unprecedented detail. Specifically, we establish the isotropic morphology of the hot gas, suggesting that it resides in hydrostatic equilibrium. The temperature profile of the gas shows a decrease with increasing radius: it drops from $kT \approx 0.7$ keV in the innermost parts to $kT \approx 0.4$ keV at 50 kpc radius. The temperature map reveals the complex temperature structure of the gas. We study the metallicity distribution of the gas, which is uniform at $Z \approx 0.1$ Solar. This value is about an order of magnitude lower than that obtained for elliptical galaxies with similar dark matter halo mass, hinting that the hot gas in spiral galaxies predominantly originates from external gas inflows rather than from internal sources. By extrapolating the density profile of the hot gas out to the virial radius, we estimate the total gas mass and derive the total baryon mass of NGC 6753. We conclude that the baryon mass fraction is $f_{\mathrm{b}} \approx 0.06$, implying that about half of the baryons are missing.

NGC 6753

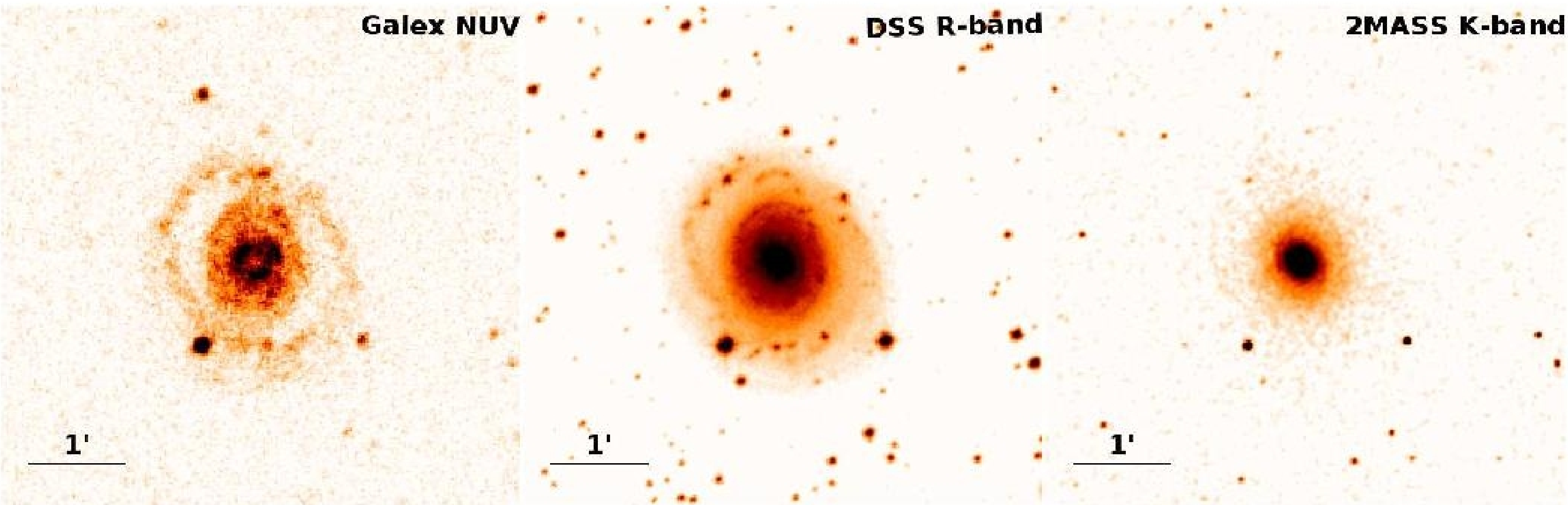
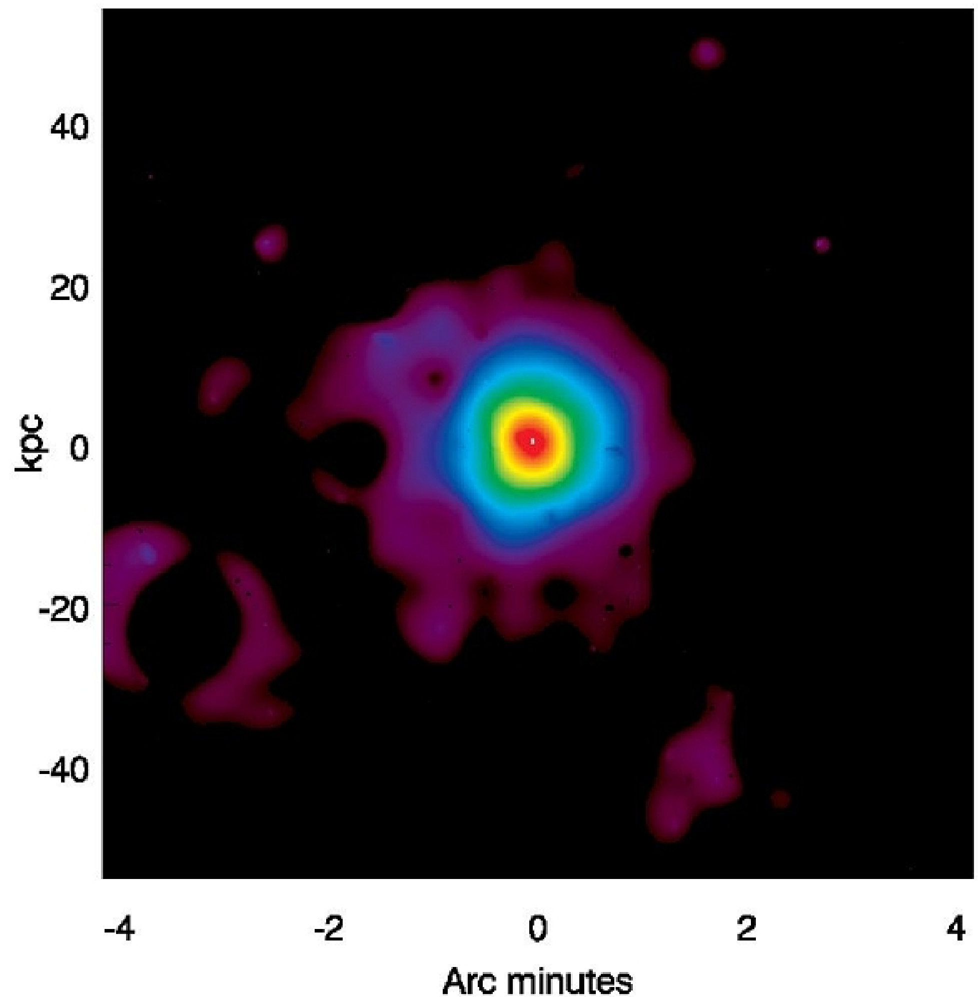
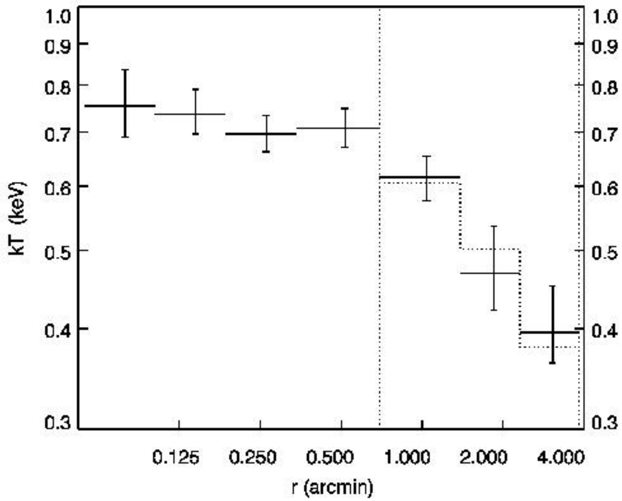


