CHILES VI: H I and H $\alpha$ observations for $z < 0.1$ galaxies; probing H I spin alignment with filaments in the cosmic web

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ABSTRACT
We present neutral hydrogen (H I) and ionized hydrogen (H $\alpha$) observations of 10 galaxies out to a redshift of 0.1. The H I observations are from the first epoch (178 h) of the COSMOS H I Large Extragalactic Survey (CHILES). Our sample is H I biased and consists of 10 late-type galaxies with H I masses that range from $1.8 \times 10^7 M_\odot$ to $1.1 \times 10^{10} M_\odot$. We find that although the majority of galaxies show irregularities in the morphology and kinematics, they generally follow the scaling relations found in larger samples. We find that the H I and H $\alpha$ velocities reach the flat part of the rotation curve. We identify the large-scale structure in the nearby CHILES volume using DisPerSE with the spectroscopic catalogue from SDSS. We explore the gaseous properties of the galaxies as a function of location in the cosmic web. We also compare the angular momentum vector (spin) of the galaxies to the orientation of the nearest cosmic web filament. Our results show that galaxy spins tend to be aligned with cosmic web filaments and show a hint of a transition mass associated with the spin angle alignment.

Key words: galaxy: evolution – galaxy: formation – galaxy: kinematics and dynamics – large-scale structure of the Universe.

1 INTRODUCTION
In the last decade, tremendous progress has been made in our understanding of structure formation in the Universe. Simulations of dark matter show that structures develop over time forming the large-scale structure of the Universe – the so-called cosmic web consisting of walls, filaments, and voids. Observations show that galaxies lie in this interconnected cosmic web and that stars trace the dark matter. However, how galaxies grow and evolve is less well understood.

Ongoing infall of gas from the intergalactic medium is thought to be important for the growth of galaxies, with cold gas accretion from the cosmic web likely a dominant factor (Sánchez Almeida et al. 2014). Simulations and models highlight physical processes that may be relevant in studying large-scale environments. Theorists...
distinguish two modes of gas infall: ‘hot mode’ accretion where gas gets shock heated to high temperatures and then slowly cools and settles in a disc, and ‘cold mode’ accretion where much cooler gas flows along filaments directly into the disc. ‘Cold mode’ accretion is a favourable scenario for gas accretion on to galaxies and simulations make very specific predictions about its dependence on galaxy mass, environment, and redshift (Kereš et al. 2005). Recently, Aragon Calvo, Neyrinck & Silk (2019) proposed the halting of cold gas accretion through cosmic web detachment. In this picture, galaxies accrete cold gas from the cosmic web until they enter regions of crossing velocity streams, including regions near large filament backbones. These interactions detach galaxies from the cosmic web and sever their cold gas supply, quenching star formation. As the interaction between galaxies and the neutral hydrogen (H I) reservoir in filaments is poorly constrained, more work is needed to confidently measure the influence large-scale structure has on galaxy evolution.

There has been a growing number of methods to quantify large-scale environment; Libeskind et al. (2018) provide a review and a comparison of different methods. Methods such as Discrete Persistent Structure Extractor (DisPerSE; Soussie 2011), a scale-free topological algorithm that uses Morse theory and Delaunay tessellations, are used to characterize the large-scale distribution of galaxies. It is by now well established that galaxy properties, such as stellar mass, colour-type and star formation rate (SFR), show dependence on location in large-scale environment (Chen et al. 2017; Kuutma, Tamm & Tempel 2017; Malavasi et al. 2017; Kraljic et al. 2018; Laigle et al. 2018; Luber et al. 2019). More recently, H I as a function of distance to cosmic web filaments has been investigated with conflicting results (Kleiner et al. 2017; Crone Odekon et al. 2018). In addition to location, there are predictions about the orientation of galaxies with respect to large-scale structure (Porciani, Dekel & Hoffman 2002; Codis, Pichon & Pogosyan 2015). A key prediction is that low-mass galaxies tend to align their angular momentum vector (spin) with their nearby filament, while high-mass galaxies tend to have their spin perpendicular to their nearby filament. This is seen in both dark matter simulations for haloes (Ganeshiah Veena et al. 2018; Wang et al. 2018) and hydrodynamic simulations for galaxies (Codis et al. 2018; Kraljic, Dave & Pichon 2019). Observational studies of galaxy spin- filament alignments show mixed results. Hints of spin alignment for galaxies have been identified by Tempel, Stoica & Saar (2013), Tempel & Libeskind (2013), Pahwa et al. (2016), Chen et al. (2019), and Welker et al. (2019), while Krolewski et al. (2019) find no evidence for alignment. The next generation of H I surveys, such as the COSMOS H I Large Extragalactic Survey (CHILES), will provide unique observations to compare to these studies and predictions.

While ongoing infall of gas from the intergalactic medium is thought to be important for the growth of galaxies, observational evidence of accretion remains challenging to obtain. Due to the intrinsic faintness of H I 21-cm emission, it has been difficult to probe beyond a redshift of $z \approx 0.1$ without prohibitively long integration times. Large single-dish radio surveys such as HIPASS (Barnes et al. 2001) and ALFALFA (Giovanelli et al. 2005) have compiled a large number of H I-detected galaxies, but only to a redshift of $z \approx 0.06$, and with relatively low angular resolution. At higher resolution, targeted interferometric surveys of varying galaxy type and environment such as WHISP (Van der Hulst, van Albada & Sancisi 2001), THINGS (Walter et al. 2008), VIVA (Chung et al. 2009), HALOGAS (Heald et al. 2011), Little THINGS (Hunter et al. 2012), and VGS (Kreckel et al. 2012) have uncovered numerous interesting H I features potentially linked to formation or accretion processes. From these observations (see Sancisi et al. 2008 for a review), we have learned much about H I distributions and kinematics and how we might infer the presence of accretion. Accretion phenomena become evident in the outskirts and extraplanar regions of spiral galaxy discs, requiring deep 21-cm emission investigations to search for lower column density and/or anomalous velocity range gas. With long integration times, the CHILES survey is beginning to probe this regime beyond the most local galaxies.

CHILES is an H I survey using the upgraded Karl G. Jansky Very Large Array (VLA). For the first time, we are imaging the H I distribution and kinematics in a single pointing of continuous redshift range $0 < z < 0.45$. CHILES will measure the H I gas reservoir over a substantial look-back time and provide H I content, morphology, and kinematics for a wide range of stellar masses and environments. CHILES will produce H I images of at least 300 galaxies across the entire redshift range, with a linear resolution of 350 pc, 19 kpc, and 42 kpc at $z = 0.03$, $z = 0.20$, and $z = 0.45$, respectively. The survey will be able to detect at the highest redshift $3.0 \times 10^{10} M_{\odot}$ at 5σ, assuming a 150 km s$^{-1}$ profile width. The 40 arcmin$\times$40 arcmin pointing in the COSMOS field (Scoville et al. 2007) is chosen such that it has no strong continuum sources. The COSMOS field is ideal for a survey like this because of the wealth of ancillary data.

In this paper, we present results for 10 galaxies out to a redshift of 0.1, from the first epoch of the CHILES survey. At 178 h, this is a unique amount of observing time as nearby galaxies are typically observed for only a few hours resulting in column density sensitivities an order of magnitude lower at similar resolution. We utilize this first epoch of data as a science verification study for the CHILES survey. Our results reveal irregularities in the morphologies and kinematics in most of the sample. Our results show a tendency of galaxy spins to be aligned with cosmic web filaments and possibly the existence of a transition mass where the alignment changes.

In addition to the H I data, we study ionized gas kinematics with optical long-slit data obtained from the Southern African Large Telescope (SALT). Observations of optical emission lines trace population I stars, particularly H II regions associated with star-forming regions in the galactic disc. These lines are a good tracer of the overall circular motion of the disc, given that they have small velocity dispersion compared to the rotation velocity. In this paper, we examine the structural relation of H I and H α discs with rotation curves of H α in the inner regions and with H I in the outer regions. The results reveal that the flat part of the rotation curve is reached for the H α data, along with disturbed kinematics due to non-circular motion in the inner region of one of the irregular galaxies in our sample.

This paper is organized as follows. In Section 2, we outline the observations and data reduction for H I and H α. In Section 3, we describe the data analysis, sample properties, individual galaxies, and the derivations of the galaxy environments. In Section 4, we analyse the stellar, H I and H α content including H I gas fraction, H I deficiency, H I size–mass relation, H I and H α line width comparison, and H I and H α baryonic Tully–Fisher relation. In Section 5, we discuss the H I morphology and kinematics as well as the H I properties as a function of distance and orientation to the cosmic web. Section 6 covers the conclusion. In the Appendix, we present figures for the individual galaxies.

Throughout this paper, we use J2000 coordinates, velocities in the optical convention, and a barycentric reference frame. This paper
et al. (2019) (CHILES IV), to the highest redshift H I detection so far at 4096 × 62.5 pixels to include 4096 pixels to include a flat Λ cold dark matter cosmology using \( H_0 = 67.3 \text{ km s}^{-1} \text{ Mpc}^{-1} \) and \( \Omega_M = 0.316 \) (Planck Collaboration et al. 2018) to calculate distances and physical sizes.

