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The HI content of isolated ultra-diffuse galaxies: a sign of multiple formation mechanisms?

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ABSTRACT

We report on the results of radio observations in the 21cm emission line of atomic hydrogen (HI) of four relatively isolated ultra-diffuse galaxies (UDGs): DGSAT I, R-127-1, M-161-1, and SECCO-dI-2. Our Effelsberg observations resulted in non-detections for the first three UDGS, and a clear detection for the last. DGSAT I, R-127-1 and M-161-1 are quiescent galaxies with gas fractions that are much lower than those of typical field galaxies of the same stellar mass. On the other hand, SECCO-dI-2 is a star forming gas-rich dwarf, similar to two other field UDGs that have literature HI data: SECCO-dI-1 and UGC 2162. This group of three gas-rich UDGs have stellar and gaseous properties that are compatible with a recently proposed theoretical mechanism for the formation of UDGs, based on feedback-driven outflows. In contrast, the physical characteristics of R-127-1 and M-161-1 are puzzling, given their isolated nature. We interpret this dichotomy in the gaseous properties of field UDGs as a sign of the existence of multiple mechanisms for their formation, with the formation of the quiescent gas-poor UDGs remaining a mystery.

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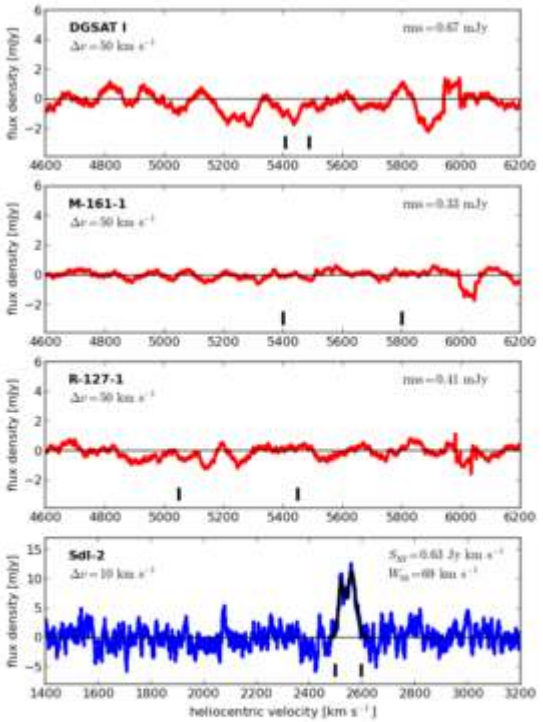

Fig. 1. HI spectra of four isolated UDGs, obtained with the Effelsberg radiotelescope. From top to bottom, the panels correspond to DGSAT I, M-161-1, R-127-1, and SdI-2. The first three spectra are non-detections. SdI-2 is instead clearly detected in the last spectrum. The black solid line is the best fitting generalized busy function profile (Westmeier et al. 2014). In all spectra, the short vertical lines denote the expected systemic velocity range from prior optical redshift measurements.

