Обзор ArXiv/astro-ph, 29-31 марта 2021 года

От Сильченко О.К.

ArXiv: 2103.17246

Recovering the origins of the lenticular galaxy NGC 3115 using multi-band imaging

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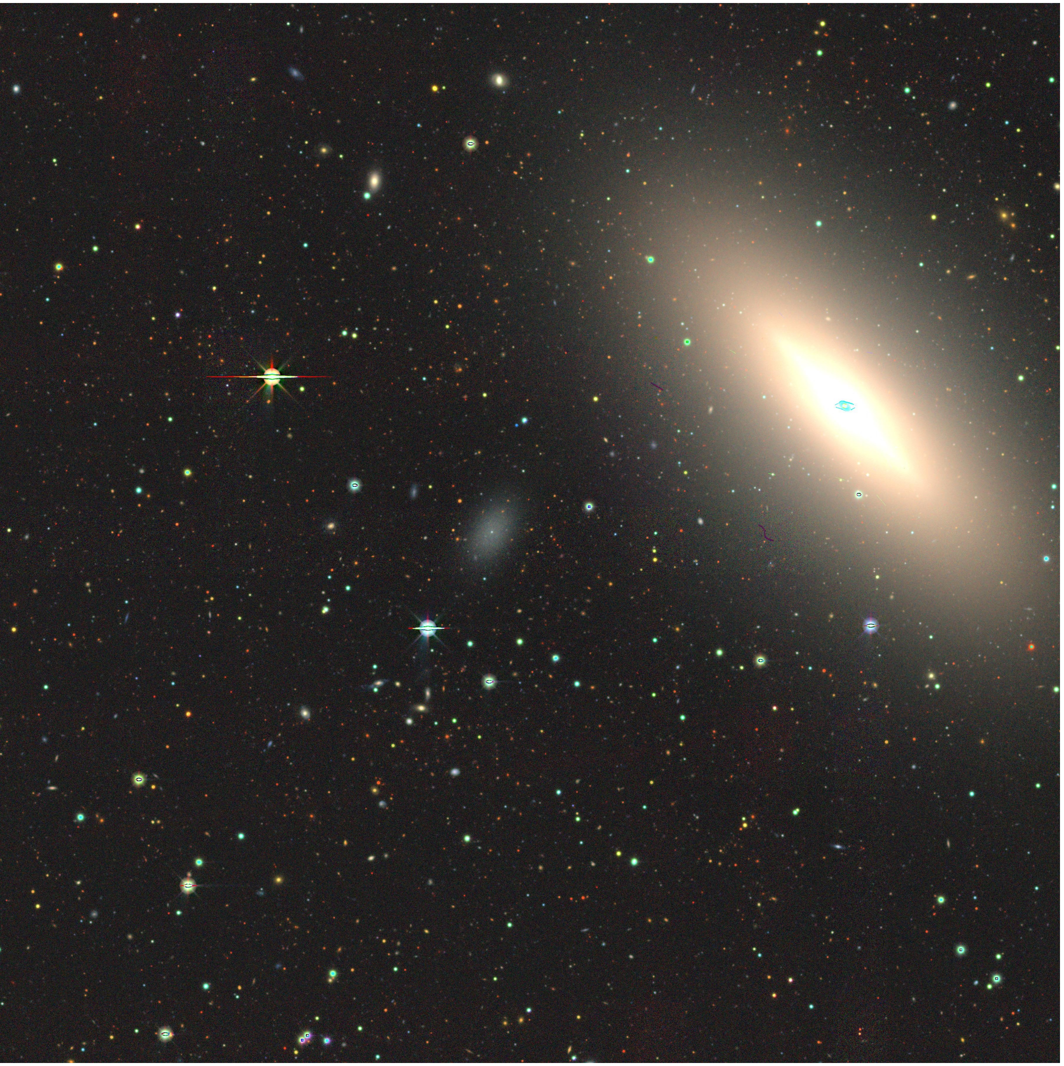
Accepted 2021 March 30. Received 2021 March 30; in original form 2020 December 31.