2 OBSERVATIONS

We carried out a 60-h pilot study (Fernández et al. 2013) (CHILES I) of the CHILES field during the commissioning of the upgraded VLA correlator. We imaged H I in the redshift range \( 0 < z < 0.193 \) and found 33 detections, from which we draw a sample to study with our 178-h first epoch of data. The full CHILES survey has been underway since late 2013 when observations began on the VLA. In this work, we focus on galaxies in the frequency range of 1300–1411 MHz that corresponds to a redshift range of \( z = 0.0068–0.0930 \). Overall, we achieve a mean rms of 80 \( \mu \text{Jy beam}^{-1} \) per 62.5 kHz channel throughout our 10 image cubes, which is close to the theoretical noise. The channel resolution corresponds to 13.3 km s\(^{-1}\) at \( z = 0 \). Smaller sub-cubes with individual galaxies are cleaned down to 1σ of the rms using a box around the emission region.

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Table 1. CHILES observation details for our sample.

<table>
<thead>
<tr>
<th>Survey epoch</th>
<th>Epoch 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation date</td>
<td>2013–2014</td>
</tr>
<tr>
<td>Array configuration</td>
<td>VLA-B</td>
</tr>
<tr>
<td>Integration (h)</td>
<td>178</td>
</tr>
<tr>
<td>Bandpass and flux density scale calibrator</td>
<td>3C286</td>
</tr>
<tr>
<td>Phase calibrator</td>
<td>J0943–0819</td>
</tr>
<tr>
<td>Frequency coverage (MHz)</td>
<td>1300–1411</td>
</tr>
<tr>
<td>Redshift range</td>
<td>0.0068–0.0930</td>
</tr>
<tr>
<td>Synthesized beam (arcsec)</td>
<td>6.4 \times 4.7^b – 6.8 \times 5.1^c</td>
</tr>
<tr>
<td>Frequency resolution (kHz)^a</td>
<td>13.3^b–14.4^c</td>
</tr>
<tr>
<td>Velocity resolution (km s(^{-1}))^a</td>
<td>62.5</td>
</tr>
<tr>
<td>Spatial resolution (kpc)</td>
<td>0.8^b–10.7^c</td>
</tr>
<tr>
<td>rms noise (( \mu \text{Jy beam}^{-1} ) channel(^{-1})(^{\mu}))</td>
<td>76.0^b–83.0^c</td>
</tr>
<tr>
<td>Typical 1σ ( N_\text{HI} ) (cm(^{-2}) channel(^{-1})(^{\mu}))</td>
<td>3.3^b–4.4^c \times 10^{19}</td>
</tr>
</tbody>
</table>

Notes. After Hanning smoothing plus additional velocity smoothing.

\(^a\)At \( z = 0.0068 \). \(^b\)At \( z = 0.0930 \).

Table 2. SALT observation details.

<table>
<thead>
<tr>
<th>C08 ID</th>
<th>Date</th>
<th>Grating</th>
<th>Slit (arcsec)</th>
<th>V (s)</th>
<th>Exp. (deg)</th>
</tr>
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<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
</tr>
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<td>1213496</td>
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<td>19.1</td>
<td>800</td>
</tr>
<tr>
<td>1180660</td>
<td>20160501</td>
<td>PG2300</td>
<td>1.5</td>
<td>17.4</td>
<td>600</td>
</tr>
<tr>
<td>1197518</td>
<td>20160501</td>
<td>PG2300</td>
<td>1.5</td>
<td>19.6</td>
<td>1700</td>
</tr>
<tr>
<td>1204837</td>
<td>20170423</td>
<td>PG2300</td>
<td>1.25</td>
<td>17.7</td>
<td>880</td>
</tr>
<tr>
<td>1227948</td>
<td>20160502</td>
<td>PG2300</td>
<td>1.5</td>
<td>19.6</td>
<td>1700</td>
</tr>
<tr>
<td>1432731</td>
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<td>PG1800</td>
<td>1.25</td>
<td>18.8</td>
<td>1600</td>
</tr>
<tr>
<td>1437568</td>
<td>20161229</td>
<td>PG1800</td>
<td>1.25</td>
<td>18.6</td>
<td>750</td>
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<td>969633</td>
<td>20170423</td>
<td>PG1800</td>
<td>1.25</td>
<td>18.6</td>
<td>1600</td>
</tr>
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<td>20161229</td>
<td>PG1800</td>
<td>1.25</td>
<td>19.8</td>
<td>1600</td>
</tr>
</tbody>
</table>

Notes. (1) COSMOS 08 ID; (2) observation date; (3) grating; (4) slit size; (5) V-band magnitude; (6) total exposure time per position angle; (7) H α position angles.

2.1 SALT observation and data reduction

The optical long-slit data are obtained (see Table 2 for observation properties) with the Robert Stobie Spectrograph (RSS) on the 11-m SALT telescope between 2016 May and 2017 April under programmes 2016-1-SCI-020, 2016-2-SCI-045, and 2017-1-SCI-047 (PI: J. Davis). The 2300 line mm\(^{-1}\) volume phase holographic grating (\( R \sim 4500 \), velocity resolution 68 km s\(^{-1}\) for wavelength regions in this paper) with a 1.5 arcsec slit is used for galaxies up to \( z = 0.067 \), after which H α shifts off the CCD. The 1800 line mm\(^{-1}\) volume phase holographic grating (\( R \sim 4000 \), velocity resolution 71 km s\(^{-1}\) for wavelength regions in this paper) with a 1.25 arcsec slit is used for the rest of the galaxies. The narrower slit for the latter observations is selected to aid in sky subtraction, as OH line complexes become increasingly dense after \( \sim 7000 \) Å. The RSS CCD has a pixel scale of 0.1267 arcsec pixel\(^{-1}\), and we employed 2 \times 2 binning for a pixel size of 0.2534 arcsec. Seeing at the SALT telescope site for the observations varied between \( \sim 1 \) and 1.5 arcsec.

SALT is a fixed altitude telescope with its instrument payload located on a prime-focus tracker. Observations of most objects...
are limited to windows averaging 50 min twice per night. With this limitation in mind, exposure times are optimized to obtain acceptable signal-to-noise ratio in the desired optical emission lines without spreading an observation over multiple nights. When possible, observations are fit into a single track to minimize sky-subtraction complications arising from changing flexure of the optical elements in the prime focus instrument payload.

When granted sufficient observing time, two slit position angles are selected for each galaxy; otherwise, one position angle (PA) is used. Primary position angles are selected to align with the major axis of the galaxy as identified in NED using r-band Sloan Digital Sky Survey (SDSS) isophotal or K, values where available. However, in some cases, acquisition of galaxies within the slit required alignment with a bright star. In these cases, the slit is aligned as closely as possible to the major axis. The secondary slit position is selected to be ∼45° offset from the major axis or aligned with any potentially interesting optical features as seen in Hubble Space Telescope ACS images of the target galaxies.

Reduction of the SALT data is carried out using the PYsALT software, a package that implements standard PYRAF procedures for SALT imaging and spectroscopic data (Crawford et al. 2010). We note that the spectra are not flux calibrated, as observations of a flux calibrator added prohibitive amounts of observing time and are deemed unnecessary for our kinematic analysis. The two-dimensional (2D) spectra are sky-subtracted and wavelength-calibrated, with exposures combined when available, resulting in signal-to-noise ratios of ∼3–50 across the emission lines of interest. All galaxies but one exhibited H α λ6563, and seven galaxies exhibited one or more of the forbidden emission lines [N II] λ6583 and the doublet [S II] λ6716, 6732. We note however that the sky subtraction for SALT at times leaves heavy residuals due to variable curvature in the skylines across the CCD, so often the [S II] doublet profile is damaged by intervening OH emission lines.

3 SAMPLE

Our sample of galaxies is drawn from H i detections found in the CHILES pilot survey and narrowed down to 10 galaxies within our H α observational limits on SALT. From the H i detections in the CHILES sample, galaxies with V-band magnitudes less than 20 and angular sizes greater than 10 arcsec are selected to ensure reasonable exposure times and sufficient spatial information for kinematic analysis. The redshift limit is set by the lowest resolution grating we are willing to use – the PG1800 (kinematic analysis. The redshift limit is set by the lowest resolution

\[ \sin i = \sqrt{\frac{(1 - b/a)^2}{1 - q_0^2}} \] (1)

where \( a \) and \( b \) are the major and minor axes, and \( q_0 = 0.2 \) is the three-dimensional (3D) axial ratio following Huang et al. (2012).

Star-forming galaxies follow a tight correlation between their stellar mass (\( M_\star \)) and SFR (Schiminovich et al. 2007), with smaller galaxies having a lower SFR. This correlation has a bimodal distribution of blue (late-type) actively star-forming galaxies and of red (early-type) galaxies with little or no current star formation. The population of galaxies shifts from blue to red near a stellar mass transition of \( 3 \times 10^{10} M_\odot \) (Kauffmann et al. 2003). In our sample of galaxies, SFR increases with increasing stellar mass (Table 4).

There is a similar bimodality in the mass dependence of the SFR per unit stellar mass. Fig. 4 shows the relation of specific star formation rate (SSFR) versus stellar mass for our sample. The blue line shows the fit to the star-forming sequence for an SDSS spectroscopic sample of galaxies using GALEX ultraviolet luminosities to measure the SFR (Schiminovich et al. 2007). Except for one, our sample appears to lie along the blue sequence. There is no clear trend when examined as a function of redshift. The SSFR increases with decreasing galaxy mass, implying that lower mass galaxies form a higher fraction of their stellar mass in the present time.