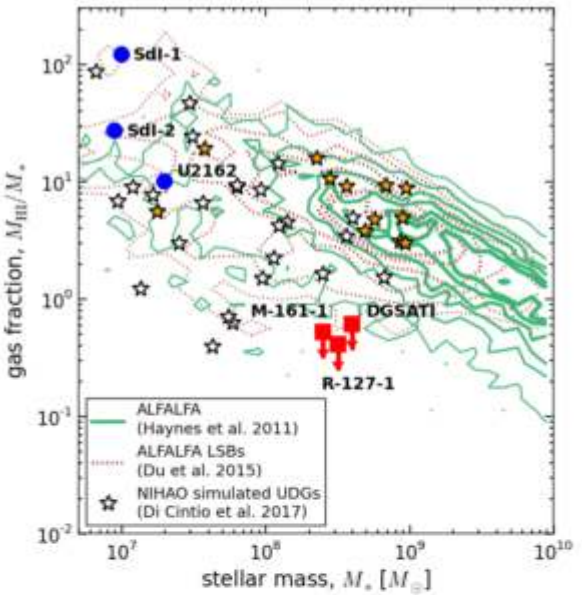

Fig. 2. Position of isolated UDGs on the stellar mass–gas fraction plane. The large symbols correspond to six known isolated UDGs, four of which have been observed in HI as part of this work (see Table 1). Red squares correspond to HI upper limits, while blue circles correspond to HI detections. The solid contours represent galaxies detected by the ALFALFA blind HI survey (40% catalog; Haynes et al. 2011). Stellar masses for ALFALFA galaxies have been estimated based on SED-fitting of pipeline SDSS photometry (Huang et al. 2012). The lowest contour encloses 95% of the ALFALFA detections, and each successive contour encloses 15% less. The dotted contours represent LSB galaxies in the ALFALFA survey, with reprocessed SDSS photometric data from Du et al. (2015). Stellar masses for the ALFALFA LSB galaxies are calculated according to the mass-to-light calibration of Roediger & Courteau (2015, Table A1). Star symbols are simulated field UDGs from the NIHAO simulation sample (Wang et al. 2015), as presented in Di Cintio et al. (2017). Those with an orange filling represent the most extended objects (r_{eff} > 3 kpc). Please refer to Sec. 4 for the scientific interpretation of this figure.

Существуют различные механизмы формирования UDG?

(ALMOST) DARK GALAXIES IN THE ALFALFA SURVEY: ISOLATED H I BEARING ULTRA DIFFUSE GALAXIES

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ABSTRACT

We present a sample of 115 very low optical surface brightness, highly extended, H I-rich galaxies carefully selected from the ALFALFA survey that have similar optical absolute magnitudes, surface brightnesses, and radii to recently discovered "ultra-diffuse" galaxies (UDGs). However, these systems are bluer and have more irregular morphologies than other UDGs, are isolated, and contain significant reservoirs of H I. We find that while these sources have normal star formation rates for H I selected galaxies of similar stellar mass, they have very low star formation efficiencies. We further present deep optical and H I synthesis follow up imaging of three of these H I-bearing ultra-diffuse sources. We measure H I diameters extending to ∼40 kpc, but note that while all three sources have large H I diameters for their stellar mass, they are consistent with the H I mass - H I radius relation. We further analyze the H I velocity widths and rotation velocities for the unresolved and resolved sources respectively, and find that the sources appear to inhabit halos of dwarf galaxies. We estimate spin parameters, and suggest that these sources may exist in high spin parameter halos, and as such may be potential H I-rich progenitors to the ultra-diffuse galaxies observed in cluster environments.

