The VANDELS ESO public spectroscopic survey: The spectroscopic measurements catalogue

M. Talia\(^1,2\), C. Schreiber\(^3\), B. Garilli\(^4\), L. Pentericci\(^3\), L. Pozzetti\(^2\), G. Zamorani\(^2\), F. Cullen\(^6\), M. Moresco\(^1,2\), A. Calabrò\(^5\), M. Castellano\(^6\), J. P. U. Fynbo\(^7,8\), L. Guaita\(^5\), F. Marchi\(^10\), S. Mascia\(^5,11\), R. McLure\(^6\), M. Mignoli\(^2\), E. Pompei\(^12\), E. Vanzella\(^2\), A. Bongiorno\(^13\), G. Vietri\(^1,4\), R. O. Amorín\(^13,14\), M. Bolzonella\(^2\), A. Cimatti\(^1,2\), G. Cresci\(^15\), S. Cristiani\(^16,17\), O. Cucciati\(^2\), J. S. Dunlop\(^6\), F. Fontana\(^16,17\), P. Franzetti\(^4\), A. Gargiulo\(^4\), M. L. Hamadouche\(^6\), N. P. Hathi\(^18\), P. Hibon\(^12\), A. Iovino\(^19\), A. M. Koekemoer\(^18\), F. Mannucci\(^15\), D. J. McLeod\(^6\), and A. Saldana-Lopez\(^20\)

\(^1\) University of Bologna – Department of Physics and Astronomy “Augusto Righi” (DIFA), Via Gobetti 93/2, 40129 Bologna, Italy
e-mail: margherita.talia2@unibo.it
\(^2\) INAF – Osservatorio di Astrofisica e Scienza dello Spazio, Via Gobetti 93/3, 40129, Bologna, Italy
\(^3\) IREX Innovations Ltd., Explorer 2, NETPark, Sedgefield, TS21 3FF, UK
\(^4\) INAF - IASF Milano, Via Alfonso Corti 12, 20133 Milano, Italy
\(^5\) INAF - Osservatorio Astronomico di Roma, via Frascati 33, 00078, Monteporzio Catone, Italy
\(^6\) INAF – Osservatorio Astronomico di Trieste, via G.B. Tiepolo 11, 34143 Trieste, Italy
\(^7\) Instituto de Investigación Multidisciplinar en Ciencia y Tecnología, Universidad de La Serena, Raul Bitrán 1305, La Serena 2204000, Chile
\(^8\) Cosmic Dawn Center (DAWN), Copenhagen, Denmark
\(^9\) Niels Bohr Institute, University of Copenhagen, Jagtvej 128, 2200 Copenhagen N, Denmark
\(^10\) Departamento de Ciencias Fisicas, Facultad de Ciencias Exactas, Universidad Andres Bello, Fernandez Concha 700, Las Condes, Santiago, Chile
\(^11\) Via Claudio Carcagni 46, 00188, Roma, Italy
\(^12\) Dipartimento di Fisica, Università di Roma Tor Vergata, Via della Ricerca Scientifica, 1, 00133 Roma, Italy
\(^13\) European Southern Observatory, Alonso de Córdova 3407, Vitacura, Santiago de Chile, Chile
\(^14\) INAF – Osservatorio Astronomico di Brera, via G.B. Tiepolo 11, 34143 Trieste, Italy
\(^15\) IFPU – Institute for Fundamental Physics of the Universe, via Beirut 2, 34151 Trieste, Italy
\(^16\) Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218, USA
\(^17\) INAF – Osservatorio Astronomico di Brera, via Brera 28, 20121 Milano, Italy
\(^18\) Department of Astronomy, University of Geneva, 51 Chemin Pegasi, 1290 Versoix, Switzerland

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ABSTRACT

VANDELS is a deep spectroscopic survey, performed with the VIMOS instrument at VLT, aimed at studying in detail the physical properties of high-redshift galaxies. VANDELS targeted ∼2100 sources at 1 < z < 6.5 in the CANDELS Chandra Deep-Field South (CDFS) and Ultra-Deep Survey (UDS) fields. In this paper, we present the public release of the spectroscopic measurement catalogues from this survey, featuring emission and absorption line centroids, fluxes, and rest-frame equivalent widths obtained through a Gaussian fit, as well as a number of atomic and molecular indices (e.g. Lick) and continuum breaks (e.g. D4000), and including a correction to be applied to the error spectra. We describe the measurement methods and the validation of the codes that were used.

Key words. catalogs – galaxies: high-redshift – techniques: spectroscopic – line: identification

1. Introduction

A major theme in extragalactic astronomy is understanding when and how galaxies formed and evolved. Spectroscopic surveys play a fundamental role in this respect, not only because they provide robust redshifts, but especially because the analysis of emission and absorption lines and spectral breaks grants access to intrinsic physical properties of galaxies such as the chemical composition of their gas and stellar populations, the ionising radiation field, and the gas and star kinematics.