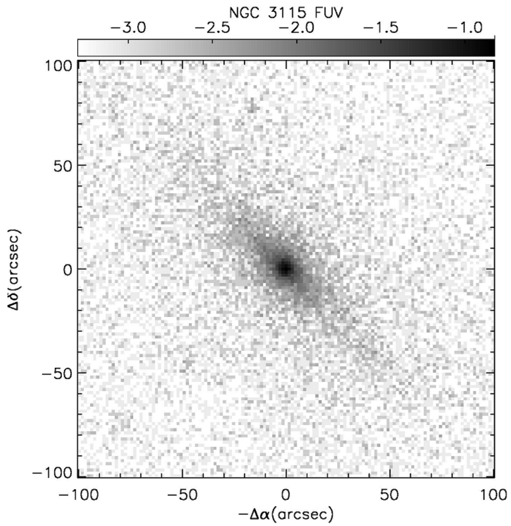
11 изображений NGC 3115

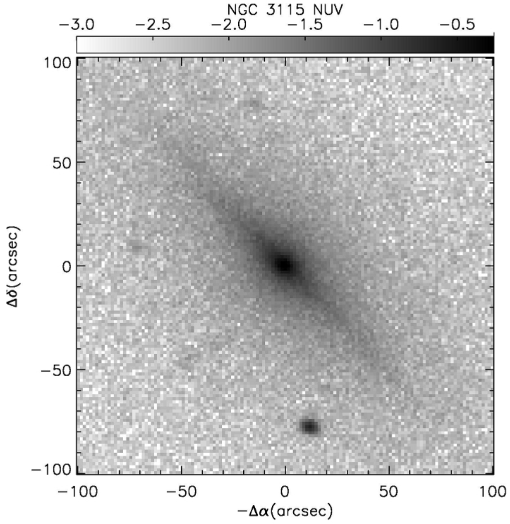
Table 1. Details about the archival data used in this work

Instrument	Band	λ (Å)	Pixel scale (")	Zero point
GALEX	FUV	1520	1.50	18.82
GALEX	NUV	2270	1.50	20.08
Subaru Suprime Cam	g	4770	0.20	30.47
Subaru Suprime Cam	r	6800	0.20	30.50
Subaru Suprime Cam	i	7630	0.20	31.50
DECam	z	9260	0.26	27.80
2MASS	J	12500	1.00	20.81
2MASS	H	16500	1.00	21.88
2MASS	Ks	21700	1.00	21.87
WISE	3.4	34000	2.75	23.20
WISE	4.6	46000	2.75	22.84

NGC 3115 – что это за S0?