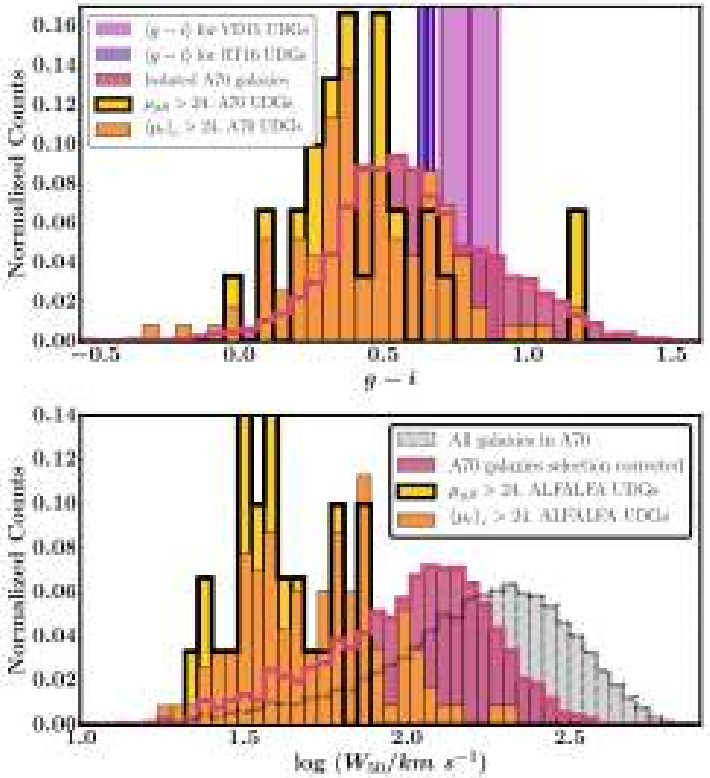
arXiv:1703.05293

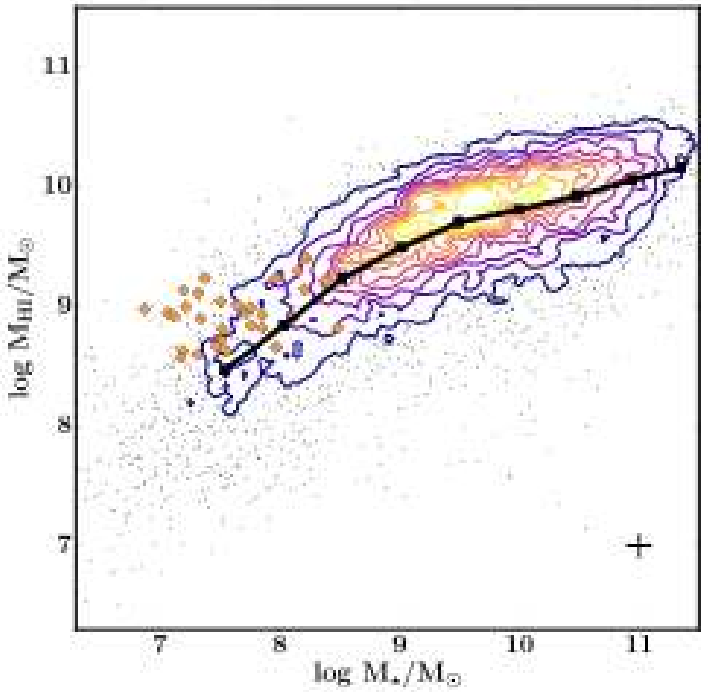
resubmitted to ApJ after revisions based on reviewer comments

Взяли за основу ALFALFA и SDSS

Составили выборку изолированных ультрадиффузных галактик с HI:
30 галактик, удовлетворяющих более строгим критериям отбора
115 галактик в расширенной выборке

Выборки аналогичны известным UDG по массам, поверхностной яркости и радиусам





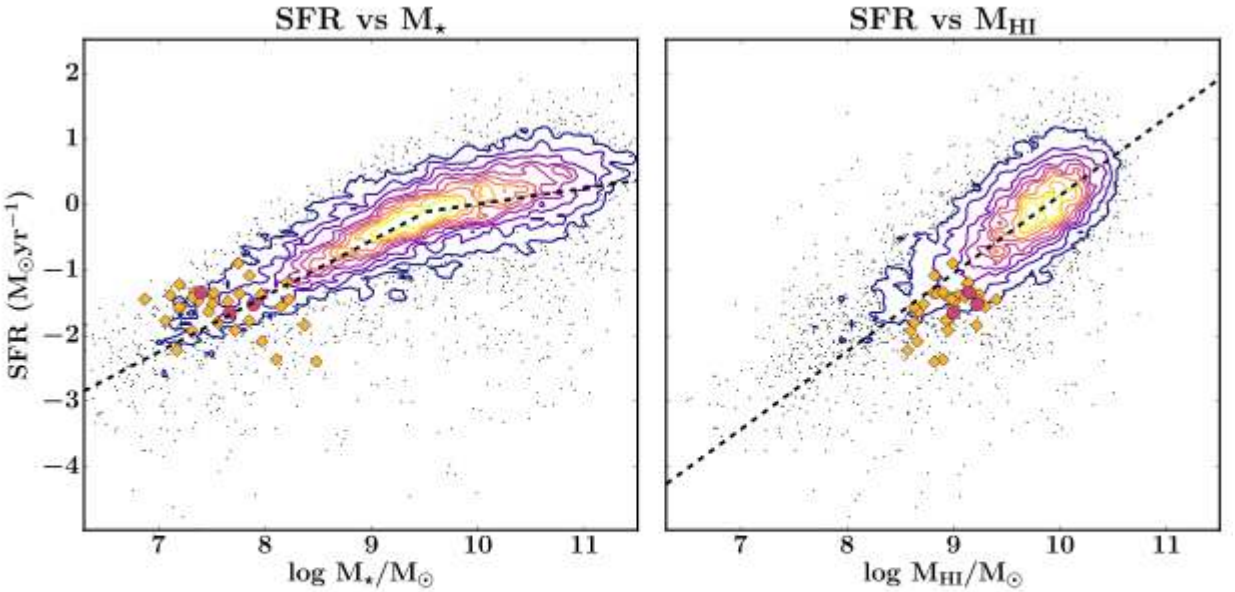


Figure 6. SFR versus stellar and H I mass of the HUDS-BG galaxies (yellow diamonds), plotted against the full Huang et al. (2012) sample. The star formation rate of these sources seems typical of H I selected sources of the given stellar mass, but low for galaxies with the given H I mass. SFRs are taken from Huang et al. (2012), and are calculated by SED fitting to GALEX+SDSS UV broadband data. The dashed lines represent the fitted trends from Huang et al. (2012). The three HUDS with follow up observations are shown by pink circles.

