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**The detection of a massive chain of
dark H i clouds in the GAMA G23
Field**

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Межгалактические облака HI встречаются исключительно во взаимодействующих системах галактик (реже- в скоплениях) , и их масса практически никогда не превышает $10^9 M_{\odot}$ (по обзорам Arecibo и HIPASS). Однако,

- *...the existence of dark matter substructure with masses below those of observed dwarf galaxies is a postulate of the standard galaxy formation theory. It appears therefore conceivable that dark galaxies exist, which, below a certain mass threshold cease to form stars completely.*
- *None of the sources has been found to lack any stellar counterpart (кроме двух небольших облачков в окрестности Virgo cl.)*

- **In this paper, we report the discovery of a massive HI cloud that does not appear to have any star formation history, located in a filamentary large scale structure, and in close proximity to a galaxy group.**
- This study is based on the survey pilot, which targeted a 10 deg² cosmic filament at redshift $0:025 < z < 0:034$ (*MeerKAT SKA Precursor*)

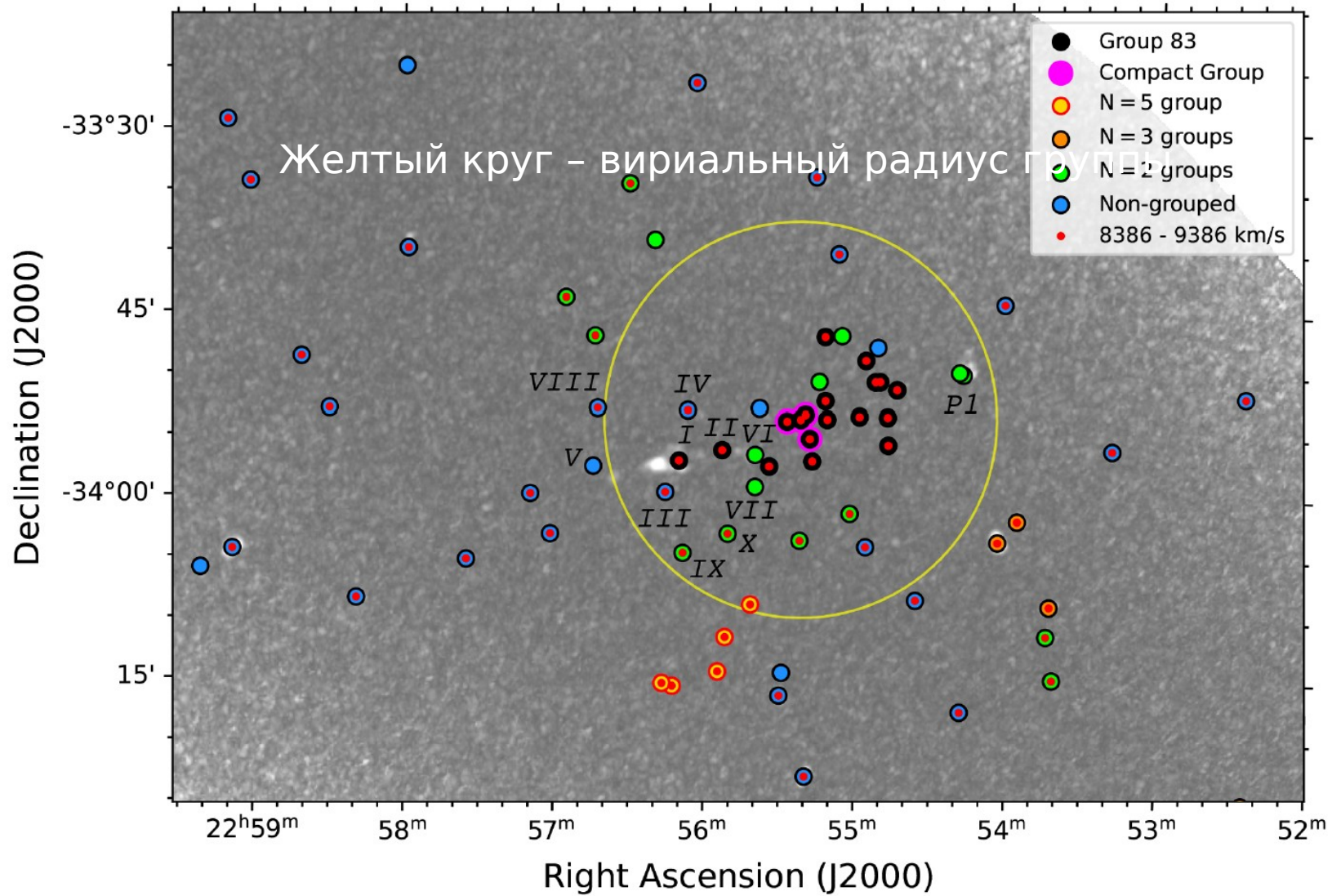


Figure 1. The immediate environment of the dark chain within the $0.025 < z < 0.034$ redshift range, highlighting different groupings of objects in the filamentary structure. The greyscale image is the H I moment-0 map whose column density ranges between 1 to 25×10^{19} atoms cm^{-2} , the dark cloud chain is the most massive gas complex in the region. The black points denote GAMA Group 83, a $N = 18$ group with $z_{\text{fof}} = 0.02891$ (8667 km s^{-1}), where the yellow circle (centred on the group) is 0.26 degrees, ~ 0.56 Mpc radius, which corresponds to the R_{200} of Group-83. Galaxies with velocities within $\pm 500 \text{ km s}^{-1}$ of the dark chain (8886 km s^{-1}). Labels I-X indicate the position of galaxies in the projected proximity of the dark H I chain ($9' \sim 320$ kpc) as discussed in Sect. 3. See Table 2 for additional information.

