A diffuse tidal dwarf galaxy destined to fade out as a "dark galaxy"

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ABSTRACT

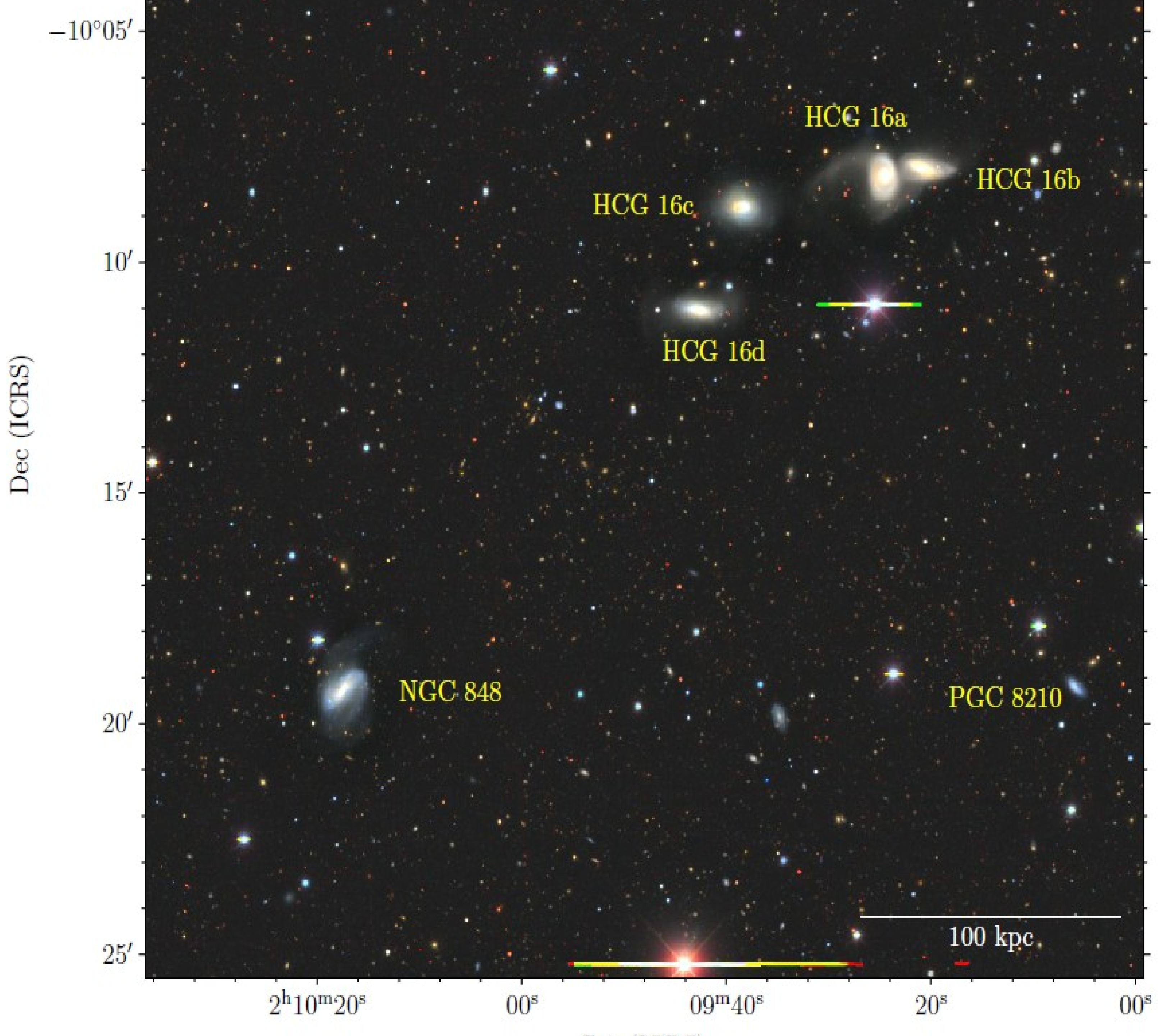
We have explored the properties of a peculiar object detected in deep optical imaging and located at the tip of an H I tail emerging from Hickson Compact Group 16. Using multiband photometry from infrared to ultraviolet, we were able to constrain its stellar age to 58^{+22}_{-9} Myr with a rather high metallicity of [Fe/H] = $-0.16^{+0.43}_{-0.41}$ for its stellar mass of $M_\star = 4.2\times10^6$ $M_\odot$, a typical signature of tidal dwarf galaxies. The structural properties of this object are similar to those of diffuse galaxies, with a round and featureless morphology, a large effective radius (r_{eff} = 1.5 kpc), and a low surface brightness ($<\mu_g>_{eff}$ = 25.6 mag arcsec^{-2}). Assuming that the object is dynamically stable and able to survive in the future, its fading in time via the aging of its stellar component will make it undetectable in optical observations in just ~2 Gyr of evolution, even in the deepest current or future optical surveys. Its high H I mass, M(HI) = 3.9×10^8 $M_\odot$, and future undetectable stellar component will make the object match the observational properties of dark galaxies, that is, dark matter halos that failed to turn gas into stars. Our work presents further observational evidence of the feasibility of H I tidal features becoming fake dark galaxies; it also shows the impact of stellar fading, particularly in high metallicity systems such as tidal dwarfs, in hiding aged stellar components beyond detection limits in optical observations.

