

A spectral and photometric study of young massive star clusters and their complexes in spiral galaxies

Alexander S. GUSEV¹, Firouz SAKHIBOV², Anatoly E. PISKUNOV³, Nina V. KHARCHENKO⁴

¹Sternberg Astronomical Institute, Lomonosov Moscow University, Moscow, Russia

²University of Applied Sciences of Mittelhessen, Friedberg, Germany

³Institute of Astronomy, Russian Academy of Sciences, Moscow, Russia

⁴Main Astronomical Observatory of National Academy of Sciences of Ukraine, Kiev, Ukraine

gusev@sai.msu.ru

Goals: to define and study the physical parameters (masses, ages, sizes, chemical abundances) in unresolved young massive star clusters (YMCs) and their complexes, embedded in giant HII regions.

Observational data: Spectroscopy + Photometry (UBVRI) + Spectrophotometry (H α)

Galaxy	Type	B _r (mag)	M _g ⁰ (mag)	Inclination (degree)	PA (degree)	R ₂₅ ⁰ (arcmin)	R ₂₅ ¹ (kpc)	D (Mpc)	A(B) _{Gal} (mag)	A(B) _{in} (mag)
1	2	3	4	5	6	7	8	9	10	11
NGC 628	Sc	9.70	-20.72	7	25	5.23	10.96	7.2	0.254	0.04
NGC 783	Sc	13.18	-22.01	43	57	0.71	14.56	70.5	0.222	0.45
NGC 2336	SB(R)bc	11.19	-22.14	55	175	2.51	23.51	32.2	0.120	0.41
NGC 6217	SB(R)bc	11.89	-20.45	33	162	1.15	6.89	20.6	0.158	0.22
NGC 6946	SABc	9.75	-20.68	31	62	7.74	13.28	5.9	1.241	0.04
NGC 7331	Sbc	10.20	-21.68	75	169	4.89	20.06	14.1	0.531	0.61
NGC 7678	Sbc	12.50	-21.55	44	21	1.04	14.46	47.8	0.178	0.23

NGC	No. of objects
628	10
783	8
2336	28
6217	3
6946	39
7331	4
7678	10
total	102

Total: 102 YMCs/complexes in seven galaxies.

Method:

Spectroscopy → Z and gas absorption (A(gas)) in the HII regions associated with YMCs

Photometry → observed colours and luminosities of YMCs → correction for the nebular emission contribution in the photometric bands → correction for the interstellar reddening (A(stars)) → “true” colours and luminosities of YMCs

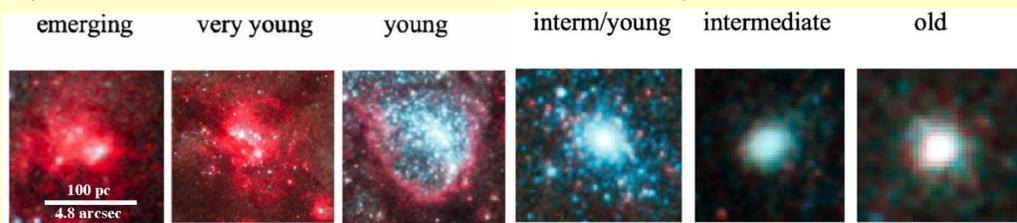
Evolutionary models → masses and ages

The main question: A(gas) vs. A(stars)?

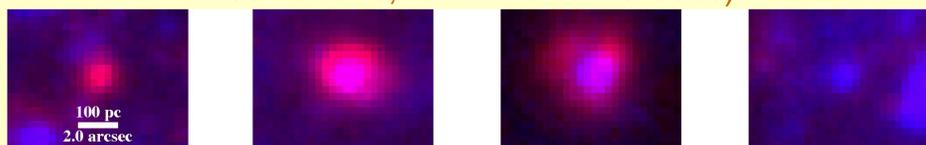
Cluster evolutionary sequence by Whitmore et al. (2011, ApJ, 729, 78)

– “resolved” YMCs

(HST observations, resolution ~0.1 arcsec):



Cluster evolutionary sequence – unresolved YMCs (ground observations, resolution ~1 arcsec):



H α emission only

A(gas)=A(stars) suspected

A(gas)>A(stars)