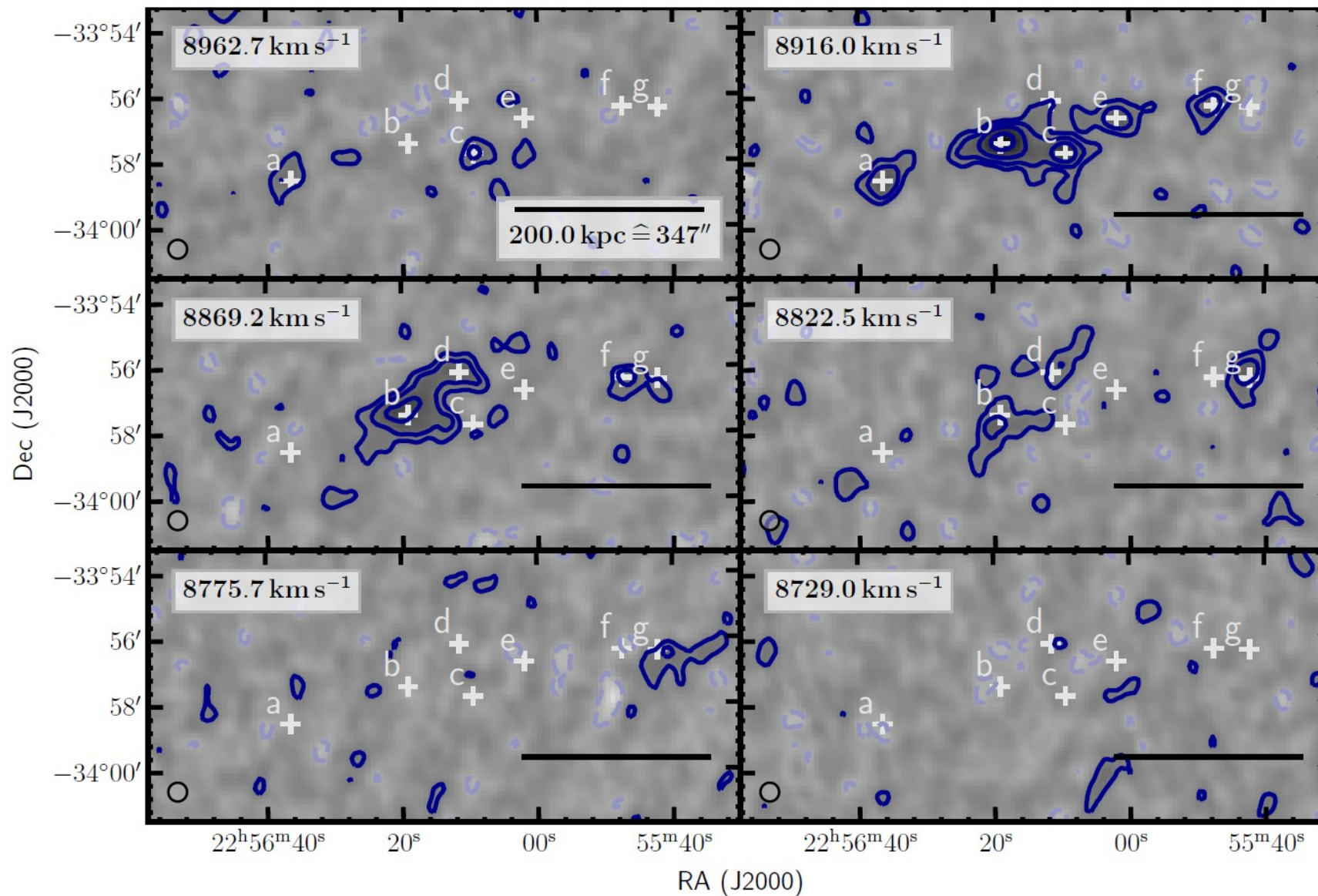


Figure 2. Observed H I data cube in the region and velocity range of the dark cloud chain. Contours denote the $-0.38, 0.38, 0.76, 1.52,$ and $3.04 \text{ mJy beam}^{-1}$ levels ($-2, 2, 4, 8, 16 \sigma_{\text{rms}}$), negative contours are dashed. White crosses mark H I detections (labeled a-g; see Table 3). The black circle in the lower left of each panel indicates the spatial resolution (HPBW). The scale bar indicates 200 kpc. The massive central concentration (Source b) has a peak intensity in the second velocity channel (8916 km s^{-1}).