Две фразы из Введения

INTRODUCTION

- There is a huge population of currently undetectable low-mass galaxies beyond the distance at which we can resolve individual stars.
- In this letter we study the properties of a peculiar object that was identified by Jones et al. (2019) as a very faint feature detected in optical data and located at the end of an Hi tail emerging from the complex interactions of Hickson Compact Group

- M.Jones et a
2019



- M.Jones et al, 2019

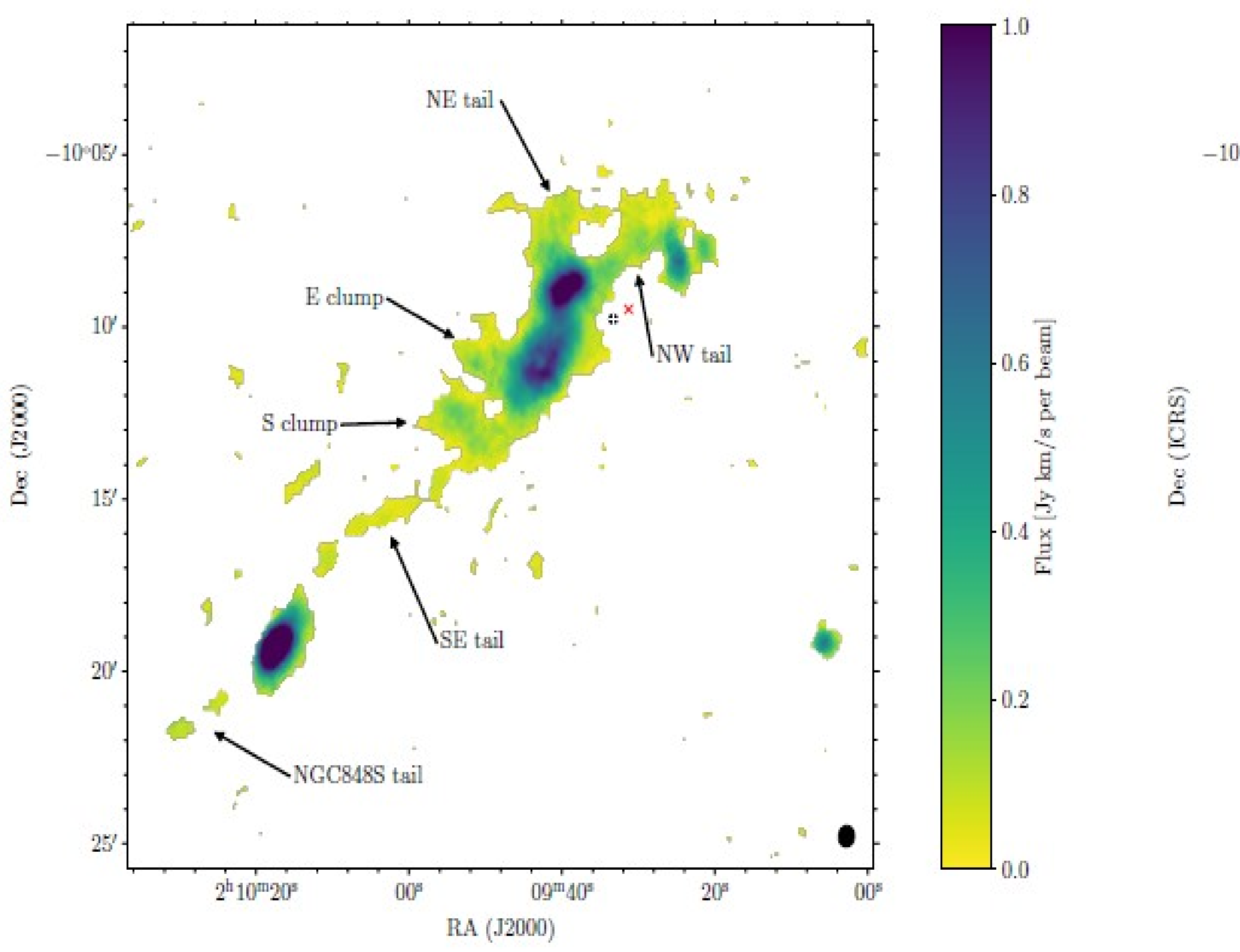
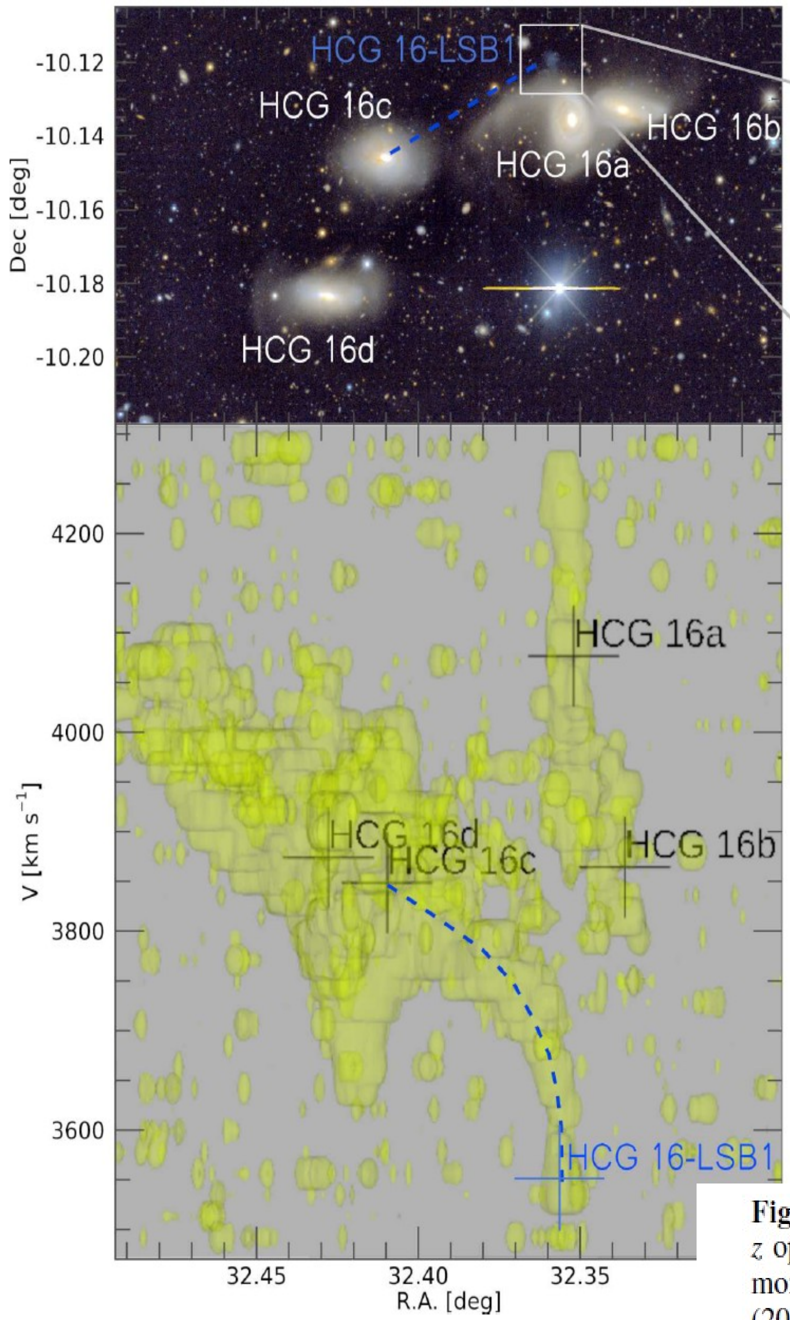