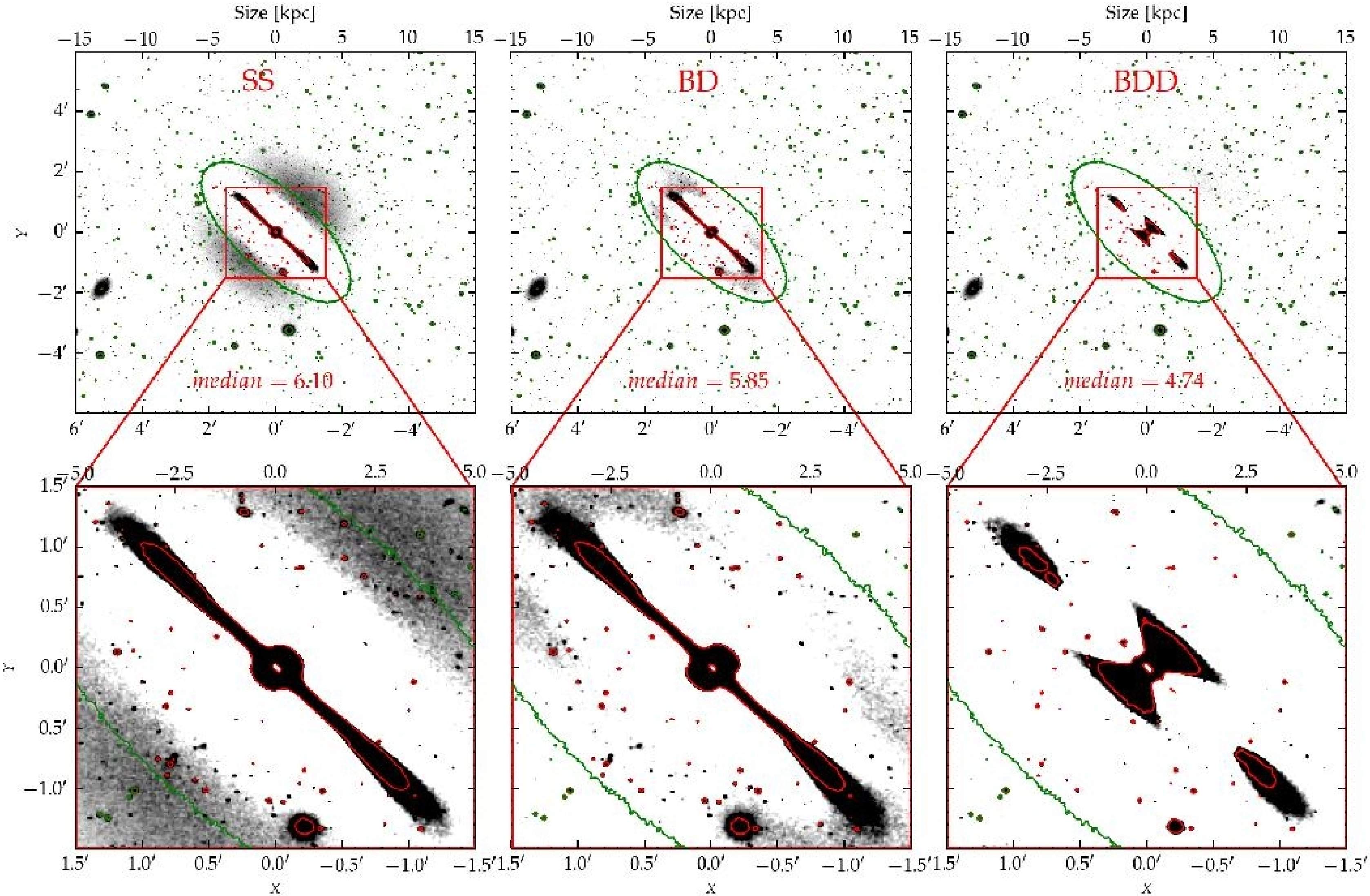




GALFITM

- Одновременная декомпозиция в разных длинах волн: решаем, сколько будет структурных компонент, делаем начальные «догадки» об их параметрах, ищется степенная зависимость параметров структур от длины волны.
- Полагаем, что НЕТ градиентов цвета внутри структурных компонент.

Как принимается решение о числе компонент?



«Начальные догадки» от SUBARU, большинство параметров фиксируются

Table 2. Results from best fit model of NGC 3115. The table shows the parameters that define the best fit of each component of the galaxy: bulge, outer spheroid and thin disc. The order of the series of each parameter are shown in the third line of the table and describe how each parameter can vary with wavelength. See section §3.1

	Bulge					Thick Disc					Thin disc				
	mag (AB)	n	Re (")	b/a	PA	mag (AB)	n	Rs (")	b/a	PA	mag (AB)	n	Rs (")	b/a	PA
Orders	9	1	1	1	1	9	0	2	1	1	9	0	2	1	1
FUV	15.07 ± 1.49	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	15.55 ± 0.51	1	61.17 ± 0.10	0.45 ± 0.01	43.42 ± 0.02	15.18 ± 0.41	1	23.13 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
NUV	15.73 ± 0.72	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	15.25 ± 0.72	1	61.60 ± 0.12	0.45 ± 0.01	43.42 ± 0.02	15.45 ± 0.60	1	23.50 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
g	12.33 ± 0.02	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	10.56 ± 0.02	1	63.05 ± 0.09	0.45 ± 0.01	43.42 ± 0.02	11.47 ± 0.01	1	24.74 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
r	11.38 ± 0.02	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	9.61 ± 0.01	1	64.22 ± 0.08	0.45 ± 0.01	43.42 ± 0.02	10.36 ± 0.01	1	25.75 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
i	11.30 ± 0.03	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	9.56 ± 0.01	1	64.70 ± 0.08	0.45 ± 0.01	43.42 ± 0.02	10.30 ± 0.02	1	26.16 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
z	11.35 ± 0.02	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	9.30 ± 0.04	1	65.64 ± 0.08	0.45 ± 0.01	43.42 ± 0.02	9.97 ± 0.02	1	26.96 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
J	10.74 ± 0.14	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	7.45 ± 0.01	1	67.51 ± 0.06	0.45 ± 0.01	43.42 ± 0.02	7.56 ± 0.01	1	28.57 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
H	8.14 ± 0.01	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	8.62 ± 0.01	1	69.82 ± 0.05	0.45 ± 0.01	43.42 ± 0.02	9.37 ± 0.02	1	30.55 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
Ks	8.23 ± 0.02	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	8.82 ± 0.01	1	72.83 ± 0.04	0.45 ± 0.01	43.42 ± 0.02	9.93 ± 0.03	1	33.12 ± 0.02	0.22 ± 0.01	44.83 ± 0.02
3.4	8.33 ± 0.02	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	8.73 ± 0.01	1	79.93 ± 0.04	0.45 ± 0.01	43.42 ± 0.02	9.82 ± 0.01	1	39.21 ± 0.03	0.22 ± 0.01	44.83 ± 0.02
4.6	9.06 ± 0.03	3.50 ± 0.01	21.68 ± 0.02	0.44 ± 0.01	44.19 ± 0.01	9.39 ± 0.01	1	86.86 ± 0.08	0.45 ± 0.01	43.42 ± 0.02	10.22 ± 0.01	1	45.16 ± 0.04	0.22 ± 0.01	44.83 ± 0.02