Римскими цифрами
отмечены ближайшие
галактики

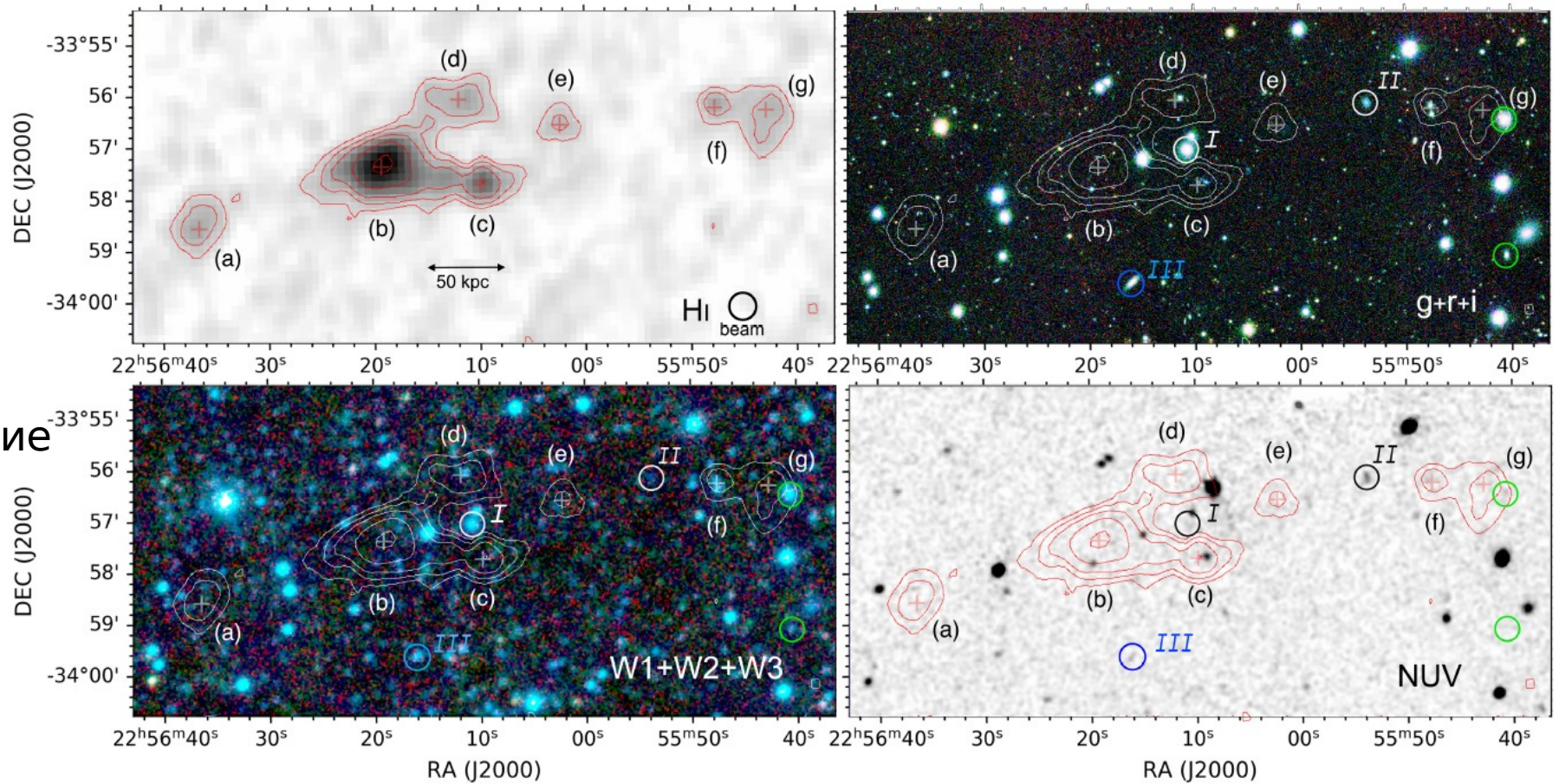


Figure 3. Dark cloud chain as seen across the electromagnetic spectrum. The four panels show the H I column density map (upper left; 8817–8931 km s^{-1} with rms noise $\sim 0.9 \times 10^{19}$ atoms cm^{-2}), KiDS g,r,i -bands (upper right), WISE 3.4–12 μm bands (lower left) and GALEX NUV (lower right). Contours of the H I column density are overlaid on all four maps, with values of 3, 5, 8, 14, and 23×10^{19} atoms cm^{-2} . Red/white crosses demark H I detections (labeled a–g; see Table 3), and the small circles denote filament galaxies as marked in Fig. 1 (blue is non-group; black/white is Group; green are galaxy pairs). The closest Group-83 galaxy to the H I is labeled I ($z=0.02805/8415$ km s^{-1}), just west of the massive gas complex. Other nearby group galaxies are labels II ($z=0.0286/8580$ km s^{-1}) and III ($z=0.0292/8760$ km s^{-1}). The central H I source (Source b) is not detected in any band.

- The total mass of the dark cloud chain is 10^{10} Ms, with the masses of the concentrations