FIG. 1.— Multi-wavelength images of NGC 6753. The star-formation activity is traced by the near-ultraviolet image taken by *Galex* (left panel). The image reveals the presence of two star-forming rings: the inner one at about $0.2'$ (≈ 2.5 kpc) and the outer one at $1'$ (≈ 12.5 kpc) from the center. The *DSS* R-band image shows the stellar light distribution (middle panel). The star-formation activity seen on the *Galex* near-ultraviolet image is associated with the spiral arms of the galaxy. The *2MASS* K-band image traces the old stellar population, hence the K-band image is more compact than the R-band image and the bulge of NGC 6753 is the most pronounced. All three images reveal that the stellar light and the associated star-formation does not extend beyond $1.2'$ (≈ 15 kpc).

Она же в рентгене



Профиль температуры и металличности



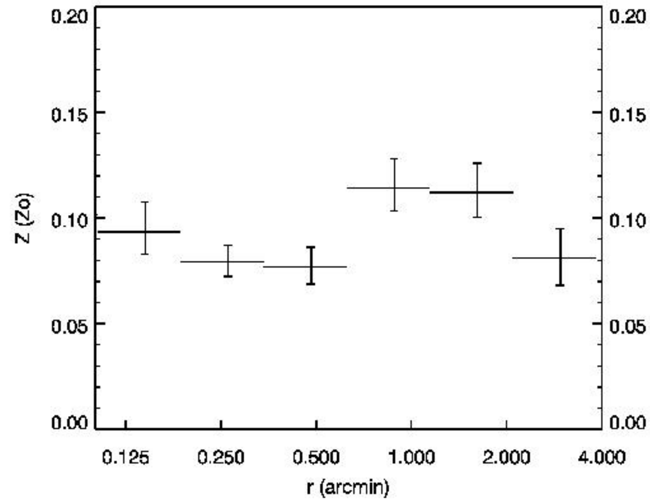


TABLE 3
BEST-FIT PARAMETERS OF THE SPECTRAL FITS.

Region (arcmin)	kT (keV)	$Z_\odot$ (Solar)
$0.055 - 0.102$	$0.75^{+0.08}_{-0.06}$	$0.102^{+0.021}_{-0.016}$
$0.102 - 0.187$	$0.74^{+0.05}_{-0.04}$	$0.094^{+0.012}_{-0.010}$
$0.187 - 0.344$	$0.70^{+0.04}_{-0.04}$	$0.079^{+0.007}_{-0.007}$
$0.344 - 0.694$	$0.71^{+0.04}_{-0.03}$	$0.077^{+0.009}_{-0.007}$
$0.694 - 1.381$	$0.61^{+0.04}_{-0.04}$	$0.118^{+0.013}_{-0.011}$
$1.381 - 2.314$	$0.47^{+0.08}_{-0.05}$	$0.124^{+0.019}_{-0.016}$
$2.314 - 3.837$	$0.39^{+0.09}_{-0.03}$	$0.075^{+0.014}_{-0.012}$

А что тут с космологической барионной плотностью?

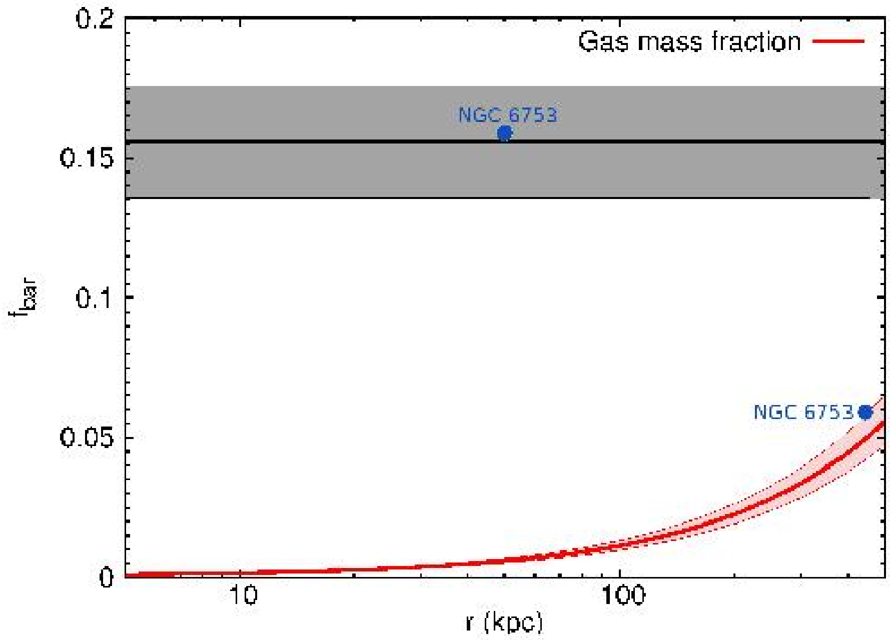


FIG. 10.— Gas mass fraction as a function of radius for NGC 6753. Note that the curve only includes the hot gas mass and other baryonic components are excluded. The shaded area represents the statistical uncertainties. The solid horizontal line and the shaded area correspond to the cosmic baryon mass fraction based on the Planck Collaboration et al. (2016). We show the total baryon mass fraction (including all baryonic components) of NGC 6753 within 50 kpc and within 440 kpc. Within 50 kpc the stellar mass dominates while the dark matter contributes to a lesser extent (see Figure 9), which results in $f_b \approx 0.16$. Within 440 kpc the baryon mass fraction falls short of the cosmic value.