Суммарные профили сравниваются с наблюдаемыми

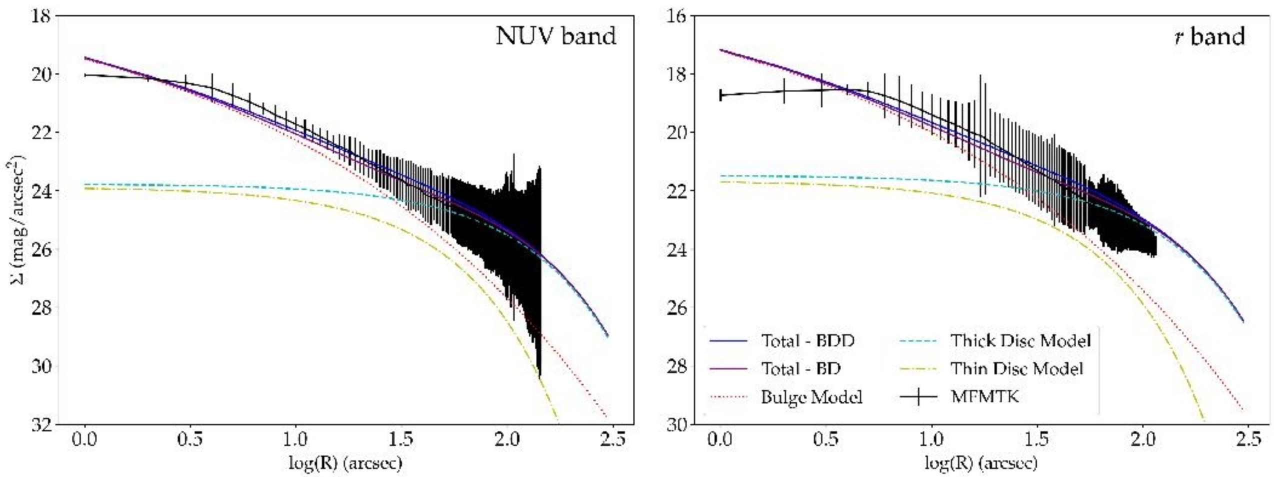


Figure 4. Surface density profiles of NGC 3115 and its components for two wavelength regimes: ultraviolet (NUV) and optical (r). Dotted red, cyan and yellow lines lines represent the extrapolation of the bulge (Sérsic), thick disc (exponential disc), and thin disc (exponential disc) fit performed with GALFITM to the stellar surface brightness data. The surface brightness profile as recovered with Morfometryka (MFMTK) fitting (black dotted line) and with GALFITM models with two (BD) and three (BDD) components (blue and magenta lines, respectively) overlap until the faint outskirts in NUV and from 60 arcsec in the optical.