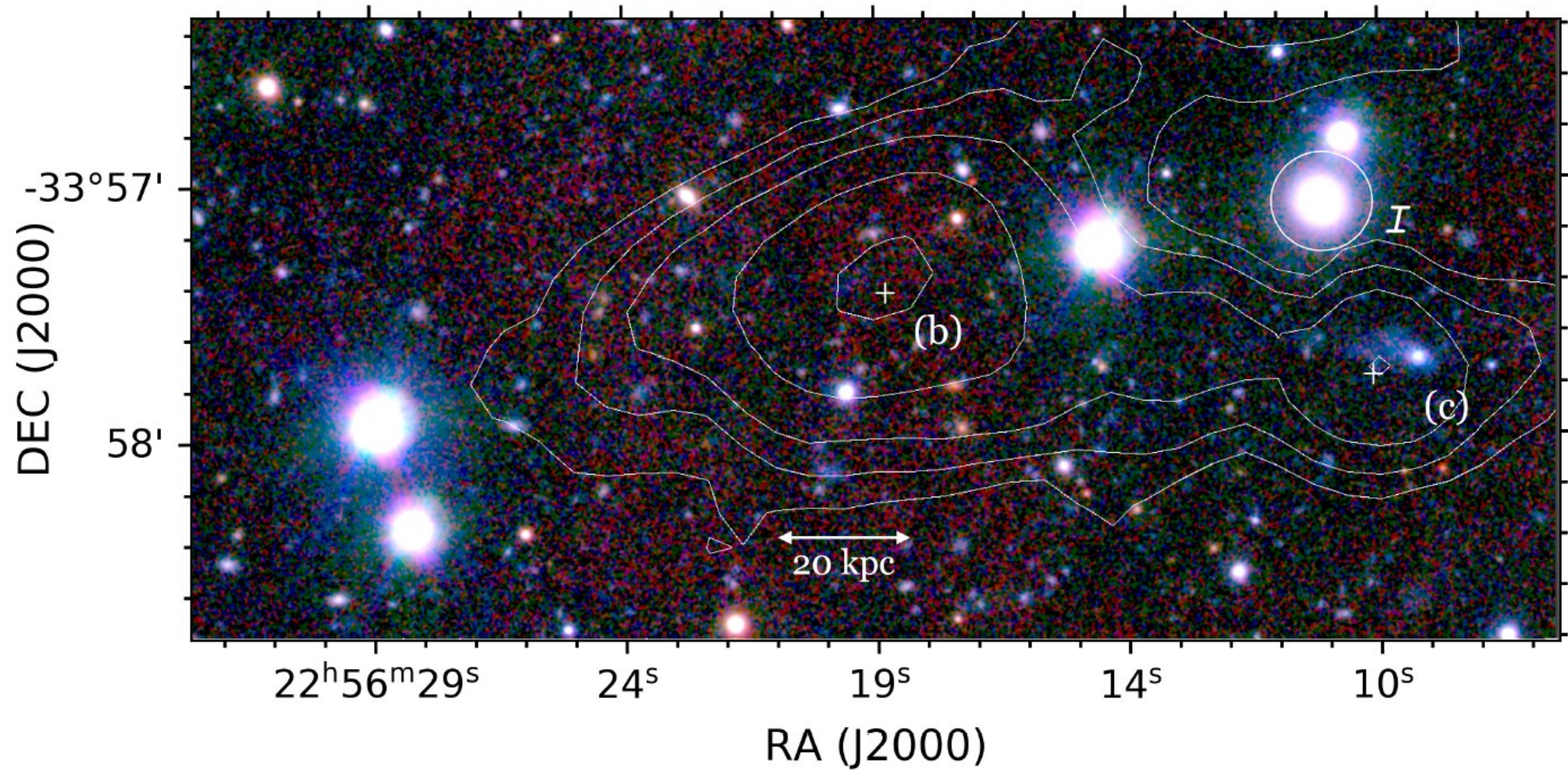


Figure 6. Central concentration of gas in the dark cloud chain shown in Fig. 3ab. The image shows the KiDS g,r,i -bands (blue, green, red), overlaid with contours of the H I column density: $3, 5., 8, 14$ and 23×10^{19} atoms cm^{-2} . White crosses demark H I detections for Source (b) and Source (c). The closest Group-83 galaxy to the Chain is labeled *I*. There are no clear optical associations with the densest gas in the entire region (Source b). However for Source (c) we do detect a small ‘blue’ dwarf galaxy; see Fig 7 for a detailed view of Source (c).

Облако (C)

If we thus consider this to be an association, and adopt the distance of Source (c), the optical r -band luminosity would be $10^{8.30} L_{\odot}$. The corresponding H I mass for this source is $10^{9.15} M_{\odot}$ (see Table 3), which would then imply a M_{HI}/L_r of ~ 8 . This is a plausible ratio (although on the high side) for dwarf and star-forming galaxies (Staveley-Smith et al. 1992;

gas-to-stellar mass ratio (M_{HI}/M) is which is well above the typical scaling relations seen in nearby galaxies, with ratios 1 (see eg. Naluminsa et al. 1).