Fig. 2. *Left*: moment-zero map (primary beam corrected) of the H I emission of HCG 16



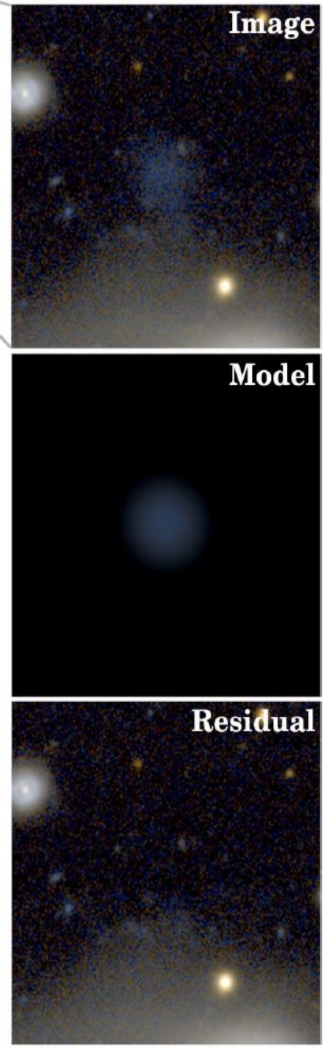


Fig. 1. Illustration of the structures present in the northwestern region of HCG16. Upper left panel: Color-composed image using the *g*, *r*, and *z* optical bands from DECaLS. Lower left panel: Pseudo zenith view (R.A. vs. H I velocity) of the H I emission higher than $3\sigma_{rms}$. Integrated moment-zero and first moment maps as well as detailed information about these data and maps for the whole group can be found in Jones et al. (2019). The dashed blue line in both left panels shows the trajectory of the H I tail, the end of which coincides with the diffuse object detected in the optical. We note that the progenitor of HCG 16-LSB1 is most likely HCG 16c and not the apparently closest galaxy (in projection), HCG 16a. Right panels: Zoom-in of the object and its fitting using optical bands through a Sérsic model.