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THE CIRCUM-GALACTIC MEDIUM OF MASSIVE SPIRALS II: PROBING THE NATURE OF HOT GASEOUS HALO AROUND THE MOST MASSIVE ISOLATED SPIRAL GALAXIES

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ABSTRACT

We present the analysis of the *XMM-Newton* data of the Circum-Galactic Medium of MASsive Spirals (CGM-MASS) sample of six extremely massive spiral galaxies in the local Universe. All the CGM-MASS galaxies have diffuse X-ray emission from hot gas detected above the background extending $\sim(30-100)$ kpc from the galactic center. This doubles the existing detection of such extended hot CGM around massive spiral galaxies. The radial soft X-ray intensity profile of hot gas can be fitted with a β-function with the slope typically in the range of $\beta = 0.35-0.55$. This range, as well as those β values measured for other massive spiral galaxies, including the Milky Way (MW), are in general consistent with X-ray luminous elliptical galaxies of similar hot gas luminosity and temperature, and with those predicted from a hydrostatic isothermal gaseous halo. Hot gas in such massive spiral galaxy tends to have temperature comparable to its virial value, indicating the importance of gravitational heating. This is in contrast to lower mass galaxies where hot gas temperature tends to be systematically higher than the virial one. The ratio of the radiative cooling to free fall timescales of hot gas is much larger than the critical value of ~ 10 throughout the entire halos of all the CGM-MASS galaxies, indicating the inefficiency of gas cooling and precipitation in the CGM. The hot CGM in these massive spiral galaxies is thus most likely in a hydrostatic state, with the feedback material mixed with the CGM, instead of escaping out of the halo or falling back to the disk. We also homogenize and compare the halo X-ray luminosity measured for the CGM-MASS galaxies and other galaxy samples and discuss the "missing" galactic feedback detected in these massive spiral galaxies.

Выборка МАССИВНЫХ спиралей

TABLE 1
PROPERTIES OF THE CGM-MASS GALAXIES.

Galaxy	Scale kpc/arcm	M_* 10^{11} $M_\odot$	M_*/L_K $M_\odot/L_\odot$	SFR $M_\odot$ yr^{-1}	M_{TF} 10^{11} $M_\odot$
UGC 12591	27.45	$5.92^{+0.14}_{-0.74}$	0.773	1.17 ± 0.13	16.1 ± 1.5
NGC 669	22.63	$3.32^{+0.02}_{-0.17}$	0.893	0.77 ± 0.07	5.32
ESO142-G019	18.78	$2.49^{+0.05}_{-0.24}$	1.137	0.37 ± 0.06	5.07 ± 0.90
NGC 5908	15.10	$2.56^{+0.02}_{-0.15}$	0.842	3.81 ± 0.09	4.88 ± 0.60
UGCA 145	20.17	$1.47^{+0.01}_{-0.08}$	0.595	2.75 ± 0.11	4.03
NGC 550	27.09	$2.58^{+0.04}_{-0.28}$	0.773	0.38 ± 0.09	5.08 ± 1.81