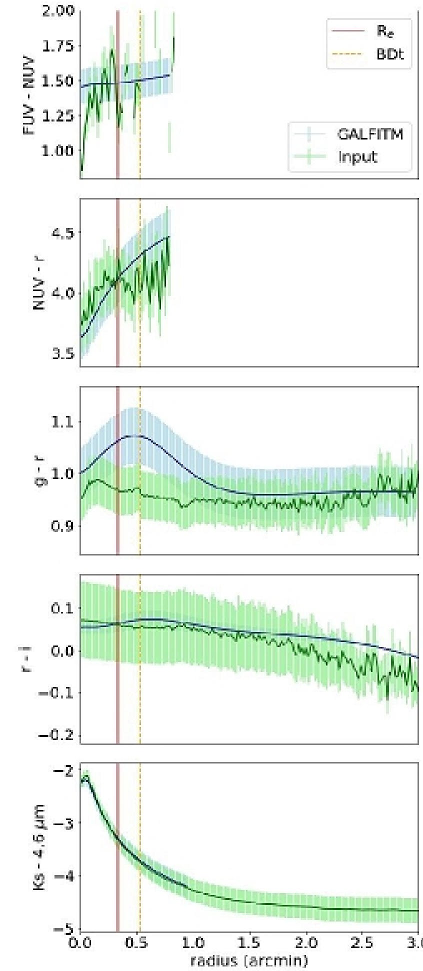


Figure 5. Colour across semi-major axis for NGC 3115, using colours in different wavelength ranges. UV: FUV-NUV and NUV-r, optical: g-r and r-i, near-IR: Ks-4.6 μm. The dark blue line reflects the GALFITM model colour measurements in each pixel from the centre to the outermost region of the galaxy, with shaded errors corresponding to 3σ, while the dark green line shows the colour gradient retrieved using the input images. The red vertical line highlights the place where the bulge ends according to our GALFITM

Фиттируют SED для каждого компонента

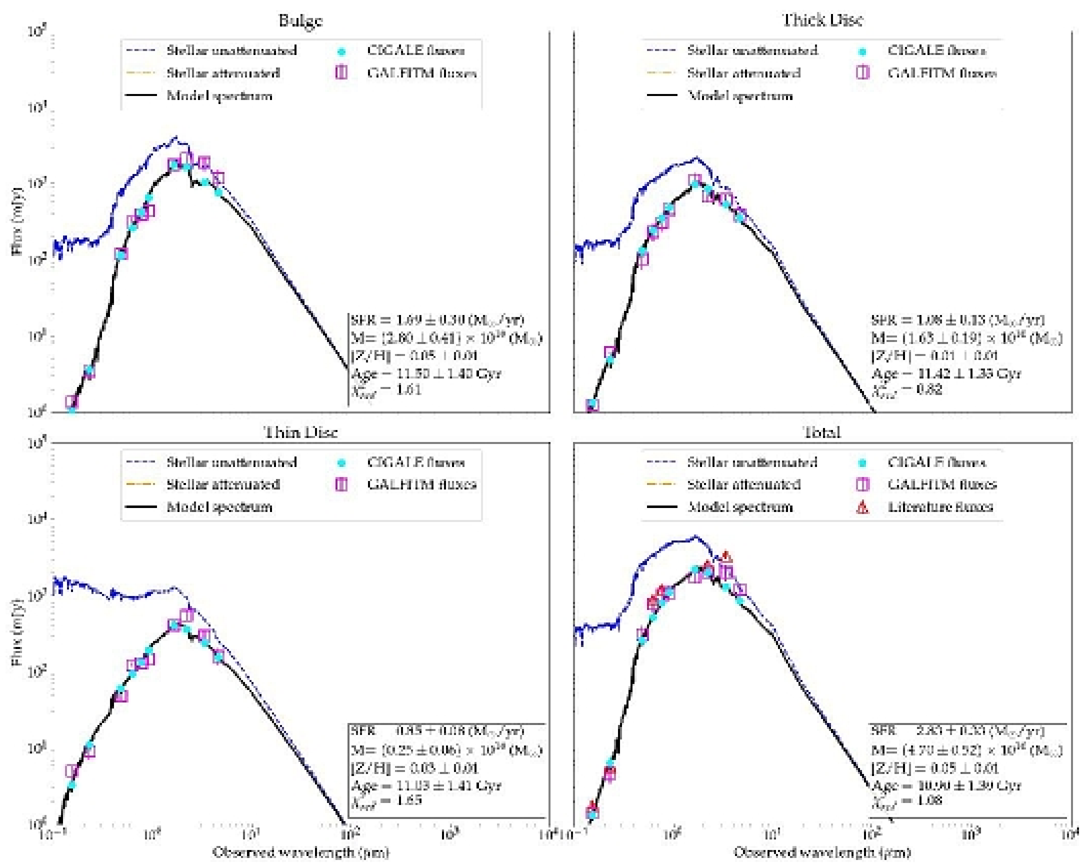


Figure 6. Spectral energy distribution of each subcomponent of NGC 3115: bulge, thick disc and thin disc, and the total model of the galaxy, respectively. In each panel, we show the retrieved physical properties. The blue squares stand for the input fluxes, the red dots are the model fluxes, the black line is the modelled spectrum, the orange line is the stellar attenuation, the red line is the dust emission and the blue dashed line is the stellar emission unattenuated.