This bimodality is not absolute, with a green valley between the red and blue sequences. This valley consists of less active star-forming galaxies representing a combination of inactive disc
Figure 1. Filamentary network of the cosmic web, based on the DisPeSE topological algorithm, overlaid on the distribution of galaxies in the redshift range \(0 < z < 0.1\). The black squares represent SDSS-DR14 galaxies with known optical spectroscopic redshifts and the pink squares show the galaxies in the H I sample. At the edges of the figure, the filaments are mostly parallel to the edge of the sample. This is an artefact of the filament detection, due to galaxy density rapidly dropping at the survey edges. Note that the CHILES field of view is a slim cone with an extent of 5 Mpc at \(z = 0.1\).

Table 3. Galaxy properties of the sample.

<table>
<thead>
<tr>
<th>Galaxy ID</th>
<th>COSMOS 08 ID</th>
<th>RA (J2000)</th>
<th>Dec. (J2000)</th>
<th>H I (Optical) Redshift</th>
<th>Dist. (Mpc)</th>
<th>(V_{\text{sys}}) ((\text{km s}^{-1}))</th>
<th>Type</th>
<th>Dist. near (Mpc)</th>
<th>Dist. fil (Mpc)</th>
<th>Fig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>J100128.00+022025.4</td>
<td>J1013496</td>
<td>1213496</td>
<td>150.3666</td>
<td>0.0068 (0.0069)</td>
<td>30</td>
<td>2041</td>
<td>dIrr</td>
<td>0.173</td>
<td>0.295 ± 0.089</td>
<td>A1</td>
</tr>
<tr>
<td>J100153.77+022449.8</td>
<td>J1013496</td>
<td>1180660</td>
<td>150.4741</td>
<td>0.0068 (0.0068)</td>
<td>30</td>
<td>2046</td>
<td>dIrr</td>
<td>0.173</td>
<td>0.319 ± 0.062</td>
<td>A2</td>
</tr>
<tr>
<td>J100115.19+021824.4</td>
<td>J1013496</td>
<td>1197518</td>
<td>150.3130</td>
<td>0.0286 (0.0266)</td>
<td>130</td>
<td>8575</td>
<td>Irr</td>
<td>1.5</td>
<td>3.7 ± 0.1</td>
<td>A3</td>
</tr>
<tr>
<td>J100115.50+022858.5</td>
<td>J1013496</td>
<td>1227948</td>
<td>150.1711</td>
<td>0.0470 (0.0425)</td>
<td>217</td>
<td>14113</td>
<td>Sp</td>
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<td>3.4 ± 0.3</td>
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<td>J100103.70+023053.1</td>
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<td>1432731</td>
<td>150.2654</td>
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<td>354</td>
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<td>bSp</td>
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<td>7.1 ± 3.5</td>
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<td>J100115.50+022858.5</td>
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<td>1432731</td>
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<td>22596</td>
<td>bSp</td>
<td>1.7</td>
<td>7.1 ± 3.5</td>
<td>A5</td>
</tr>
</tbody>
</table>

Notes. (1) Galaxy ID; (2) COSMOS 08 ID; (3) units of right ascension are in degrees; (4) units of declination are in degrees; (5) H I redshift is from CHILES and optical redshifts are from the G10/COSMOS v05 catalogue; (6) distance to target galaxy; (7) system velocity; (8) galaxy morphological classification, done by eye; (9) distance to nearest neighbour; (10) distance to nearest filament; (11) figure in the Appendix.

Table 4. Stellar and H I properties of the sample.

<table>
<thead>
<tr>
<th>COSMOS 08 ID</th>
<th>rms ((\mu)Jy bm(^{-1}))</th>
<th>Beam (arcsec(^2))</th>
<th>Abs. mag. (W)</th>
<th>NUV – (r)</th>
<th>SFR ((M_{\odot}) yr(^{-1}))</th>
<th>(M_{\ast}) ((M_{\odot}))</th>
<th>(M_{\text{HI}}) ((M_{\odot}))</th>
<th>(M_{\text{HI}}/M_{\ast})</th>
<th>D(_{\text{Opt}}) (kpc)</th>
<th>D(_{\text{HI}}) (kpc)</th>
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<tr>
<td>J100128.00+022025.4</td>
<td>6.42 \times 4.74</td>
<td>14.0</td>
<td>1.8</td>
<td>0.002</td>
<td>0.0006</td>
<td>0.018 ± 0.006</td>
<td>30.7</td>
<td>1.3</td>
<td>1.4</td>
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<tr>
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<td>6.42 \times 4.74</td>
<td>15.1</td>
<td>1.4</td>
<td>0.02</td>
<td>0.02</td>
<td>0.029 ± 0.005</td>
<td>1.3</td>
<td>3.0</td>
<td>2.3</td>
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</tr>
<tr>
<td>J100115.19+021824.4</td>
<td>6.49 \times 4.83</td>
<td>18.0</td>
<td>1.8</td>
<td>0.05</td>
<td>0.4</td>
<td>1.7 ± 0.2</td>
<td>4.2</td>
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<td>22</td>
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<tr>
<td>J100115.50+022858.5</td>
<td>6.60 \times 4.93</td>
<td>21.6</td>
<td>4.3</td>
<td>0.2</td>
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<td>0.03</td>
<td>0.2</td>
<td>0.9 ± 0.3</td>
<td>5.3</td>
<td>7.3</td>
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<td>19.7</td>
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<td>0.6</td>
<td>8.2</td>
<td>11.2 ± 3.1</td>
<td>1.4</td>
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<td>11.5</td>
<td>9.6 ± 2.9</td>
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<tr>
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<td>20.7</td>
<td>2.4</td>
<td>2.4</td>
<td>7.6</td>
<td>6.3 ± 3.8</td>
<td>0.8</td>
<td>26</td>
<td>34</td>
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<tr>
<td>J100116.44+022704.0</td>
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<td>0.9</td>
<td>2.5</td>
<td>3.2 ± 2.5</td>
<td>1.3</td>
<td>16</td>
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</tr>
</tbody>
</table>

Notes. (1) COSMOS 08 ID; (2) mean rms of the image cube; (3) synthesized beam FWHM of the image cube; (4) SDSS \(z\)-band absolute magnitude; (5) NUV – \(r\), using GALEX NUV magnitude and SDSS-DR7 \(r\)-band magnitude; (6) SFR; (7) stellar mass; (8) \(H_{\text{I}}\) mass, corrected for the primary beam; (9) gas fraction; (10) optical diameter along the SDSS \(r\)-band isophotal major axis; (11) \(H_{\text{I}}\) diameter along the \(H_{\text{I}}\) major axis, corrected for the beamwidth.
Figure 2. Total H I intensity maps of the sample. The total integrated flux contours are 2, 4, 8, 16, and 32σ. The contour values in cm$^{-2}$ are listed in the Appendix (Figs A1–A10) for each galaxy.

Figure 3. Global H I profiles for the sample. The H I system velocity is indicated with an upward-pointing arrow on the profile.

Table 5. Stellar, H I, and H $\alpha$ properties of the sample.

<table>
<thead>
<tr>
<th>COSMOS 08 ID</th>
<th>Inc. (deg)</th>
<th>$W_{\text{int}}$ (km s$^{-1}$)</th>
<th>$W_{20}$ (km s$^{-1}$)</th>
<th>$W_{\text{peak}}$ (km s$^{-1}$)</th>
<th>$V_{\text{H} \alpha}$ (deg)</th>
<th>PA$_{\text{HI}}$ (deg)</th>
<th>PA offset (deg)</th>
<th>Spin$_{\text{H} \alpha}$ Diff (deg)</th>
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<td>135</td>
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<td>350</td>
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<td>240</td>
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<td>1419315</td>
<td>49</td>
<td>300</td>
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<td>265</td>
<td>230</td>
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<td>240</td>
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<td>13</td>
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<tr>
<td>1221696</td>
<td>49</td>
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<td>125</td>
<td>150</td>
<td>120</td>
<td>36</td>
<td>180</td>
<td>180</td>
<td>36</td>
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</tbody>
</table>

Notes. (1) COSMOS 08 ID; (2) inclination is calculated such that 0° is face-on; (3) H I line width over which the global H I profile is integrated; (4) H I line width measured at 20 per cent of the peak flux density; (5) H I line width measured at the maximum velocity of the rising and declining parts of the H I PV diagram; (6) H $\alpha$ line width measured at the maximum velocity of the rising and declining parts of the H $\alpha$ rotation curve; (7) Optical PA; (8) H $\alpha$ PA; (9) H I PA; (10) difference between the optical and H I PAs; (11) difference between the stellar spin angle and filament angle; (12) difference between the H I spin angle and filament angle.
galaxies and active bulge-dominated galaxies. The one outlier in our sample, 1204837, appears to lie in this green valley. In the HST image, this galaxy appears to be a bulge-dominated system, which has a high stellar mass, a lower SFR, and an NUV − r of 4.3.

3.2 HI data analysis

Sub-cubes with individual intensity maps, described in Section 2.1, are used to produce total H I intensity maps (zeroth moment) and velocity fields (first moment) using SoFiA, the Source Finding Application (Serra et al. 2015). A noise scaling filter is applied along the velocity axis to normalize the cube by the local noise level per channel to account for variable noise characteristics throughout the cube. The S&C algorithm (Serra, Jurek & Föll 2012) is used to search for emission at multiple resolutions by smoothing the cube in three dimensions with specified kernels. The cube is smoothed at two resolutions in the sky using Gaussian kernels. The kernels are 4 × 4 and 6 × 6 pixels, which equal roughly 1.5 and two times the synthesized beam, respectively. The cube is smoothed at multiple resolutions in velocity using boxcar kernels. The kernels vary from 3 to 11 times the channel width, with the combination depending on the width of the spectrum of the galaxy. At each resolution, a specified relative flux threshold (in multiples of the noise level) is applied to extract and mark the significant pixels on each scale. The threshold varies from 3.5 to 4 for moment 0 maps. Higher threshold ranges of 4–6 are used for moment 1 maps, as they are more sensitive to the noise. A final mask is produced through the union of the masks constructed at the various resolutions, with significant pixels merged into this final source mask that is then applied to the input cube.