Личики

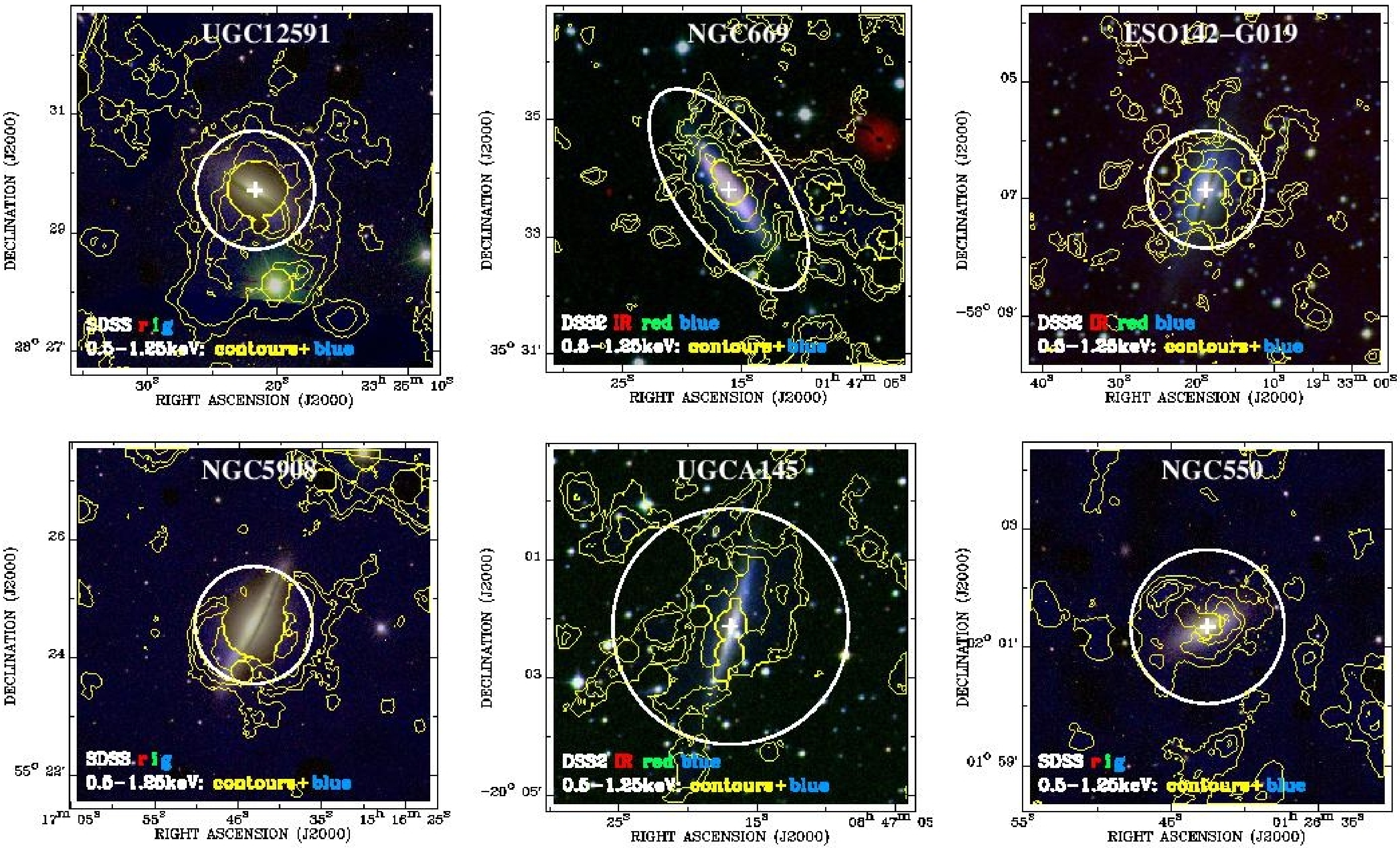