Параметры фиттинга

Table 4. Parameters used in the SED fitting procedure with CIGALE

Parameter	Value
	Double exp. decreasing SFH
τ_{main} (Gyr)	9,10,11,12,13
f_{burst}	0.20
age_{burst} (Gyr)	0.1,1,2
τ_{burst} (Gyr)	1,5
	Simple Stellar Population - BC03
IMF	Chabrier (Chabrier 2003)
Metallicity [Z/H]	0.008, 0.02,0.05
	Dust attenuation
A_V (mag)	0.50, 1.0, 2.0, 3.0, 5.0
	AGN (Fritz et al. 2006)
τ	0.1,0.3
β	-0.75, -0.50, -0.25, 0.00
γ	0.0, 2.0, 4.0, 6.0
Opening angle (deg)	60., 100., 140
AGN fraction	0.001,0.1
# of models - without AGN	2160
# of models - with AGN	829440

Table 5. SED Fitting results obtained from CIGALE. The properties obtained with CIGALE are divided in three: containing AGN models in the fitting process, without AGN models, and including literature infrared data.

	Component	SFR ($M_\odot\,yr^{-1}$)	Z	$M_\star$ ($M_\odot$)	sSFR (yr^{-1})	Age (Gyr)
With AGN	Bulge	1.6 ± 0.4	0.05 ± 0.01	$(2.8 \pm 0.5) \times 10^{10}$	$(7.1 \pm 2.2) \times 10^{-11}$	11.2 ± 1.4
Without AGN	Bulge	1.7 ± 0.3	0.05 ± 0.01	$(2.8 \pm 0.4) \times 10^{10}$	$(6.0 \pm 1.4) \times 10^{-11}$	11.5 ± 1.4
	Thin disc	0.8 ± 0.1	0.03 ± 0.01	$(0.3 \pm 0.1) \times 10^{10}$	$(2.7 \pm 1.1) \times 10^{-10}$	11.0 ± 1.4
	Thick disc	1.1 ± 0.1	0.01 ± 0.01	$(1.6 \pm 0.2) \times 10^{10}$	$(9.2 \pm 2.4) \times 10^{-11}$	11.4 ± 1.3
	Total	2.8 ± 0.3	0.05 ± 0.01	$(4.7 \pm 0.5) \times 10^{10}$	$(6.0 \pm 0.9) \times 10^{-11}$	10.9 ± 1.4
With IR	Total	2.6 ± 0.3	0.05 ± 0.01	$(4.3 \pm 0.4) \times 10^{10}$	$(6.0 \pm 0.9) \times 10^{-11}$	11.2 ± 1.1
	ELLIPSE	2.3 ± 0.2	0.04 ± 0.02	$(3.6 \pm 0.7) \times 10^{10}$	$(6.4 \pm 1.3) \times 10^{-11}$	11.5 ± 1.1