We present figures for individual galaxies in the Appendix (Figs A1–A10). The total H I intensity or moment 0 maps of each galaxy are overlaid as contours on Hubble Space Telescope (HST) Advanced Camera for Surveys (ACS) I-band (F814W) mosaic images (Figs 2, 13, and A1–A10) obtained from the COSMOS Archive and IRSA cut-out service (Koekemoer et al. 2007; Massey et al. 2010). The optical centre is marked with a white cross. The H I major axis is shown as a dotted line with the PA of the receding side. The optical major axis is also shown as a dotted line. The H I intensity-weighted velocity fields or moment 1 maps are similarly overlaid as contours on HST images. On the velocity field, the line passing through the cross represents the H I system velocity, $V_{HI}$. All nearby background galaxies with known redshifts in the HST images are confirmed to be distant enough to be ruled out of association or interaction with our targets. Only one target (1221696) has a neighbouring galaxy’s emission detected in the SALT spectra, but it is >30000 km s$^{-1}$ in separation.

3.3 Hα data analysis

The ionized gas rotation curves are constructed using PYTHON curve-fitting routines to fit single Gaussians to the emission-line features in the 2D SALT spectra. A Gaussian is fit to each pixel row in the region of the emission line, sampling the spatial extent of the galaxy image on the CCD until the signal became too low to fit. From the optimized curve fit, a continuum fit, amplitude, wavelength centre, and full width at half-maximum (FWHM) is obtained. We use the wavelength centres to calculate a velocity. The spatial centres are assigned by finding the mid-point row of the emission profile. We note that by sampling the velocity centres at each pixel row, we are oversampling with respect to the seeing (0.25 arcsec versus ∼1 arcsec), but even when averaged, the rotation curve shape remains intact. Additionally, we note that while single Gaussians fit most of the emission-line data well, two galaxies (1197 518 and 1419 315) exhibited profiles that are not well fit by a single Gaussian. Details on the fitting of these two galaxies can be found in the sample descriptions in Section 3.6.

For seven of the galaxies in the sample, the optical SALT spectra exhibited one or both lines of the doublets [N II] λ6548, 6583 and [S II] λ26716, 6732. Though not necessary for the kinematic analysis, we use these emission lines to derive line ratios across the slit region of each galaxy to search for any potentially interesting features in the ionized gas. The [N II] and [S II] lines are fit with the same method as described for H α. The optimal continuum fit is then subtracted before calculating the area under the fit for H α, [N II], and [S II]. The ratios [N II]/H α and [S II]/H α are then calculated row by row, sampling the ratio across the galaxy. One-sigma errors are derived from the Gaussian fits and propagated. Due to heavy residuals from the subtraction of night skylines, it is not always possible to fit one or both of the [S II] doublet lines. Given that the [S II] doublet lines are often comparable in intensity, for the galaxy in which we could not fit both lines, we make a very rough approximation of simply doubling the value derived from the fitted line.

The median of the line ratios across each disc is compared to the star-forming sequence for an SDSS spectroscopic sample of galaxies using GALEX ultraviolet luminosities to measure the SFR in Schiminovich et al. (2007). Open symbols are small galaxies with uncertain stellar masses.
Table 6. Line ratio summary.

<table>
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<th>CO8 ID</th>
<th>N/Hα Obs</th>
<th>S/Hα Obs</th>
<th>N/Hα SDSS</th>
<th>S/Hα SDSS</th>
<th>S/Hα SDSS</th>
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<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1197518</td>
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<td>–</td>
<td>0.85</td>
<td>0.95</td>
<td>1.30</td>
</tr>
<tr>
<td>1204837</td>
<td>0.43 ± 1.20</td>
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<td>0.29 ± 0.03</td>
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<td>0.35</td>
<td>0.30</td>
</tr>
<tr>
<td>1432731</td>
<td>0.28 ± 0.03</td>
<td>0.33 ± 0.03</td>
<td>0.41</td>
<td>0.37</td>
<td>0.43</td>
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</tr>
<tr>
<td>1437568</td>
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<td>0.34 ± 0.12</td>
<td>0.60</td>
<td>0.26</td>
<td>0.36</td>
</tr>
<tr>
<td>969633</td>
<td>0.51 ± 0.12</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1419315</td>
<td>0.33 ± 0.06</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1221696</td>
<td>0.15 ± 0.03</td>
<td>0.51 ± 0.09</td>
<td>–</td>
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</tbody>
</table>

Notes. *Median value of all fit points across target; †values for 3 arcsec diameter fibre centred on target.

some or all of these forbidden lines, representing galaxies with SFRs between 0.05 and 2.4 M⊙ yr⁻¹. While the median line ratio values for these galaxies agree with SDSS values, we find that there is some variation in the values across the discs. The [Nii] emission in 1204 837, the galaxy with the lowest SFR of the six galaxies, is too weak for spatially resolved study, but for the other six galaxies, we are able to trace the line ratio across the inner disc (Fig. 5). Only the innermost disc (out to radii of 3–6 arcsec) is measured (see plots in Figs A1–A10 for galaxy images). None of the galaxies for which there are SDSS O[III] data are beyond the star-forming region of a Baldwin–Phillips–Terlevich (BPT) diagram (Baldwin, Phillips & Terlevich 1981). As a final probe, we apply the simple metallicity scaling relationship developed by Dopita et al. (2016) across the disc (Fig. 5). This relationship uses a ratio of [Nii]/[S ii] and [Nii]/Hα to obtain a 12 + log(O/H) metallicity value without the use of oxygen lines, which suffer from reddening effects or go unobserved without multiple spectrograph configurations. For the galaxies that contained the necessary nitrogen and sulphur lines, we find that, like the [Nii]/Hα ratio, the metallicity peaks in the centre and decreases with increasing radius in the disc, as expected from typically negative radial metallicity gradients found in the discs of late type galaxies (Marino et al. 2013; Belfiore et al. 2017). The line ratio properties of each target are discussed in Section 3.6.

3.4 H I and H α properties

H I properties for the galaxies are listed in Tables 3 and 4. The H I mass is calculated as

\[ M_{HI} = 49.8 \, d^2 \int s(v)dv [M_\odot]. \]  (2)

where \( d \) is the luminosity distance in Mpc, \( s \) is the flux density in Jy, \( v \) is the frequency in Hz, and \( s \) is the integral of \( dv \) in Jy Hz. The integrated flux is determined as the sum of all flux density in Jy Hz. The Hα mass sensitivity of our observations over 150 km s⁻¹ is 1.9 × 10⁻³ M⊙ at \( z = 0.0068 \) and 3.5 × 10⁻² M⊙ at \( z = 0.0930 \). Our sample galaxies have H I masses ranging from 1.8 × 10² (velocity width 120 km s⁻¹) to 1.1 × 10³ M⊙, with six galaxies between 10¹ and 10² M⊙ and one galaxy above 10³ M⊙. The HI masses have been corrected for the primary beam. Throughout the HI cubes, we used the areas outside of the HI emission to measure the rms. We estimate the HI mass to have an uncertainty on the order of 20 per cent.

The column densities for individual galaxies are given in the captions of Figs 2 and A1–A10 in the Appendix. The HI column density is calculated as

\[ N_{HI} = \frac{2.34 \times 10^{20}}{\theta_1 \theta_2 (1+z)^4} \int s(v)dv (cm^{-2}), \]  (3)

where \( \theta_1 \) and \( \theta_2 \) are the FWHM of the major and minor axes of the synthesized beam in arcsec, \( z \) is the redshift, \( s \) is the flux density in Jy, \( v \) is frequency in Hz, and \( s \) is the integral of \( dv \) in Jy Hz. We reach the theoretical noise in our image cubes and reach the predicted column density of \( 3 \times 10^{19} \) cm⁻² (13 km s⁻¹ channel at \( z \sim 0 \)).

Additional H I properties listed in Tables 3 and 4 are the system velocity, the line width of the galaxy, the radial extent of the H I, and the PA of the H I. \( V_{sys} \) is taken as the velocity value at the optical centre of the velocity field. \( W_{int} \) is the line width over which the global H I profile is integrated and is taken from the channel range of the source mask used to generate moment 0 images in SoFiA. \( W_{20} \) is the line width measured at 20 per cent of the peak flux density. \( W_{sys} \) is the line width measured at the maximum velocity of the rising and declining parts of the H I PV diagram. Similarly, \( W_{vsys} \) is the line width measured at the maximum velocity of the rising and declining parts of the H α rotation curve. Errors of 27 km s⁻¹ in the H I line widths reflect uncertainties of one channel on either side.

The radial extent of the H I diameter \( D_{HI} \) is measured along the H I major axis of the \( P-V \) diagram at a limiting column density of \( 1.25 \times 10^{20} \) cm⁻² (1 M⊙ pc⁻²), \( D_{HI} \) is corrected for beam smearing effects using a Gaussian approximation (Wang et al. 2016):

\[ D_{HI} = \sqrt{(D_{HHα}^2) - (B^2)}. \]  (4)

where \( D_{HHα} \) and \( D_{HHα} \) are the corrected and uncorrected H I diameters, and \( B \) is the synthesized beam along the major axis. Errors of 11 arcsec in the H I radial extent reflect uncertainties of one beamwidth on either side.