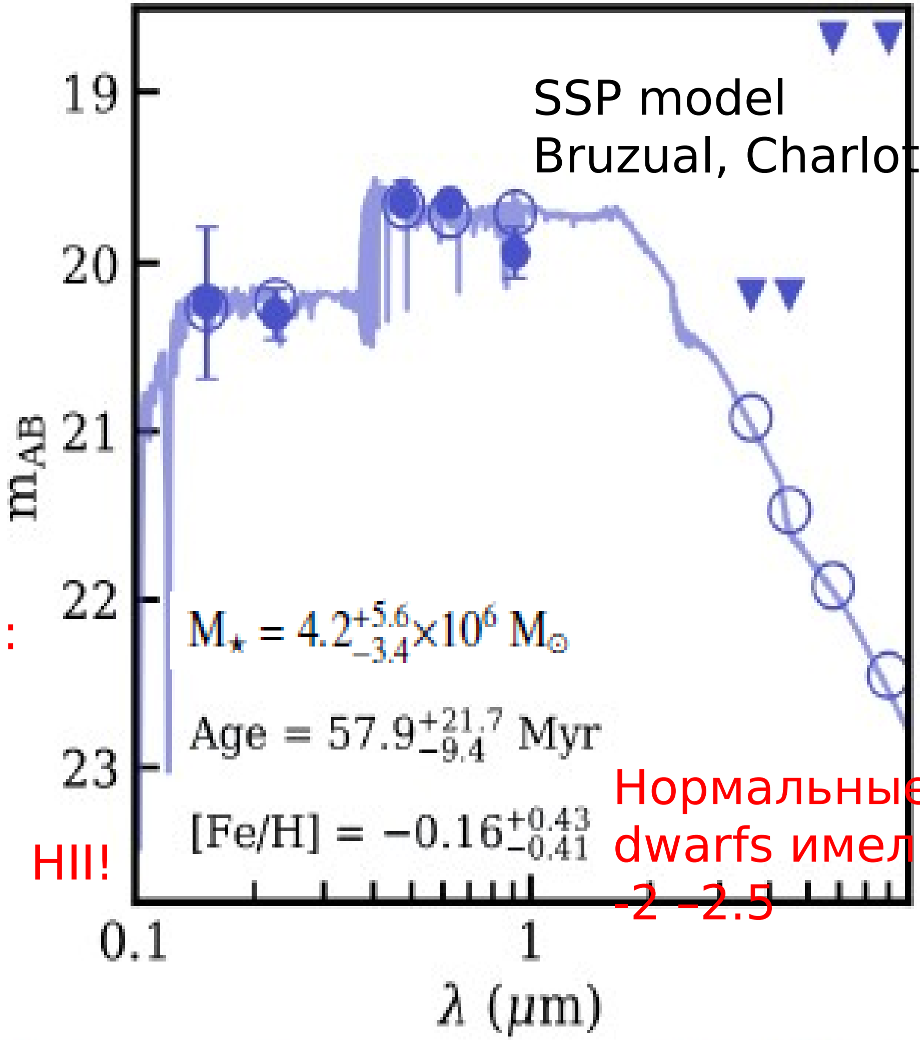
The properties of HCG 16-LSB1 are peculiar.
Its morphology and low surface brightness place it in the category of ultra diffuse galaxies (UDGs).

Parameter	Value
R.A.	32.3587
Dec.	-10.1194
r_e	1.5 ± 0.1 kpc
$< \mu_g >$	25.6 ± 0.1 mag/arcsec^2
$\mu_g(0)$	25.2 ± 0.1 mag/arcsec^2
Sérsic index	0.48 ± 0.01
Axis ratio	0.96 ± 0.01
M_g	-14.05 ± 0.04 mag
H I velocity	3552 ± 2 km s^{-1}
Far-UV band	20.24 ± 0.45 mag
Near-UV band	20.30 ± 0.15 mag
g-band	19.64 ± 0.04 mag
r-band	19.64 ± 0.06 mag
z-band	19.94 ± 0.20 mag
IRAC1$_{3.6\mu m}$ band	< 20.19 mag
IRAC2$_{4.5\mu m}$ band	< 20.19 mag
IRAC3$_{5.8\mu m}$ band	< 18.68 mag
IRAC4$_{8.0\mu m}$ band	< 18.68 mag

Table 1. Summary of the properties of HCG 16-LSB1. All photometric values are corrected from extinction (Schlafly & Finkbeiner 2011).