Для балджа пробуют с AGN

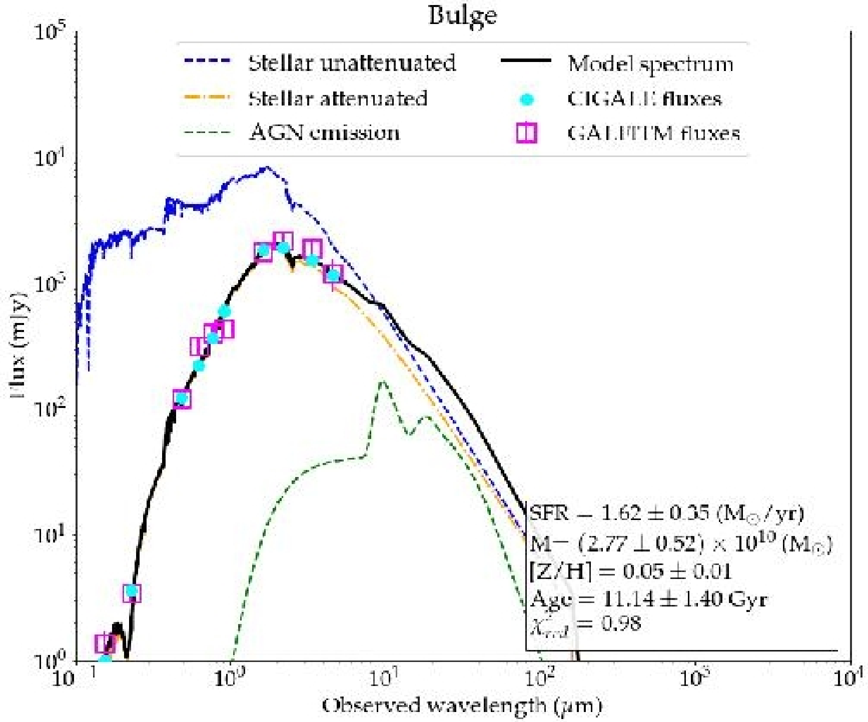
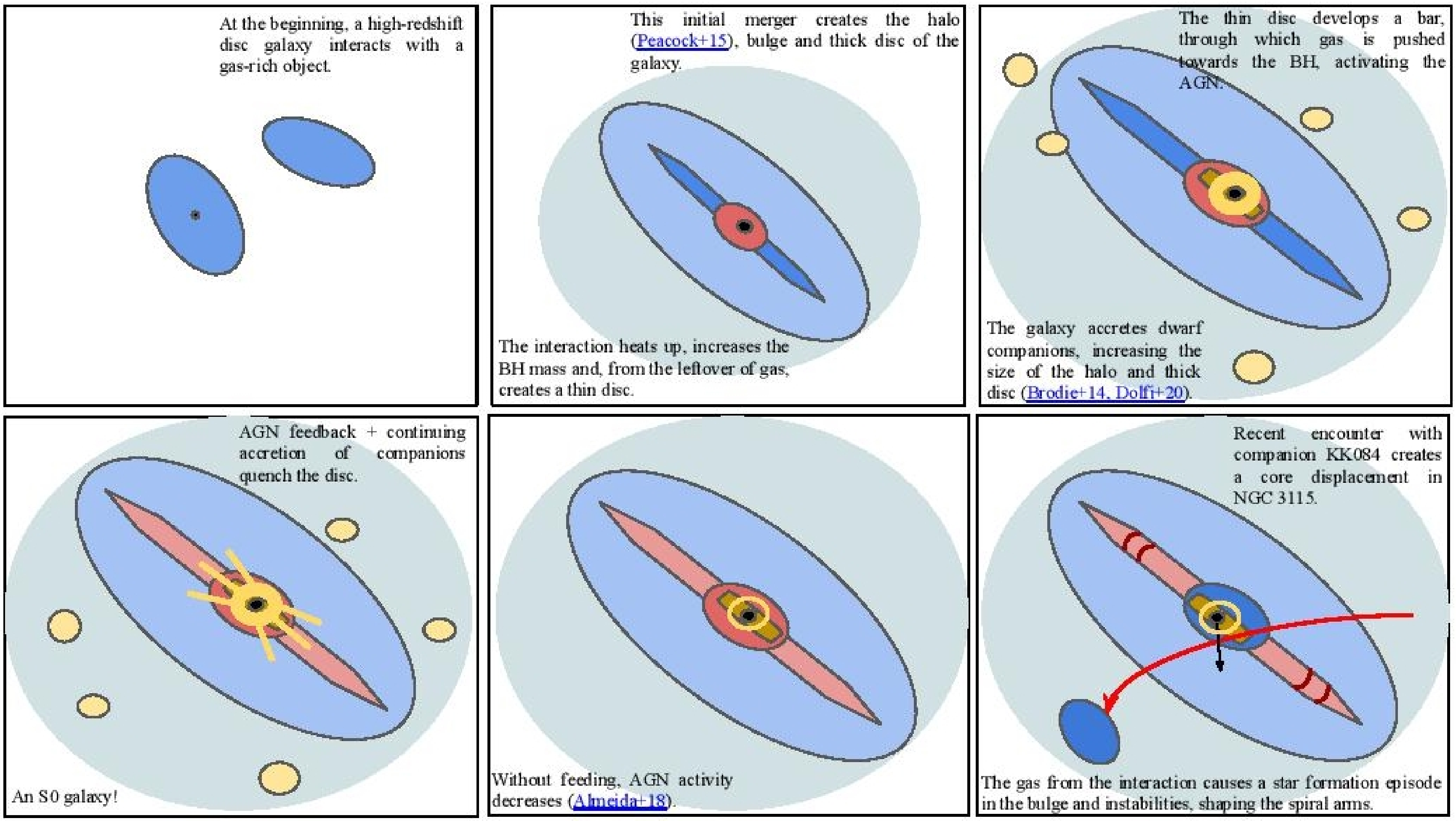


Figure 7. Spectral energy distribution of the bulge of NGC 3115 including AGN models. The blue squares stand for the input fluxes, the red dots are the model fluxes, the black line is the modelled spectrum, the orange line is the stellar attenuation, the red line is the dust emission, blue dashed line is the stellar emission unattenuated and green line is the AGN emission.