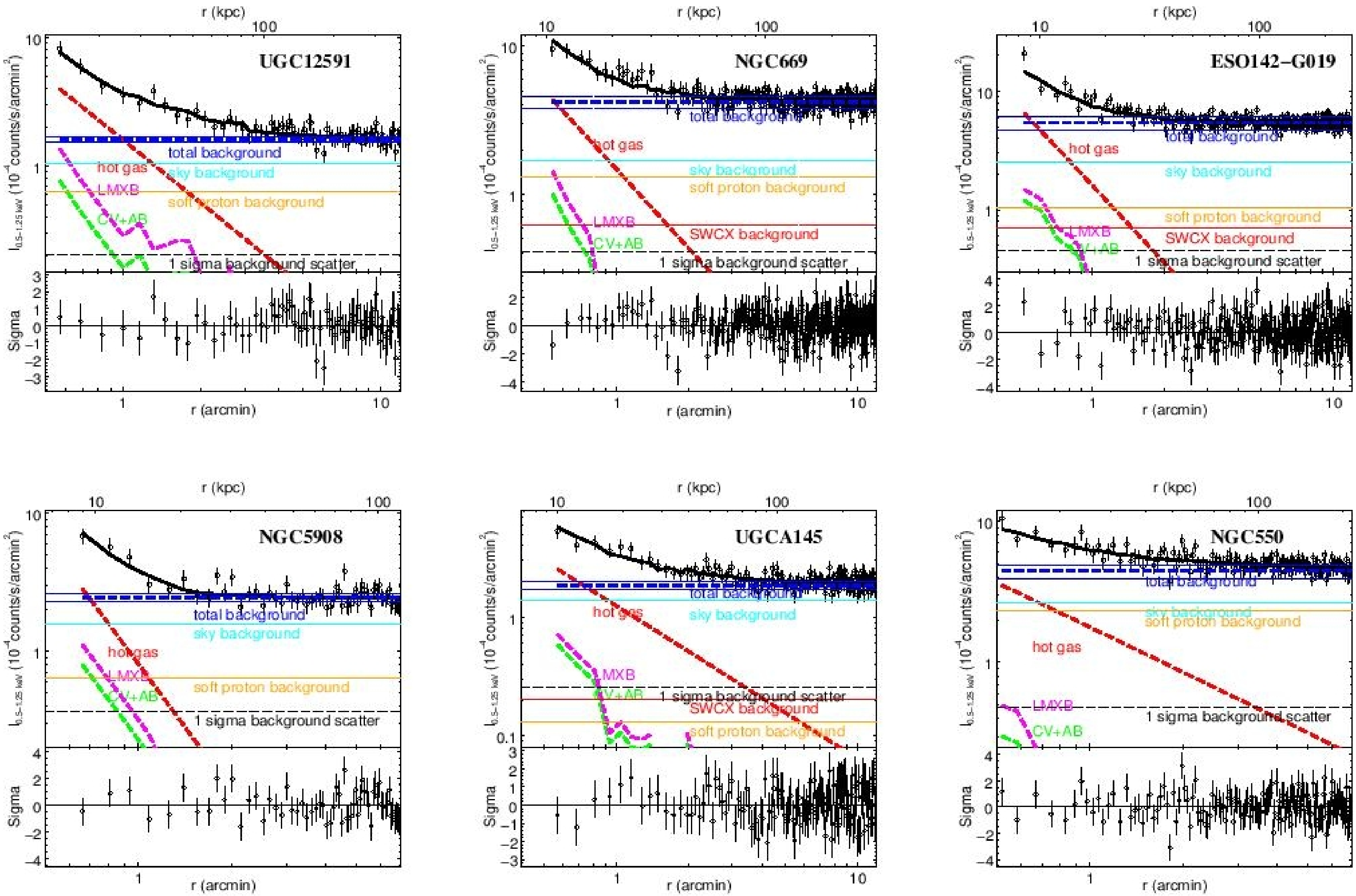