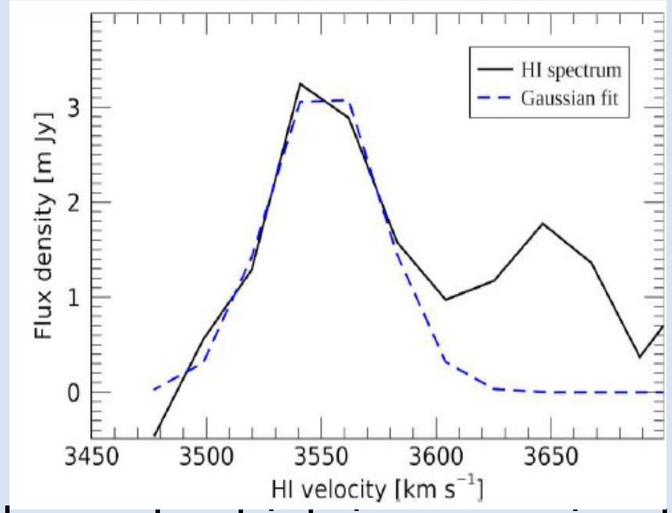
ФОТОМЕТРИЯ:
CFHT archive
HST archive
GALEX
Нет областей HII!

SSP model
Bruzual, Charlott



Нормальные dwarfs имели бы -2 –2.5

Fig. 2. Spectral energy distribution of the galaxy. The filled circles are the observed magnitudes of the galaxy, while the inverted triangles correspond to the upper limits in those bands where the galaxy was not detected. The open circles are the expected flux after convolving the best fit model with the filter responses.