\( PA_{HHα} \) is calculated using SoFiA to determine the flux-weighted centroid of the emission in each channel of the image cube and then fitting a straight line to the set of centroids. Errors of 10° in the H I PA reflect an uncertainty estimate of 5° on either side. The PA is compared by eye to the H I kinematic major axis of the velocity field. The PA is adjusted to match the H I kinematic major axis of the velocity field in 1432731 and 1221696. \( PA_{HHα} \) is taken at the optical major axis or close to it, as described in Section 2.2.

3.5 Identifying galaxy environments

To quantify the environments of galaxies, we look at their location in the cosmic web and the distance to the nearest neighbour. Luber et al. (2019) has developed the use of DisPerSE for the CHILES volume using a catalogue of 11 500 spectroscopic redshifts from the G10/COSMOS v04 catalogue (Davies et al. 2015). They show that for this small volume sensible results are obtained that are consistent with larger surveys. Here, we use the same method, but we use redshifts from SDSS-DR14 rather than from G10/COSMOS v04 since too few redshifts are available at this low redshift in G10/COSMOS v04. We search SDSS-DR14 for all galaxies with spectroscopic redshifts with coordinates 148° < RA < 153°, and 0° < Dec. < 5° which corresponds to a thickness of 70 Mpc at the higher end of the redshift range and 15 Mpc at the lower end of the redshift range. We choose an area that is sufficiently wider than the actual CHILES field, to properly reconstruct the large-scale structure in the CHILES field.

We run DisPerSE over this galaxy catalogue with a mirror boundary condition and a significance level of four. See Luber et al.

Figure 5. Top and middle row: Line ratios of [NII]λ6583/Hα (red) and [S II]λ(6716 + 6732)/Hα (blue) as a function of offset from the galaxy centre for all galaxies in which these emission lines are measurable. Bottom row: Metallicity across the disc of the galaxy using the relationship from Dopita et al. (2016). (2019, section 4) for further explanation of the method and these experimentally determined parameters. DisPerSE identifies various types of structures in a density field of points by characterizing topological features that correlate to indexed manifolds that then correspond to various components of the cosmic web (voids, walls, filaments, and clusters). We extract the filament spines, with the tracers of this filamentary structure referred to as critical points. We calculate the distance of a galaxy to its nearest filament spine by finding the distance of that galaxy from the nearest critical point. The error in distance is bound by half the distance between the critical point used and the next closest one. Fig.1 shows the 3D slice of our field of view collapsed into a 2D projection. The position of galaxies in relation to the filamentary structure is also shown in Fig.1 and discussed in Section 5. Note that contrary to some other work where 2D distances are used (Kleiner et al.2017; Laigle et al. 2018; Luber et al. 2019), we use 3D distances in our analysis.

The distance to the nearest neighbour is calculated by assuming all velocities are purely due to expansion, converting RA, Dec., and redshift to physical units, and finding which galaxy is the minimum distance in physical units. It is important to note that this is done with the spectroscopic catalogue as photometric redshifts are not accurate enough for low z.

3.6 Notes on individual galaxies

1213496 and 1180660: The two nearest galaxies in our sample are dwarf irregulars (Fig. A1 and A2). They are close spatially with a separation of around 70 kpc, as shown in Fig. 6(a), and have a velocity difference of 5 km s$^{-1}$. Both 1213496 and 1180660 lie within ~300 kpc of filamentary structure. These galaxies have H I masses on the order of 10$^7$ M$_\odot$ and have the highest SSFR of our sample. Both galaxies have H I offset from the optical major axis as well as asymmetric H I morphology. In each galaxy, the optical PA follows the outer H I intensity contours while the H I PA follows the velocity field of the inner disc. For 1213496, the northern part of the velocity field in the outer disc seems to shift more towards polar. For 1180660, the velocity field looks even more disturbed with the contours to the west nearly perpendicular to the H I major axis, more like a polar ring of counter-rotating gas. Given their proximity, the disturbances in the outer disc may be an indication that these two galaxies are gravitationally interacting.

Ionized gas is not detected in 1213496 and is limited in extent in 1180660, consistent with their low SFRs. When viewing 1180660’s ionized gas rotation overlaid on its H I PV diagram, we see that the ionized gas is well-aligned along with the system velocity for PA 84$^\circ$, and fits well within the H I contours for PA 137$^\circ$, though with a slightly steeper slope.

1419315 and 1221696: The two farthest galaxies in our sample are close spatially with a separation of around 170 kpc, and have a velocity difference of 94 km s$^{-1}$. 1221696 (Figs A10 and 6b) has a tail that extends in the direction of 1419315 (Fig. A9). This feature along with their proximity may indicate that they are gravitationally interacting. Both 1419315 and 1221696 are located ~5.6 Mpc from filamentary structure. These galaxies have H I and stellar mass on the order of 10$^9$ M$_\odot$ and have SFRs that are some of the highest in our sample. Both have asymmetric H I morphology.

The ionized gas rotation curves in both of these galaxies mostly agree with the H I PV diagram contours. However, in 1419315, the ionized gas rotation seems to flatten/decline at a lower velocity than the H I towards the receding edge of the galaxy. The H I and H α are decoupled at large radii, which is a unique phenomenon in this sample. Galaxy 1419315 did not have measurable [S II], but did demonstrate enhanced [NII]/H α ratio at the centre, and asymmetric values (high on the approaching side and low on the receding side). This is consistent with a negative radial metallicity gradient. In galaxy 1221696, we again see little variation in the...
1432731: 1432731 (Fig. A6) is a spiral galaxy and is the most face-on galaxy of our sample, inclined at 14°. It is at a distance of 1.2 Mpc from its nearest neighbour. This galaxy has the largest H I mass in the sample at $1.1 \times 10^{10}$ M$_\odot$ and resides 9.6 Mpc from a filament spine. 1432731 has an H I diameter that is 71 kpc across, extending over six times past the optical diameter. The H I distribution and morphology are very asymmetric and the PV diagram shows lower velocity low-level emission on the receding side that could indicate counter rotation.

The ionized gas overall consistently traces the H I contours. There is a region of ionized gas emission on the receding edge, likely corresponding to a bright H II region in one of the faint extended spiral arms visible in the HST image of the galaxy. In 1432731, both [N II]/H $\alpha$ and [S II]/H $\alpha$ are similar values in the central region of the disc, but [N II] emission diminishes while [S II] emission increases at increasing radii. The decreased [N II] emission is consistent with decreasing metallicity. Though [S II]/H $\alpha$ may also trace metallicity, it does so much less reliably. When the [S II]/H $\alpha$ ratio is unusually high (>0.4), it can be attributed to supernova remnants (SNRs) or diffuse ionized gas (Zhang et al. 2017). Our line widths do not seem wide enough for SNRs, so the enhanced [S II]/H $\alpha$ at the edges of the measurable region may therefore be attributable to diffuse ionized gas. Given that the ‘flared’ [S II]/H $\alpha$ occurs around the point where the slit traverses inter-arm regions rather than spiral arms on both sides of the galaxy, this seems plausible.

1197518: 1197518 (Fig. A3) is an irregular galaxy and one of the more isolated galaxies in our sample, at a distance of 1.5 Mpc from its nearest neighbour and 3.7 Mpc from a filament spine. It is the brightest H I detection so far in the full survey and has extended H I with very asymmetric morphology. The H I mass is several times its stellar mass and the SFR is low at $0.05$ M$_\odot$ yr$^{-1}$.

The ionized gas kinematics for this galaxy are the most irregular in the sample. Weak [N II] 6583 Å is present along with H $\alpha$. Though it fits within the H I contours, the rotation curve exhibits a central kink. In the outer regions of the galaxy ($\sim$10 to $-7.5$ arcsec and $+2.5$ to $+10$ arcsec), the emission-line profiles are well fit by a single Gaussian. The central region is highly asymmetric, suggesting at least two components, with the dominant component shifting from red to blue as one moves from bottom to top of the galaxy spatially.

The steep rise and fall of the ionized gas in the central region may be indicative of a strong bar, though the galaxy seems to be viewed almost edge-on, making this conclusion difficult to confirm. Sofue et al. (1999) identified that, while barred galaxies exhibit similar general properties compared to unbarred galaxies, they have larger velocity amplitude variation in the innermost disc. This large velocity variation arises from the barred potential, and simulations of PV diagrams for edge-on barred galaxies show many tens of km s$^{-1}$ fluctuations, superposed on the usual flat rotation curve (Athanassoula & Bureau 1999).

Considering this is a highly inclined galaxy, the PV diagram can also be interpreted as to have a steeply rising rotation curve at the approaching side, and a more slowly rising rotation curve at the receding side, not inconsistent with the H $\alpha$. The optical morphology of the outer disc in the HST image of the galaxy seems suggestive of a warp. The H I contours have a mild curvature, but the ionized gas is more dramatically perturbed. With a nearest neighbour 1.5 Mpc away, a merging event seems unlikely but cannot be conclusively ruled out and lends a possible explanation for the disturbed kinematics of the ionized gas.