FIG. 1.— X-ray contours overlaid on the DSS or SDSS optical tri-color images of the central 6′ × 6′ of the sample galaxies. Contours are the diffuse soft X-ray images at different rms noise levels above the background: 5, 10, 20, 30 σ for UGC 12591; 3, 5, 10, 20 σ for NGC 669

Профили в рентгене; красное – горячее газовое гало



Параметры горячих газовых гало; на этот раз – без металличности

TABLE 3
Derived Parameters of the Hot Gas Component

Galaxy	n_0	P_0	$t_{\rm cool,0}$	$M_{\rm hot,r<r_{200}}$	$E_{\rm hot,r<r_{200}}$	$r_{\rm cool}$	$N_{\rm p,0}$	$\dot{M}_{\rm cool,r<r_{cool}}$
	$10^{-3}f^{-1/2}{\rm cm}^{-3}$	$f^{-1/2}{\rm eV\ cm}^{-3}$	$f^{1/2}{\rm Gyr}$	$10^{11}f^{1/2}{\rm M}_\odot$	$10^{59}f^{1/2}{\rm erg}$	kpc	$10^{20}f^{-1/2}{\rm cm}^{-2}$	${\rm M}_\odot\ {\rm yr}^{-1}$
UGC 12591	$7.53^{+3.45}_{-1.82}$	$12.79^{+5.97}_{-3.41}$	$1.51^{+0.39}_{-0.71}$	$3.08^{+1.41}_{-0.74}$	$11.85^{+5.53}_{-3.16}$	$11.17^{+15.05}_{-8.37}$	$4.84^{+3.77}_{-1.74}$	$0.062^{+0.041}_{-0.022}$
NGC 669	$8.33^{+2.73}_{-1.65}$	$11.20^{+3.91}_{-2.73}$	$1.08^{+0.25}_{-0.39}$	$1.05^{+0.34}_{-0.21}$	$3.19^{+1.11}_{-0.78}$	$10.86^{+3.91}_{-2.81}$	$3.66^{+1.65}_{-1.00}$	$0.054^{+0.026}_{-0.017}$
ESO142-G019	$16.73^{+8.43}_{-4.09}$	$22.63^{+11.56}_{-6.41}$	$0.54^{+0.14}_{-0.28}$	$0.61^{+0.31}_{-0.15}$	$1.88^{+0.96}_{-0.53}$	$11.49^{+2.14}_{-2.24}$	$4.43^{+2.48}_{-1.31}$	$0.10^{+0.07}_{-0.04}$
NGC 5908	$46.26^{+105.04}_{-17.78}$	$34.48^{+97.77}_{-15.58}$	$0.11(<0.30)$	$0.14^{+0.33}_{-0.06}$	$0.24^{+0.69}_{-0.11}$	$13.85^{+4.91}_{-6.43}$	$6.60^{+15.13}_{-2.87}$	$0.37(<1.55)$
UGCA 145	$4.76^{+1.47}_{-0.95}$	$10.22^{+3.59}_{-2.46}$	$3.02^{+0.79}_{-1.02}$	$1.46^{+0.45}_{-0.29}$	$7.08^{+2.49}_{-1.71}$	$5.37(<91.24)$	$4.49^{+10.04}_{-1.94}$	$0.006^{+0.003}_{-0.002}$
NGC 550	$3.04^{+1.26}_{-0.74}$	$5.15^{+2.17}_{-1.44}$	$3.75^{+0.96}_{-1.64}$	$1.98^{+0.82}_{-0.48}$	$7.59^{+3.20}_{-2.13}$	$6.45(<532.5)$	$14.72^{+19.85}_{-12.13}$	$0.007^{+0.004}_{-0.003}$