Существенно более голубые, с более иррегулярной морфологией, чем неизолированные UDG
Темп ЗО — типичный для их звездных масс, однако M_HI/M_stars повышен

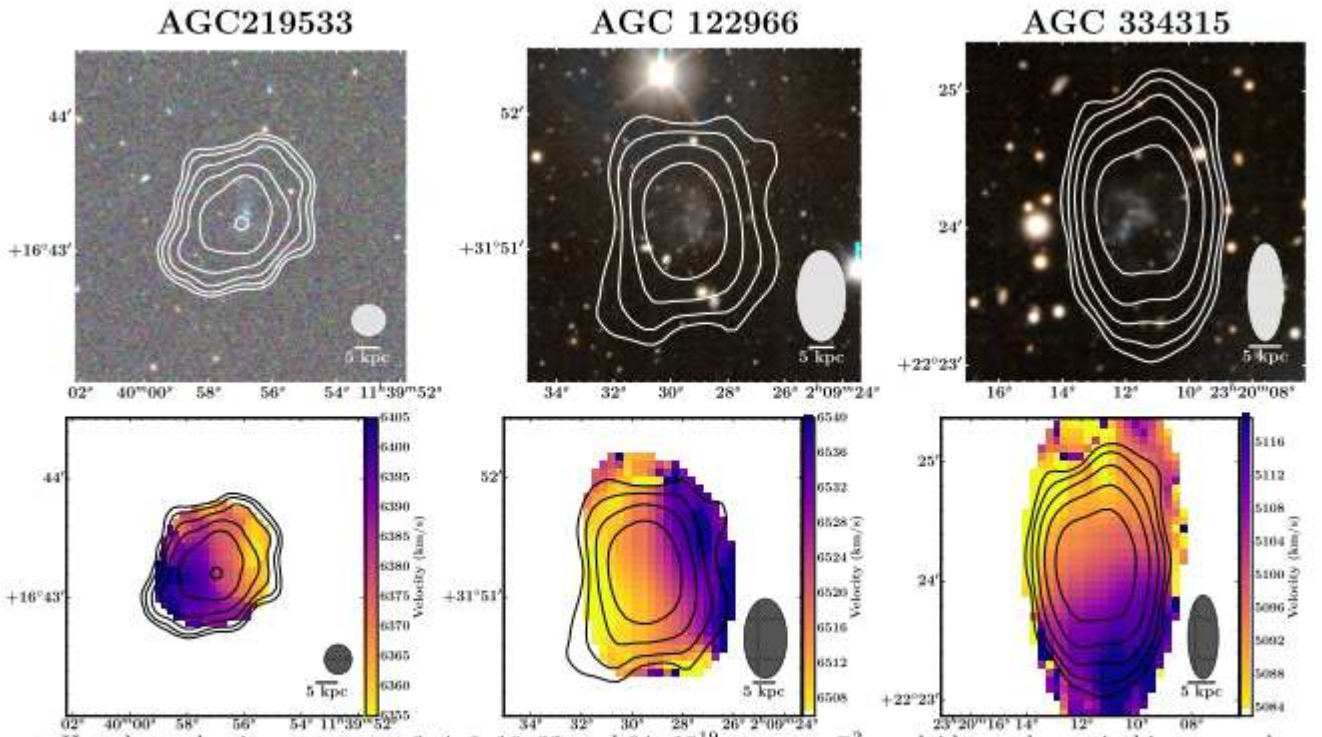


Figure 3. H I column density contours at 2, 4, 8, 16, 32, and 64×10^{19} atoms cm^{-2} overlaid on color optical images and moment 1 velocity maps for three HUDS, AGC 219533, 122966, and 334315 from left to right. For AGC 219533 (far left) the H I data is VLA C-array and the optical data is from SDSS; the others have H I data from WSRT, and optical data from pODI on the WIYN 3.5m. The optical emission is blue, diffuse, and shows irregular morphology. The H I is resolved even at this low physical resolution, is significantly extended relative to the diffuse optical emission, and shows evidence of ordered rotation. RA and Dec are in J2000 coordinates.

3 галактики отнаблюдали на VLA и WSRT.
Протяженные диски HI
Скорости вращения указывают на то, что галактики сидят в «карликовых» гало, предположительно с высоким моментом вращения.