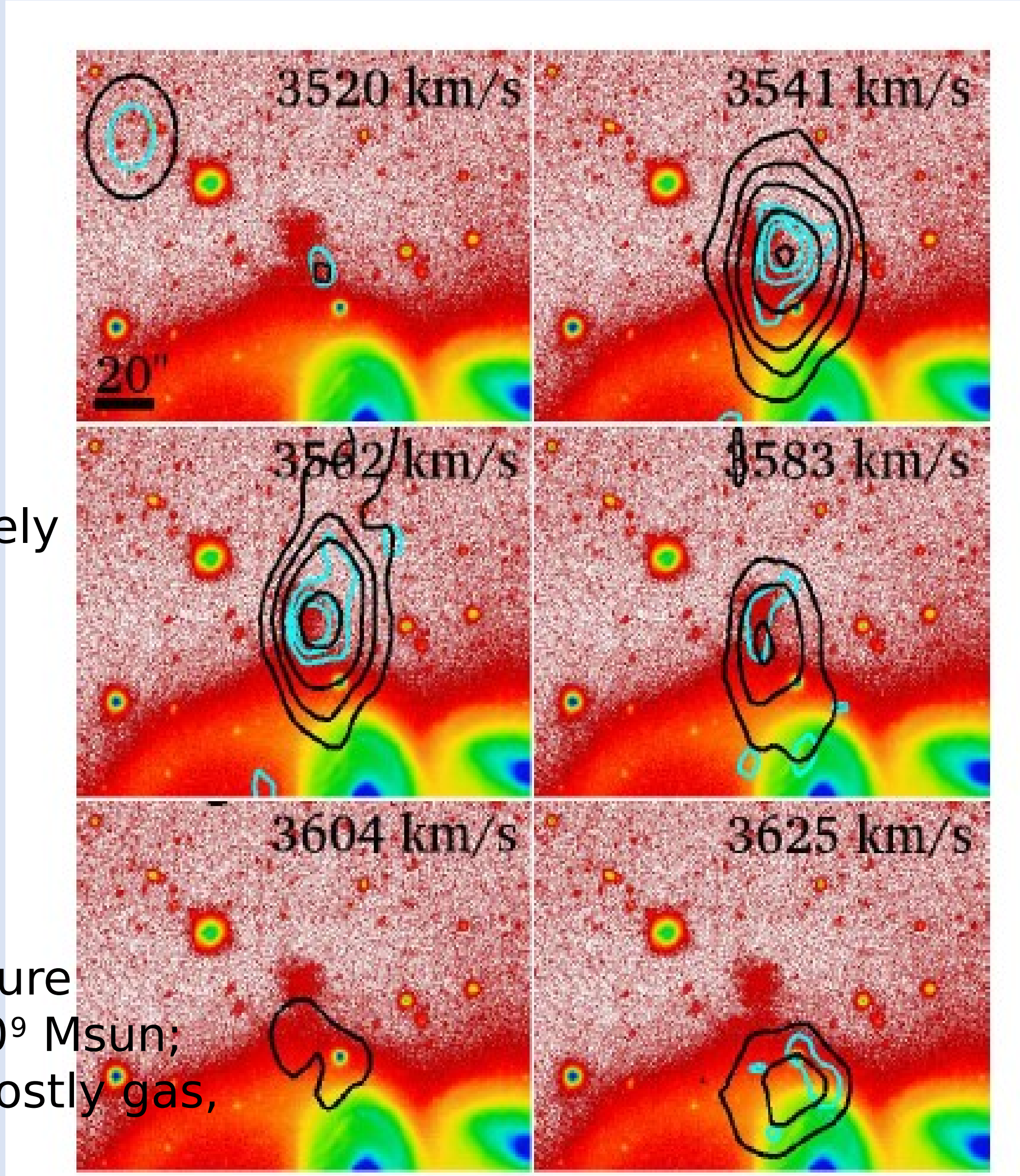


Fig. 3. H I distribution of HCG 16-LSB1. Upper panels: Velocity channel maps corresponding to high (light blue) and low (black) resolutions of the H I emission plotted over a high contrast $g + r$ optical image. The beam size for both resolutions is placed in the upper left corner (see

et is 5.5” for the 3562 km/s channel, which is approximately
value of the effective radius (1.5 kpc).
shift could indicate a certain degree of gas stripping
spatial asymmetry between both components.

model parameters of the fitted Gaussian distribution
\sigma HI = 24.2 pm 2.8 km/s.
to the apparent absence of a rotation pattern within the
ution limits, we assumed that the dynamic mass is pressure
orted, producing a value interval of Mdyn = [1.2, 4.1] 10^9 Msun;
value is in contrast with the baryonic content, which is mostly gas,
(HI) = 3.9 10^8 Msun. (!!!!!)
ever, a source of uncertainty is the low spectral resolution
km/s),

- The 3D component of the velocity is expected to be higher than the escape velocity of 400 km/s, and therefore HCG 16-LSB1 will likely escape from the gravitational influence of the group and its interactions that could destroy it.