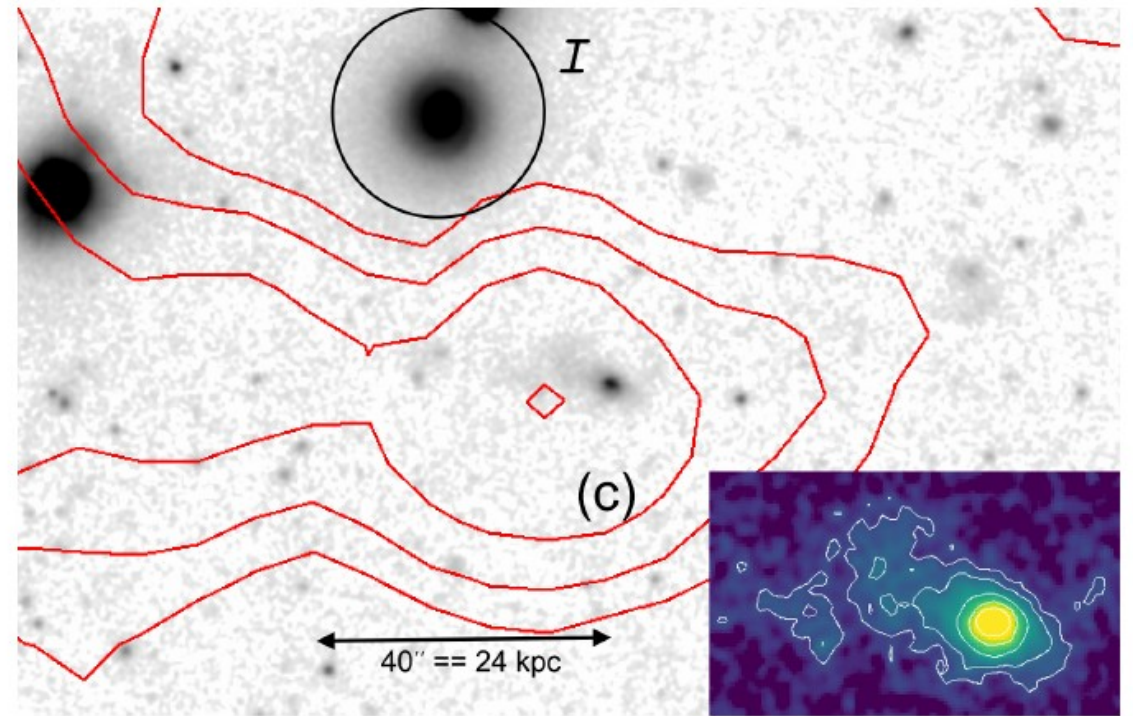


Figure 7. Close view of Source (c) with KiDS r -band imaging. As in the previous figures, the H I contours (red) indicate the gas distribution, with the (c) concentration in close proximity to the optical galaxy. Shown in the lower right is an inset image of a zoomed view of the optical source (with colour transform “viridis”), located at (deg J2000) 344.03668 -33.961783. The white contours, ranging from 25.8 to 22.5 mag arcsec $^{-2}$, delineate the low surface brightness ‘tidal tail’ extending to the eastward toward the massive dark cloud core.

| src | w_{20} | I_{peak} | F_{tot} | D_{L} | $\text{Log}M_{\text{HI}}$ |
|-----|--------------------|---------------------------|-----------------------|----------------|---------------------------|
| – | km s^{-1} | 10^{19} cm^{-2} | Jy km s^{-1} | Mpc | M_{\odot} |
| (a) | 106 | 8.77 | 0.200 | 126.6 | 8.88 |
| (b) | 139 | 26.26 | 1.353 | 125.9 | 9.70 |
| (c) | 105 | 16.05 | 0.374 | 126.4 | 9.15 |
| (d) | 132 | 10.98 | 0.357 | 125.5 | 9.12 |
| (e) | 86 | 7.32 | 0.181 | 126.3 | 8.83 |
| (f) | 110 | 8.85 | 0.151 | 126.1 | 8.75 |
| (g) | 135 | 8.18 | 0.189 | 124.9 | 8.84 |

Резюме

- We identified a 'chain' of H i emission with a total H i mass of $10^{10} M_{\odot}$ that did not have optical counterparts. Further investigation, using deep ultraviolet, optical and infrared imaging (GALEX, and WISE, respectively), reveal this gas chain to be extremely dark: there is no emission from stars or star formation in proximity to the dark chain, Most notably is the massive central source, with $10^{9.7} M_{\odot}$ in neutral hydrogen within 50 kpc diameter, implying an extreme gas mass-to-light ratio.

Облако – на расстоянии 400 кпс от центра группы в основном из галактик раннего типа, бедных газом.

Нет вращения. Для грав. связанности