1437568 and 969633: Two barred spirals are the most isolated galaxies in our sample, at a distance of 1.7 Mpc from their nearest neighbour. Both 1437568 (Fig. A7) and 969633 (Fig. A8) are

| Figure 6. | Galaxies in close proximity. Fig. 6(a) shows total H I intensity maps for the two nearest galaxies in our sample. They are close spatially with a separation of around 70 kpc and have a velocity difference of 5 km s$^{-1}$. For both galaxies, the H I velocity field of the outer disc shifts more towards being perpendicular to the H I major axis, indicative of a polar ring. Their disturbed H I morphology and kinematics along with their proximity may indicate they are gravitationally interacting (Figs A1 and A2). Fig. 6(b) shows total H I intensity maps for the two farthest galaxies in our sample. They are close spatially with a separation of around 1 kpc and have a velocity difference of 94 km s$^{-1}$. 1221696 has a tail that extends in the direction of 1419315. This H I feature along with their proximity may indicate they are gravitationally interacting (Figs A9 and A10). |

| Line Ratios | The [S II]/H $\alpha$ ratio is, however, higher at all points across the measured area of the disc. Given the limited region probed, it is difficult to draw any conclusions about these line ratio values. |

| 1204837 and 1227948: 1204837 (Fig. A4) and 1227948 (Fig. A5) are two galaxies that are within 371 kpc of their nearest neighbour. Both galaxies have extended H I with asymmetric morphology and are located $\sim$3.5 Mpc from filamentary structure. Both have H I offset from the optical major axis, with irregular galaxy 1227948 having a PA offset of 68°. |

| The ionized gas rotation fits well with the H I PV diagram of 1204837, with both neutral and ionized gas missing from the centre of the galaxy. 1204837 has the most dominant bulge in our sample, which may account for the lack of neutral and ionized gas in the centre of the PV diagrams. 1204837 has very weak [N II] 6583 Å emission. In 1227948, the ionized gas lays along with the system velocity for both position angles, agreeing well with the H I contours (albeit with some scatter since the galaxy is irregular and one of the smallest in the sample). |

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[References]

- Athanassoula & Bureau 1999
- Sofue et al. 1999

[Note]

- All astronomical distances and masses are in units of Mpc and solar masses (M$_\odot$), respectively.
located several Mpc from filamentary structure at 7.1 and 6.0 Mpc, respectively. These galaxies are large in stellar mass and have higher SFRs. Both galaxies have extended H I and 1437568 has asymmetric H I morphology.

The ionized gas emission in 969633 extends to 8 arcsec along PA = 60°, corresponding to a distance of 19.9 kpc, or ~ 80 per cent of the stellar radius (R_∗ = 24.44 kpc). The profile of this galaxy differs from the rest of the sample due to the presence of a very broad, bright central region. The outer disc is fit by relatively narrow (FWHM < 1 Å) Gaussians, but the central region has characteristic widths of 3 Å or 120 km s^{-1}. The galaxy is not, however, an AGN. Line ratios measured using H α, [N II], and [S II] from the SALT spectrum, as well as SDSS spectrum values for [O III]λ5007/H β, place this galaxy firmly within the star-forming region of a BPT diagram (Baldwin et al. 1981). We thus attribute the broad-line widths in the galaxy firmly within the star-forming region of a BPT diagram (Baldwin et al. 1981). We thus attribute the broad-line widths in the galaxy firmly within the star-forming region of a BPT diagram.

In galaxy 1437568, the line ratios remain relatively flat across the measured portion of the disc, albeit with more scatter than other galaxies in the sample. Though it is a barred spiral, we do not see a significant enhancement of [N II]/H α (see 969633 notes). The most interesting of the sample in terms of line ratios is 969633, with enhanced [N II]/H α and suppressed [S II]/H α in the central region. Given that this galaxy has the broadest line widths in the centre in H α, it would seem there is intense activity in the innermost part of the disc, though it does not qualify as an AGN. The enhanced [N II]/H α likely arises from the bar in 969633. Florido et al. (2015) find that barred galaxies exhibit an enhanced N/O ratio, and thus higher [N II]/H α. They find no similar effect on [S II]/H α in agreement with the [S II]/H α values remaining mostly flat across the region of enhanced [N II]/H α.

4 SCALING RELATIONS

We analyse ancillary stellar data along with the observed H I and H α properties of our sample and find our data follow known galaxy scaling relations. Our sample follows expected trends for star formation rates, H I gas fraction, and the H I size–mass relation as well as the baryonic Tully–Fisher relation for the H I and H α.

4.1 H I gas fraction

The relation between M_∗ and M_HI for our sample is shown in Fig. 7. The diagonal grey solid line indicates equal amounts of stellar and H I mass. The average gas fraction (M_HI/M_∗) of our sample is 1.8 (Table 4). This is excluding 1213 496, which has a gas fraction of 31 and our highest SSFR. We compare our sample with the galaxy population detected by ALFALFA, the largest wide-field blind H I survey at low redshift (Haynes et al. 2011). The orange line shows the median values from the spectroscopic ALFALFA–SDSS galaxy sample in Maddox et al. (2015). Our sample shows M_HI increasing as a function of M_∗ and agrees quite well with the median values of the ALFALFA sample. Galaxies with stellar masses below 10^8 M_⊙ have more H I than stars, and galaxies with stellar masses above 10^{10} M_⊙ have less H I than stars. The galaxies in our sample with stellar masses below 10^{9.5} M_⊙ are all classified as irregular.

4.2 H I deficiency

The H I content of galaxies can be characterized by scaling relations between the H I content and other intrinsic properties of galaxies. These H I scaling relations can be useful in identifying galaxies that have either more H I than expected or less H I than expected, as galaxies like these may have been affected by recent processes including the removal or accretion of gas. One way to characterize the H I gas content of galaxies is with H I deficiency. H I deficiency is the logarithmic difference between the observed H I mass and the expected H I mass:

\[ H_{\text{def}} = \log M_{\text{H I}}^{\text{exp}} - \log M_{\text{H I}}^{\text{obs}}. \]

where \( M_{\text{H I}}^{\text{exp}} \) is the expected H I mass calculated from scaling relations, and \( M_{\text{H I}}^{\text{obs}} \) is the measured H I mass taken from observations (Haynes & Giovanelli 1984). Generally, a galaxy is considered to have a normal H I gas content if its H I deficiency is between -0.3 and 0.3 (Dénes, Kilborn & Koribalski 2014), with an H I excess if \(< -0.3 \) and H I deficiency if \( > 0.3 \).

Studies use H I-selected samples combined with SDSS optical properties to derive scaling relations. With the GASS survey, Catinella et al. (2012) found that a good predictor of the H I content is the linear combination of stellar surface density and NUV−r colour. We examine the H I deficiency of our sample adapting results using the H I to stellar mass fraction function shown in fig. 8 from Catinella et al. (2012):

\[ \log M_{\text{H I}}/M_\star = a \log \mu_\star + b (\text{NUV} - r) + c, \]

with \( a = -0.285, b = -0.366, \) and \( c = 2.872. \) This function is the relation between H I mass fraction and a linear combination of stellar mass surface density and NUV−r colour with the relation obtained using the subset galaxies with NUV − r ≤ 4.5 mag. The stellar mass surface density is calculated from the formula

\[ \mu_\star = \frac{M_\star}{2 \pi R_{50}}, \]

where \( R_{50} \) is the radius containing 50 per cent of the Petrosian flux in z-band from SDSS DR7, and NUV − r is the GALEX (Martin et al. 2005) NUV magnitude minus the SDSS DR7 r-band magnitude.

Figure 7. Relation of the H I mass and stellar mass. The diagonal grey solid line indicates equal amounts of stellar and H I mass. The orange line shows the median values from the spectroscopic ALFALFA–SDSS galaxy sample in Maddox et al. (2015). Open symbols are small galaxies with uncertain stellar masses.
4.3 H I size–mass relation

H I often extends beyond the optical disc, where it can trace events of removal and accretion of gas. Observationally, these events can be revealed by the asymmetries of the morphology and kinematics of H I (Sancisi et al. 2008). The majority of galaxies in our sample show extended H I. There is a tight correlation between the H I mass and the beam-corrected diameter of the H I discs, as shown in Fig. 9. The radial extent of our H I diameters, $D_{\text{HI}}$, is measured along the H I major axis of the PV diagram at a limiting column density of $1.25 \times 10^20$ cm$^{-2} \times (1 \, \text{M}_\odot \, \text{pc}^{-2})$ and corrected for beam smearing. The line green line is the correlation found by Wang et al. (2016), the dark green line represents the correlation found by Verheijen & Sancisi (2001) and the olive green line is the correlation found by Martinsson et al. (2016). Note that these papers use azimuthally averaged surface density to measure $D_{\text{HI}}$, while we use a 1D PV diagram.

The results for H I deficiency are shown in Fig. 8. A solid grey line is drawn for deficiency $= 0$ and a dotted grey line for deficiency $= +0.3$ and $-0.3$. Figs 8(a) and 8(b) show the H I deficiency in relation to the log of stellar mass and distance to filament, with no obvious trends. In Catinella et al. (2012), the results for a sample of galaxies with stellar mass greater than $10^{10}$ M$_\odot$ are above stellar mass $10^{10}$ M$_\odot$. Since only three galaxies (1204837, 1437568, 969633) are above stellar mass $10^{10}$ M$_\odot$, this method is not well calibrated for our lower mass sample. With that said, none of the galaxies are H I deficient and half of the sample has H I excess. This is of course not surprising for a small H I-selected sample.

4.4 H I and H $\alpha$ line widths

With our sample of galaxies, we study the structural relation of H I and H $\alpha$ discs with rotation curves of H $\alpha$ in the inner regions and with H I in the outer regions. The H $\alpha$ traces the kinematics at a spatial resolution of 1 arcsec and a velocity resolution of 70 km s$^{-1}$. The H I traces the kinematics at a spatial resolution of 5 arcsec and a velocity resolution of $\sim 13$ km s$^{-1}$.