no H α emission

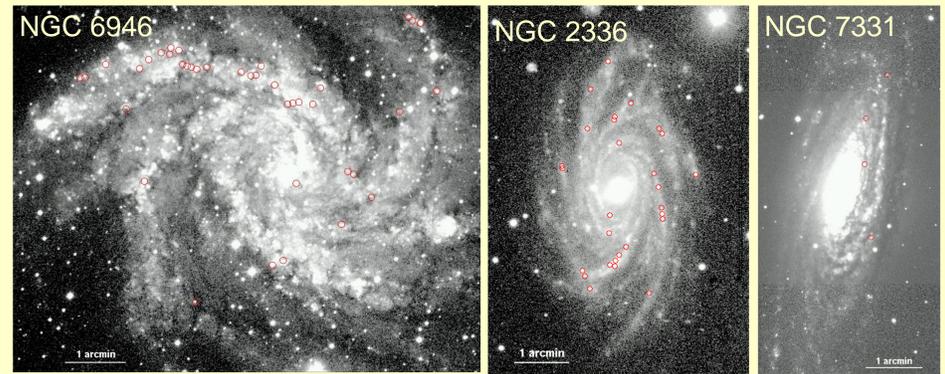
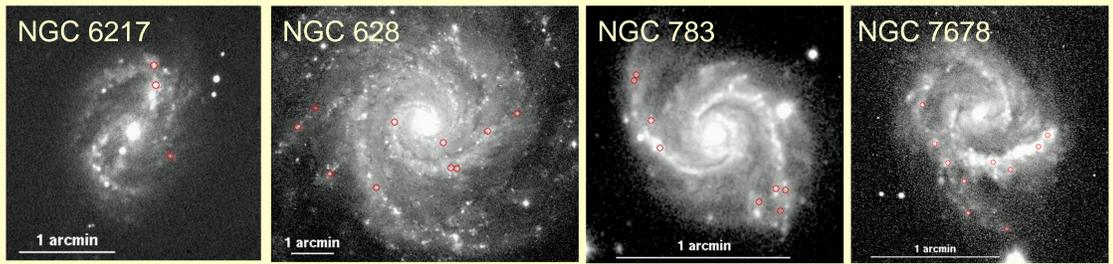
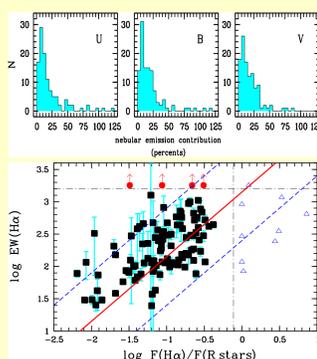
Tests:

i) nebular emission contribution in the B, V bands > 40% →

A(gas)≠A(stars)

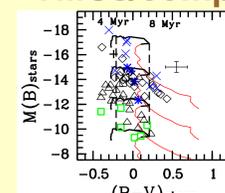
ii) log EW(H α) ≠

log [F(H α)/F(R_{stars})] + 3.15 → A(gas)≠A(stars)

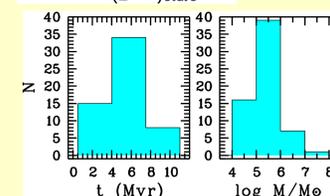


Results and Conclusions:

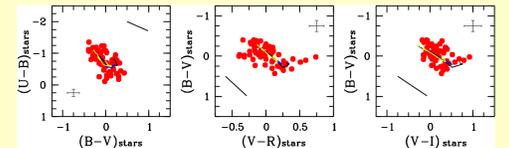
Estimates of ages for 57 and masses for 63 of 102 YMCs/complexes were obtained.



True colours and luminosities of SF regions in studied galaxies compared to SSP models. Different symbols are objects in different galaxies. The mean of the absolute error of true colour–magnitude values and evolutionary tracks for the models with Salpeter's IMF and Z = 0.012 are shown.



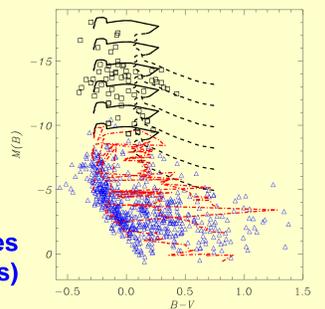
Frequency distribution of ages and masses of YMCs/complexes.



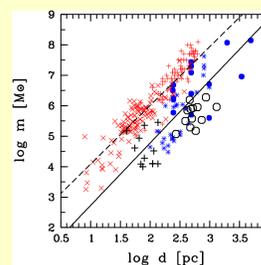
Colour-colour diagrams for the cluster complexes. Curves show SSP models with Salpeter IMF and Z = 0.019, 0.012, and 0.008. The mean accuracy of the colours of the objects and the extinction vector are shown.

Extragalactic YMCs and MW open star clusters represent a single evolutionary sequence of objects at different stages of their evolution.

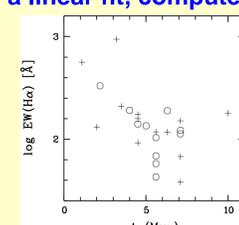
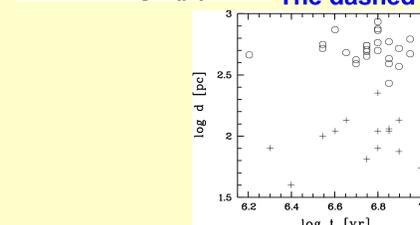
Colour-magnitude diagram for YMCs/complexes (black squares) and Galactic OCs (blue triangles) compared with different SSP models.



We confirm the uniform dependence “size – mass” for YMC complexes and GMCs, $m \sim d^2$.



The “size–mass” diagram for SF regions in nearby (YMCs, black crosses) and distant (YMC complexes, black circles) galaxies of our sample, YMC complexes in galaxies (blue filled circles and stars) by Adamo et al. (2013, ApJ, 766, 105), giant molecular clouds (GMCs) from Bolatto et al. (2008, ApJ, 686, 948) and Wei et al. (2012, ApJ, 750, 136) (red pluses and crosses). The solid line is a linear fit, computed for YMC complexes. The dashed line is a linear fit, computed for GMCs.



The “age–size” and “age–EW(H α)” diagrams for the studied SF regions in nearby (YMCs, crosses) and distant (YMC complexes, circles) galaxies.

See for detail

Gusev A.S., Sakhibov F., Piskunov A.E., Kharchenko N.V., Bruevich V.V., Ezhkova O.V., Guslyakova S.A., Lang V., Shimanovskaya E.V., Efremov Y.N. MNRAS, 457, 3334 (2016) [arXiv: 1601.07470]