Время остывания большое!

Гидростатическое равновесие?

Лед тронулся: массивные спирали с горячими гало – уже выборка

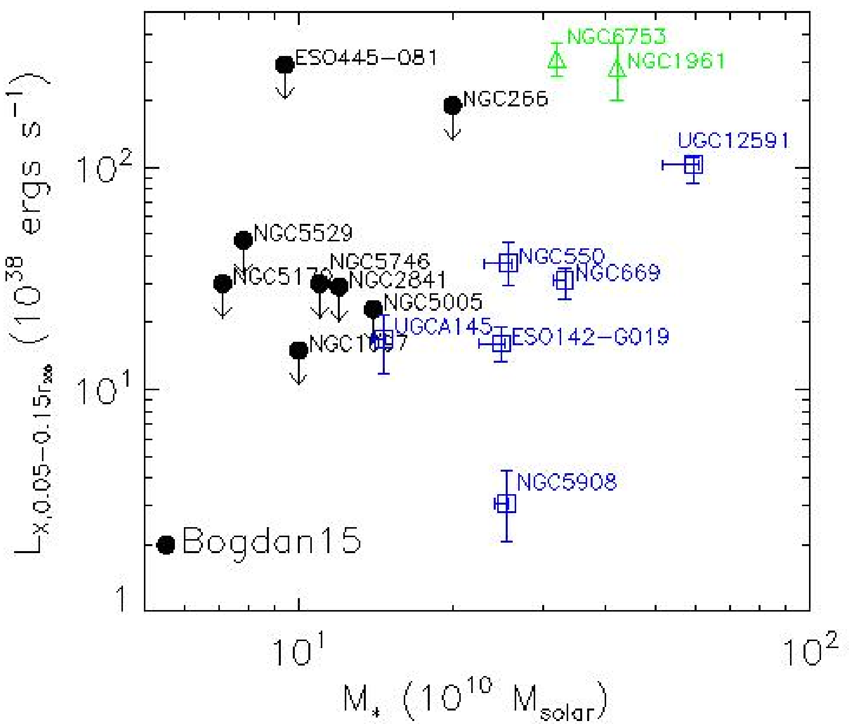


FIG. 6.— 0.5-2 keV luminosity measured in $r = (0.05 - 0.15)r_{200}$ ($L_{X,0.05-0.15r_{200}}$) v.s. stellar mass (M_*) of the CGM-MASS galaxies (blue boxes) and the massive spiral galaxies in Bogdán et al. (2015)'s sample (green triangles and black circles). All the galaxies in Bogdán et al. (2015), except for NGC 1961 and NGC 6753, have just upper limit constraint on the X-ray luminosity measured in this radial range. $L_{X,0.05-0.15r_{200}}$ of the CGM-MASS galaxies are estimated based on the luminosity measured in the spectral analysis region and the best-fit radial intensity profile (Table 3).