A comparison of H I and H $\alpha$ at low redshift is useful for studies at high redshift, where only optical lines are observable. Studies at higher redshift provide information for scaling relations used in mass modelling of galaxies and in studying the evolution of the Tully–Fisher relation. We compare the line width of the H I versus the line width of the H $\alpha$ for our sample, as shown in Fig. 10(a). The H $\alpha$ PA is taken at the optical major axis or close to it, as described in Section 2.2. The H I PA is taken at the kinematic major axis, which differs from the optical major axis in more than half of the sample and may be a reason for the slight difference in widths between the H I and H $\alpha$. Except 1197518 and 1204837, the line width of the H $\alpha$ is of the same order as the line width of the H I. This indicates that the flat part of the rotation curve is reached for H I and H $\alpha$, even though the rotation curve may not completely flatten for all our galaxies in H $\alpha$. Uncertainty on the H $\alpha$ measurements has been visualized.

References

Martinsson et al. (2016), Swaters et al. (2002) examine 73 late-type dwarf galaxies and find that lopsidedness is as common among dwarf galaxies, as it is in spiral galaxies. Furthermore, Jütte et al. (2013) conduct a statistical investigation of 76 H I discs finding at least 50 per cent of galaxies have lopsided discs and that generally morphological and kinematic irregularities are correlated. Most of the galaxies in our sample have irregularities in the morphologies and kinematics of their gas discs and our results do not appear to be that unusual.

Figure 8. H I deficiency using scaling relations from Catinella et al. (2012). A solid grey line is drawn for deficiency $= 0$ and a dotted grey line for deficiency $= +0.3$ and $-0.3$. Figs 8(a) and 8(b) show the H I deficiency in relation to the log of stellar mass and distance to filamentary structure based on the DisPeSE topological algorithm. Open symbols are small galaxies with uncertain stellar masses.

Figure 9. Relation of the H I mass and H I disc diameter. To the radial extent of the H I diameter $D_{\text{HI}}$, is measured along the H I major axis of the PV diagrams at a limiting column density of $1.25 \times 10^{20}$ cm$^{-2} \times (1 \, \text{M}_\odot \, \text{pc}^{-2})$ and corrected for beam smearing. The lime green line is the correlation found by Martinsson et al. (2016), the dark green line represents the correlation found by Verheijen & Sancisi (2001) and the olive green line is the correlation found by Martinsson et al. (2016). Note that these papers use azimuthally averaged surface density to measure $D_{\text{HI}}$, while we use a 1D PV diagram.

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1197518 1197518

Figure 10. Line widths of the neutral and ionized gas. Fig. 10(a) shows the relation of the width of H I and the width of H α. The diagonal grey solid line indicates equal widths of H I and H α. Fig. 10(b) shows the Baryonic Tully–Fisher relation with total mass \((M_{\text{HI}} + M_{\star})\) versus the width of H I and H α. The BTFR from McGaugh et al. (2000) is shown in orange. Open symbols are small galaxies with uncertain stellar masses.

4.5 H I and H α baryonic Tully–Fisher relation

Despite the diverse formation histories of individual galaxies, local disc galaxies exhibit a tight relationship between their rotation velocity and their luminosity or mass, namely the Tully–Fisher (TF) relation (Tully & Fisher 1977). Combining the stellar mass with observed gas mass results in a Baryonic Tully–Fisher Relation (BTFR) that is linear over many decades in mass (Verheijen 2001).

Fig. 10(b) shows BTFR for our sample, with the total mass \((M_{\text{HI}} + M_{\star})\) versus the line width of the H I and H α. Line widths used in our Tully–Fisher comparisons are corrected for inclination, with \(i = 14^\circ\) and \(i = 25^\circ\) excluded from the relation. Lelli et al. (2019) study the BTFR at \(z = 0\) using 153 galaxies from the SPARC sample with H I and H α rotation curves. They find the tightest BTFR is given by using the mean velocity along the flat part of the rotation curve with a best-fitting slope of \(3.85 \pm 0.09\). The slope of the line using the H I widths from our sample is \(3.68 \pm 0.66\) and the slope of the line using the H α widths is \(4.11 \pm 0.83\). This is excluding 1204837 as this galaxy is an outlier in Fig. 10(a), which causes a significant difference in the slopes for H I and H α. Note that the slope should be interpreted with caution, since there is a large scatter around this fit. The BTFR from McGaugh et al. (2000) is shown in orange for reference.

5 RESULTS

We use ancillary stellar data and observed H I data to examine the role local environment plays in our sample by comparing galaxy properties with respect to the location of the nearest neighbour. In addition, we examine the role large-scale environment plays by comparing galaxy properties with respect to location and orientation of the nearest cosmic web filament.

5.1 H I morphology and kinematics

An indication in our data that neighbours may have an impact on the morphology is shown in Fig. 11. Six out of 10 galaxies have the PA offset between the H I kinematic major axis and the optical photometric major axis by 30° or greater. For our sample, the more offset the PA the closer the galaxy is to its nearest neighbour. Another indication that neighbours may impact morphology and kinematics is the two dwarf irregular galaxies (1213496, 1180660) shown in Figs 6(a), A1, and A2. They have a separation in the sky of around 70 kpc and a difference in velocity of 5 km s\(^{-1}\). For both galaxies, the H I velocity field of the outer disc shifts more towards
Figure 12. Relation of the galaxy properties and galaxy location. Fig. 12(a) shows the relation of H I mass and distance from the filament. Fig. 12(b) shows the relation of SSFR and distance from the filament. Fig. 12(c) shows the relation of gas fraction and distance from the filament. Figs 12(d), (e), and (f) show the stellar and the H I properties of our sample with respect to the nearest neighbour. Fig. 12(d) shows the relation of H I mass and distance from the nearest neighbour. Fig. 12(e) shows the relation of gas fraction and distance from the nearest neighbour. Fig. 12(f) shows the relation of SSFR and distance from the nearest neighbour. Open symbols are small galaxies with uncertain stellar masses.

being perpendicular to the H I major axis, indicative of a polar ring (Stanomik et al. 2009).

There are several galaxies in the sample with more prominent irregularities in their H I morphology and/or kinematics. For example, 1432731 has the most disturbed H I distribution, 1437568 has the most asymmetric H I morphology, 1180660 has the most shifted H I kinematics compared to the optical disc, and 1204837 has the most noticeable H I PA misalignment com-
Figure 13. Relation of the galaxy spin vector and its nearest filament. In each panel (a–f), the grey line highlights the filament that is closest to each galaxy (shown with an x). The closest filament is calculated in three dimensions and is found by selecting the three closest critical points. Once the closest filament is identified, it is projected in two dimensions onto the sky as shown in the plots in each panel. The plot axes are distance from the field centre in Mpc (at the distance of the filament) and are comparable to right ascension and declination. The galaxy name and distance (in three dimensions) to the filament are shown next to each x. The redshift range is shown in the upper corner of each panel. Total HI intensity maps for the H I are shown along with the spin vectors for the H I gas (yellow-dashed line) and the spin vectors for the stellar disc (orange-dashed line). The axes are right ascension and declination.

5.2 Distance to cosmic web filaments

Both theory and observations suggest that large-scale structure impacts galaxy evolution in addition to known trends in local density. For example, observations show that at the same local density, redder, passive, and more massive galaxies are found closer to their filaments (Chen et al. 2017; Malavasi et al. 2017; Kraljic et al. 2018; Laigle et al. 2018). Studies on H I content have mixed results. Crone Odekon et al. (2018), using the ALFALFA catalogue,
find that H I deficiency decreases as the distance from the filament increases and that most gas-rich galaxies are in small tendrils within voids. In contrast, Kleiner et al. (2017), using stacked spectra from the H I gas and the photometric major axis of the stellar disc. The location of our sample of galaxies lies within a range of 3D distances from the cosmic web. The two dwarf galaxies are around 300 kpc from a filament spine and the rest of the sample is from 3.4 to 9.6 Mpc from a filament spine. Since our low-mass sample is H I biased, it can be expected that our galaxies may be more isolated (Kreckel et al. 2012). Fig. 12(a) shows the SSFR decreases with increasing distance from filaments. The study finds no difference in H I fraction between galaxies at 0.7 and 5 Mpc from filaments at smaller stellar mass log \( M_*/M_\odot < 11 \).

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Figure 15. Relation of the spin-filament angle to mass. Fig. 15(a) shows the angle between the stellar spin and filament versus stellar mass. Fig. 15(b) shows the angle between the stellar spin and filament versus H I mass. Fig. 15(c) shows the angle between the H I spin and filament versus stellar mass. Fig. 15(d) shows the angle between the H I spin and filament versus H I mass. A dotted grey line is drawn at 45 deg. Open symbols are small galaxies with uncertain stellar masses.

components with a majority less than 45°. The average spin angle for the H I component is 41° and the average spin angle for the stellar component is 29°.

A transition between the aligned and perpendicular orientations of galaxy spins is found in some simulations, including the recent work by Kraljic et al. (2019). They find a transition in orientation at a stellar mass of \( \sim 10^{10} M_\odot \) and a transition in orientation at an H I mass of \( \sim 10^{9.5} M_\odot \), both based on the spin of the stellar component. Observationally, Welker et al. (2019) find a stellar transition mass from aligned to perpendicular orientations of galaxy spins bracketed between \( 10^{10.4} M_\odot \) and \( 10^{10.9} M_\odot \). They also compare their results to simulations finding that the transition mass varies with the mass scale used to define the filaments and that more refined filaments seem to lead to lower transition masses. Fig. 15 shows the spin-filament angles as a function of mass. If the three smallest galaxies are removed (1213496, 1180660, and 1227948), there seems to be a hint of transition in orientation just around \( \sim 10^{10} M_\odot \) in stellar mass (Fig. 15a) and a more bracketed hint of transition just below \( \sim 10^{10} M_\odot \) in H I mass (Fig. 15b), both based on the stellar spins. At most, these are marginal hints of the predicted trends. Figs 15(c) and (d) show a less convincing trend in transition for the H I spin in relation to stellar mass and H I mass. The results from our small sample are quite interesting and provide an opportunity to look at individual galaxies. However, a larger sample with better statistics is needed to draw firm conclusions and provide more profound insight into the alignment of spin vectors with filaments.