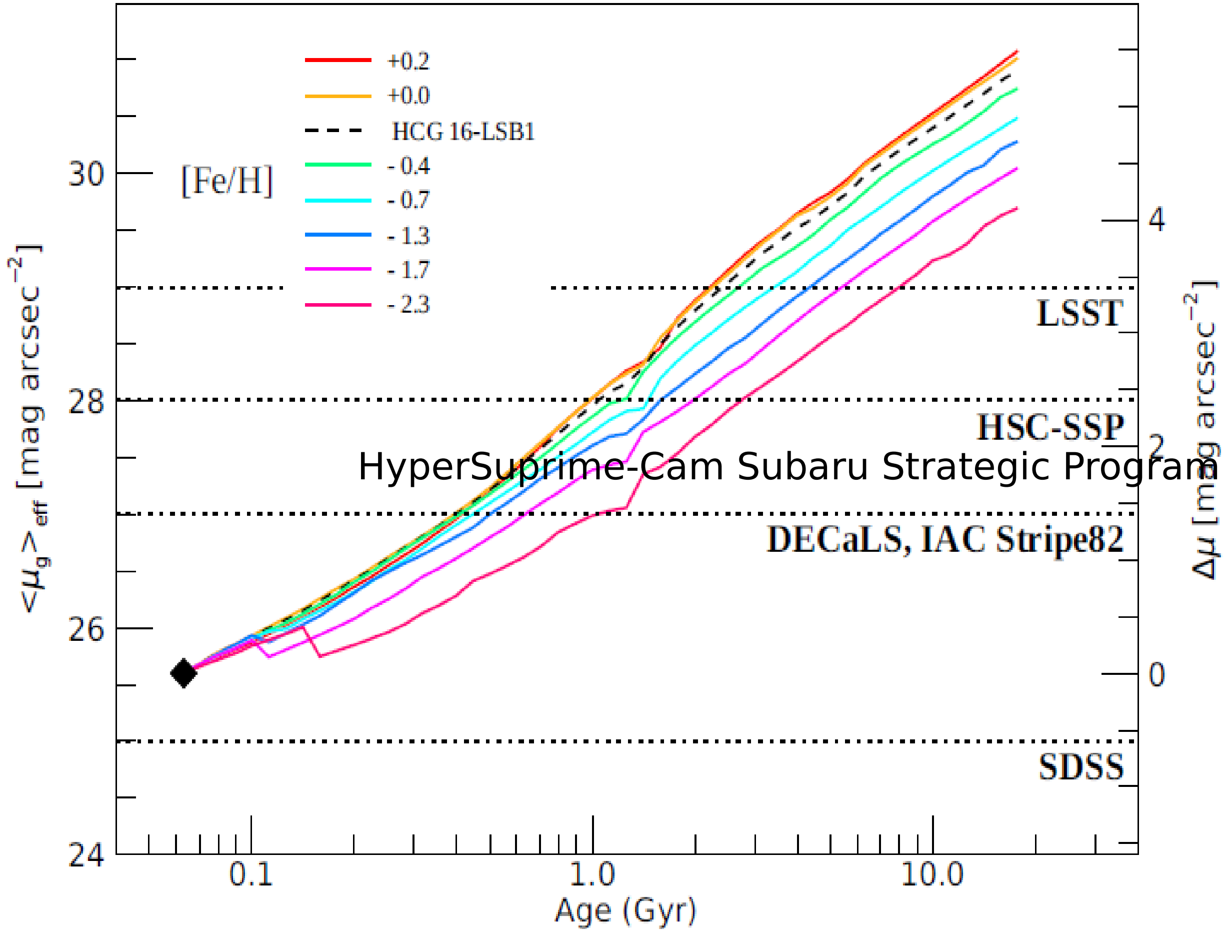


Fig. 4. Evolution of the surface brightness of HCG 16-LSB1 in time. The black diamond symbol marks the observed age and surface brightness. The tracks in different colors mark the theoretical temporal evolution of the surface brightness that would correspond to different metallicities. The dashed black line corresponds to the evolution calculated for the metallicity of HCG 16-LSB1 ([Fe/H] = -0.16). Approximate limits on the maximum surface brightness of detectable galaxies are marked with dotted lines for the Sloan Digital Sky Survey (SDSS; York et al. 2000), DECaLS (Dark Energy Survey Collaboration et al. 2016), the IAC Stripe82 Legacy Survey (Fliri & Trujillo 2016; Román & Trujillo 2018), the HSC-SSP (Aihara et al. 2018), and the future LSST (LSST Science Collaboration et al. 2009).

We can see that in just 400 Myr, the surface brightness will decrease enough to be undetectable in the optical data that we use in this work (DECaLS). In 1 Gyr of evolution, it would be undetectable in
the deepest currently available survey, which is the HSC-SSP.

Объект остается непонятным

Its high metallicity and its location at the end of an Hi tail makes HCG 16-LSB1 compatible with a recently formed TDG.

Однако:

Почему-то нет текущего SF и мелкой структуры

Вероятно присутствие DM, не ожидаемое для tidal dwarfs.

- If the galaxy survives and is held together gravitationally – even if it loses a significant fraction of its gas component,– its observational properties will be compatible with adark matter halo in which only gas is detectable, with no optical counterpart, therefore mimicking the observational properties of dark galaxies without actually being one.
- It is expected that the new era of deep optical surveys will reveal a systematic presence of objects of this type, preferentially in strongly interacting galactic associations