И, наконец, сценарий, большинство деталей которого ниоткуда не следуют



Насчет согласия с предшественниками – MUSE!

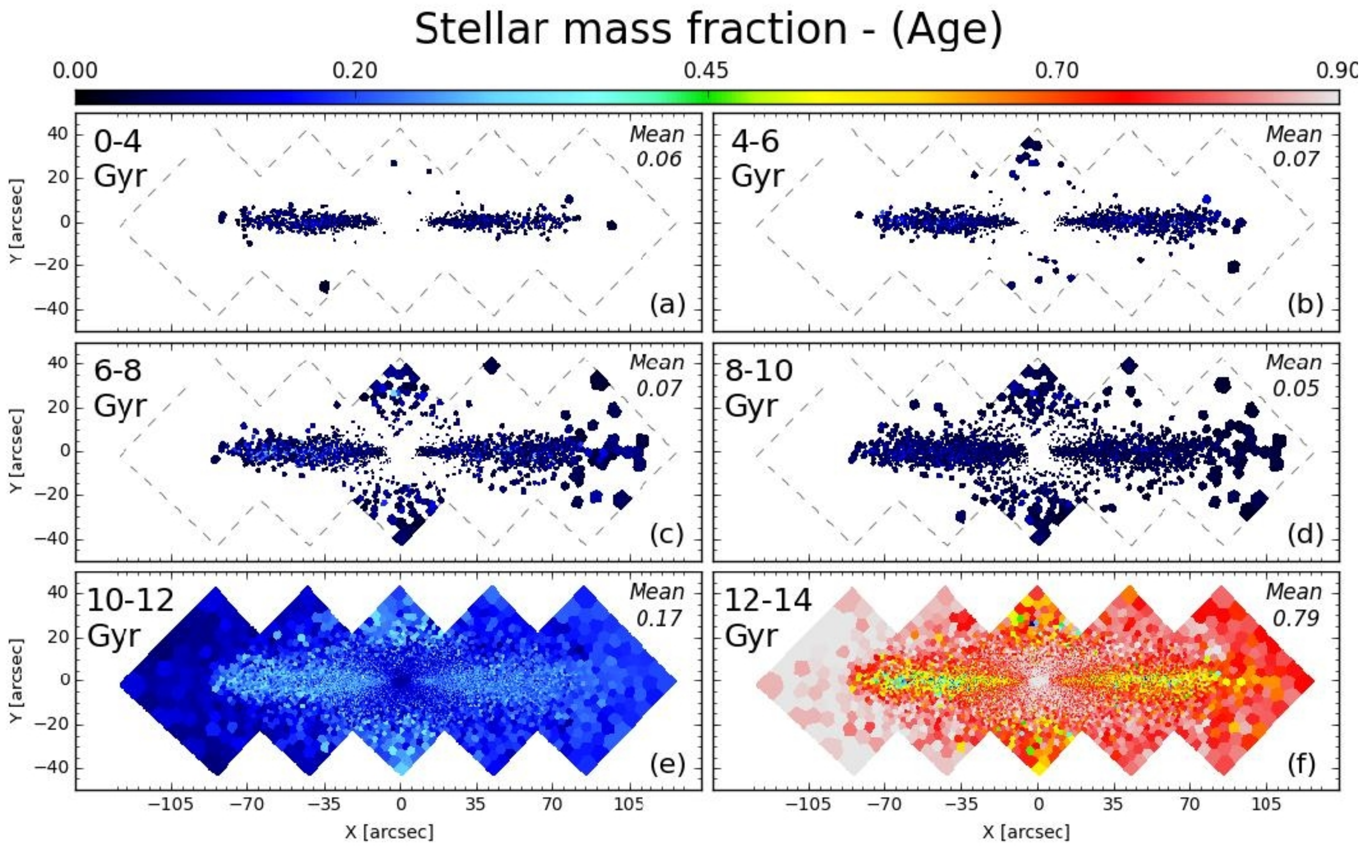


Fig. 7. Stellar mass fraction maps of NGC 3115 in six age bins, obtained by projecting the stellar model weighting distribution solution, obtain with pPXF, onto the grid parameters (Age, [Z/H]). For each panel, the age bin limits are indicated in the top left corner, the mean stellar ma fraction in the top right corner, and the colour scheme by the colour bar at the top of the figure. Spaxels containing a stellar mass fraction low

Guerou et al. 2016