6 CONCLUSIONS

We present H I observations of 10 galaxies out to a redshift of 0.1 from the first epoch of CHILES. We find a large fraction (9 out of 10) of galaxies is somewhat disturbed, with large H I discs measuring the flat part of the rotation curve. The two dwarf irregular galaxies have disturbances in their outer discs that are indicative of polar rings and may be an indication that these two galaxies are gravitationally interacting. We compare the neutral and ionized gas for our sample of galaxies. It appears that H α rotation curves approach the flat part, making them useful for measuring dark matter content and TF studies.

We explore galaxy properties as a function of location to cosmic web filaments. We find that galaxy spins tend to be aligned with cosmic web filaments and a hint of the predicted transition mass
associated with the spin angle alignment. Our sample of galaxies lies within a range of distances from the cosmic web with the H1 mass increases with increasing distance from filaments and SSFR decreases with increasing distance from filaments.

We utilize this small sample of nearby galaxies for a science verification study using our first 178 h. We find that our data follow known scaling relations and demonstrate the use of cosmic web filaments to study the impact of the large-scale environment on these systems. With the full 1000 h of the CHILES survey, we will be able to further study galaxy properties and orientation with respect to the cosmic web with images of close to 400 galaxies, using a broader mass sample, over the continuous redshift range (0 < z < 0.45) of the entire survey.

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This research made use of ASTROPY, a community-developed core PYTHON package for Astronomy (Astropy Collaboration 2013). Rotation curve overlays are made using MATPLOTLIB (Hunter 2007).

Facilities: NED, SALT, VLA software: ASTROPY, CASA, IDL, IRAF, PY SALT

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**APPENDIX A: FIGURES FOR INDIVIDUAL GALAXIES**

We present figures for individual galaxies (Figs A1–A10).

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**Figure A1.** Properties for galaxy 1213496. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 76 (rms) × −4, −2 (dashed), 2, 4, 6, 8 μJy beam$^{-1}$; H I total integrated flux: 6.6 (2σ, 13.3 km s$^{-1}$ channel), 13.2, 26.5, 53.0 × 10$^{19}$ cm$^{-2}$; H I velocity field: 2041 (system) ± 5 km s$^{-1}$; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. No H α is detected for this galaxy.
Figure A2. Properties for galaxy 1180660. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 76 (rms) × −4, −2 (dashed), 2, 4, 6, 8, 10, 12 µJy beam$^{-1}$; H I total integrated flux: 6.6 (2σ, 13.3 km s$^{-1}$ channel), 13.2, 26.5, 53.0, 106.0 × 10$^{19}$ cm$^{-2}$; H I velocity field: 2046 (system) ± 3 km s$^{-1}$; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. H$\alpha$ is represented by the red points, and the red shaded region is the SALT velocity resolution (∼70 km s$^{-1}$), taken here as the uncertainty.

Figure A3. Properties for galaxy 1197518. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 74 (rms) × −4, −2 (dashed), 2, 4, 6, 8, 10, 12, 14 µJy beam$^{-1}$; H I total integrated flux: 6.8 (2σ, 13.6 km s$^{-1}$ channel), 13.6, 27.3, 54.6, 109.0 × 10$^{19}$ cm$^{-2}$; H I velocity field: 8575 (system) ± 10 km s$^{-1}$; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. H$\alpha$ is represented by the red points, and the red shaded region is the SALT velocity resolution (∼70 km s$^{-1}$), taken here as the uncertainty. The upper rightmost image is the 2D SALT spectrum, showing the H$\alpha$ emission line. The emission line is poorly fit by a single Gaussian and results in the H$\alpha$ rotation curve kink, due to the clump indicated by the grey arrow on the redward side of the normal rotation component. This clump could also be gas in non-circular motion due to the bar, and in front so we do not see the corresponding back side due to extinction.
Figure A4. Properties for galaxy 1204837. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 79 (rms) × −4, −2 (dashed), 2, 4, 6 μJy beam$^{-1}$; H I total integrated flux: 7.5 (2σ, 13.8 km s$^{-1}$ channel), 14.9, 29.8, 59.7, 119.0 × 10$^{19}$ cm$^{-2}$; H I velocity field: 13335 (system) ± 20 km s$^{-1}$; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. Hα is represented by the red points, and the red shaded region is the SALT velocity resolution (∼70 km s$^{-1}$), taken here as the uncertainty.

Figure A5. Properties for galaxy 1227948. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 79 (rms) × −4, −2 (dashed), 2, 4 μJy beam$^{-1}$; H I total integrated flux: 7.5 (2σ, 13.8 km s$^{-1}$ channel), 15.1, 30.1 × 10$^{19}$ cm$^{-2}$; H I velocity field: 14113 (system) ± 5 km s$^{-1}$; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. Hα is represented by the red points, and the red shaded region is the SALT velocity resolution (∼70 km s$^{-1}$), taken here as the uncertainty.
Figure A6. Properties for galaxy 1432731. Detailed descriptions can be found in Section 3.6. HI PV diagrams: 86 (rms) $\times -4, -2$ (dashed), 2, 4 $\mu$Jy beam$^{-1}$; HI total integrated flux: $8.5 \ (2\sigma, 14.1 \ km \ s^{-1} \ channel), 17.0, 34.1, 68.2 \times 10^{19} \ cm^{-2}$; HI velocity field: 21554 (system) $\pm 50 \ km \ s^{-1}$; HI PA: HI major axis PA is taken from the receding side. The global HI profile is shown in Fig. 3. H$\alpha$ is represented by the red points, and the red shaded region is the SALT velocity resolution ($\sim 70 \ km \ s^{-1}$), taken here as the uncertainty. Note: The system velocity $V_{sys}$ is indicated with the horizontal dotted line in the PV diagrams and is taken as the velocity value at the optical centre of the velocity field. For G146, this value appears higher than where the system velocity is expected to fall on the PV diagrams, at the centre between the maximum velocity of the rising and declining parts of the HI emission.

Figure A7. Properties for galaxy 1437568. Detailed descriptions can be found in Section 3.6. HI PV diagrams: 86 (rms) $\times -4, -2$ (dashed), 2, 4, 6 $\mu$Jy beam$^{-1}$; HI total integrated flux: $8.6 \ (2\sigma, 14.1 \ km \ s^{-1} \ channel), 17.3, 34.6, 69.1, 138.0 \times 10^{19} \ cm^{-2}$; HI velocity field: 22596 (system) $\pm 30 \ km \ s^{-1}$; HI PA: HI major axis PA is taken from the receding side. The global HI profile is shown in Fig. 3. H$\alpha$ is represented by the red points, and the red shaded region is the SALT velocity resolution ($\sim 70 \ km \ s^{-1}$), taken here as the uncertainty. Note: The system velocity $V_{sys}$ is indicated with the horizontal dotted line in the PV diagrams and is taken as the velocity value at the optical centre of the velocity field. For 1437568, this value appears higher than where the system velocity is expected to fall on the PV diagrams, at the centre between the maximum velocity of the rising and declining parts of the HI emission.
Figure A8. Properties for galaxy 969633. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 86 (rms) × −4, −2 (dashed), 2, 4, 6 μJy beam^{-1}; H I total integrated flux: 8.6 (2σ, 14.1 km s^{-1} channel), 17.3, 34.6, 69.1 × 10^{19} cm^{-2}; H I velocity field: 22676 (system) ± 25 km s^{-1}; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. Hα is represented by the red points, and the red shaded region is the SALT velocity resolution (∼70 km s^{-1}), taken here as the uncertainty.

Figure A9. Properties for galaxy 1419315. Detailed descriptions can be found in Section 3.6. H I PV diagrams: 83 (rms) × −4, −2 (dashed), 2, 4 μJy beam^{-1}; H I total integrated flux: 8.8 (2σ, 14.3 km s^{-1} channel), 17.6, 35.3, 70.5 × 10^{19} cm^{-2}; H I velocity field: 27896 (system) ± 30 km s^{-1}; H I PA: H I major axis PA is taken from the receding side. The global H I profile is shown in Fig. 3. Hα is represented by the red points, and the red shaded region is the SALT velocity resolution (∼70 km s^{-1}), taken here as the uncertainty.
Figure A10. Properties for galaxy 1221696. Detailed descriptions can be found in Section 3.6. PV diagrams: 83 (rms) × −4, −2 (dashed), 2, 4 μJy beam$^{-1}$; HI total integrated flux: 8.8 (2σ, 14.3 km s$^{-1}$ channel), 17.6, 35.2, 70.5 × 10$^{19}$ cm$^{-2}$; HI velocity field: 27802 (system) ± 30 km s$^{-1}$; HI PA: HI major axis PA is taken from the receding side. The global HI profile is shown in Fig. 3. H$\alpha$ is represented by the red points, and the red shaded region is the SALT velocity resolution (≈70 km s$^{-1}$), taken here as the uncertainty.

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