Over the past two decades, several multi-slit and multi-fibre surveys have been carried out, targeting increasingly distant galaxies: from the Sloan Digital Sky Survey (SDSS) in the local Universe (Abazajian et al. 2003; Abdurro’uf et al. 2022), passing through the VIMOS VLT\(^1\) Deep Survey (VVDS; Le Fèvre et al. 2013; Garilli et al. 2008), zCOSMOS (Lilly et al. 2007), VIMOS Public Extragalactic Redshift Survey (VIPERS; over the past two decades, several multi-slit and multi-fibre surveys have been carried out, targeting increasingly distant galaxies: from the Sloan Digital Sky Survey (SDSS) in the local Universe (Abazajian et al. 2003; Abdurro’uf et al. 2022), passing through the VIMOS VLT\(^1\) Deep Survey (VVDS; Le Fèvre et al. 2013; Garilli et al. 2008), zCOSMOS (Lilly et al. 2007), VIMOS Public Extragalactic Redshift Survey (VIPERS; 1) Visible Multi Object Spectrograph (VIMOS); Very Large Telescope (VLT).
The VANDELS spectra cover a wavelength range of 4800 Å < λ_{obs} < 9800 Å, with a dispersion of 2.5 Å pixel$^{-1}$ and a spectral resolution of R ~ 650, corresponding to a FWHM$_{res}$ ~ 460 km s$^{-1}$ (or FWHM$_{res}$ ~ 11.2 Å at 7300 Å). The main targets of the survey were massive passive galaxies at 1 < z < 2.5, bright star-forming galaxies (SFGs) at 2.4 < z < 5.5, and fainter SFGs at 3 < z < 7 Lyman-break galaxies, plus a small sample of AGN, pre-selected using various multi-wavelength criteria. The VANDELS spectroscopic targets were pre-selected using high-quality photometric redshifts and were observed for a minimum of 20 h and up to 80 h, depending on their brightness, in order to ensure an approximately homogeneous S/N on the continuum within each class of galaxy. The data reduction was carried out using the recipes provided by the VIMOS Interactive Pipeline and Graphical Interface (VIPGI) package (Scodelligo et al. 2005) and the EASYLIFE environment (Garilli et al. 2012). The measured S/N per resolution element is higher than ten for all passive and star-forming galaxies, and higher than five for 85% of Lyman-break galaxies and AGN (Garilli et al. 2021). Spectroscopic redshifts were determined for all objects using the Easy redshift (EZ) software package within the PANDORA environment (Garilli et al. 2010).

A redshift confidence flag was also assigned to each target, according to the following scheme, already applied to previous VIMOS surveys (e.g. VVDS, Le Fèvre et al. 2005; zCOSMOS, Lilly et al. 2007; VUDS, Le Fèvre et al. 2015).

- Flag 4: a highly reliable redshift (estimated to have a > 99% probability of being correct), based on a high S/N spectrum and supported by obvious and consistent spectral features.
- Flag 3: also a very reliable redshift, comparable in confidence with Flag 4, supported by clear spectral features in the spectrum, but not necessarily with a high S/N.
- Flag 2: a fairly reliable redshift measurement, although not as straightforward to confirm as those for Flags 3 and 4, supported by cross-correlation results, continuum shape, and some spectral features.
- Flag 1: a reasonable redshift measurement, based on weak spectral features and/or continuum shape.

An a posteriori analysis of the redshift reliability showed that the reliability of Flag 2 redshifts is ~79%, while that of Flag 1 redshifts is 41% (Garilli et al. 2021).

- Flag 0: no reliable spectroscopic redshift measurement was possible.
- Flag 9: a redshift based on only one single clear spectral emission feature. An a posteriori analysis confirmed a redshift reliability of ~95% for spectra with this flag.
- Flag -10: spectrum with clear problems in the observation or data-processing phases.

Serendipitous (also called secondary) objects appearing by chance within the slit of the main target were identified by adding a ‘2’ in front of the main flag.

The redshift accuracy, estimated by internal comparison between different observations, is $\sigma_{z/(1+z)} = 0.0007$ (Garilli et al. 2021). The redshift distribution of the entire VANDELS sample is shown in Fig. 1.

In the official catalogues, we include only the measurements for the 1811 objects with a reliable redshift confidence flag (2, 3, 4, and 9 and the equivalent for BLAGN and secondary objects), whose redshift distribution is also shown in Fig. 1.

We measured spectroscopic features using two methods: Gaussian fit and direct integration.

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2} KBSS = Keck Baryonic Structure Survey.
3. Gaussian fit measurements

Gaussian fit measurements were performed using slinefit\(^3\) (Schreiber et al. 2018), an automated code that models the observed spectrum of a galaxy as a combination of a stellar continuum model and a set of emission and absorption lines.

### 3.1. slinefit parameters

A set of templates from EAZY (Brammer et al. 2008), based on the Bruzual & Charlot (2003) stellar population models, is linearly combined to best fit the continuum. Table 1 summarises the parameters that were set to produce the official VANDELS catalogue. The code searches for lines around their expected locations given by the input redshift: lines with a S/N lower than offset\_snr\_min are fixed at their expected position, while a velocity offset with respect to the measured redshift is allowed for lines with a higher S/N, with a maximum value set by the offset\_max parameter. We stress that in the catalogue the $\sigma$ of each line is provided, not the FWHM.

We measured 40 individual lines, including 7 resolved doublets, which are listed in Table 2. Unresolved doublets (e.g. CIV.1550 and CIIJ.1908) were treated as a single line. For the NII\_6548,6583 and SIIJ.6716,6730 doublets, we fixed the line flux ratios to 0.33:1 and 1:0.75, respectively, while no constraints were imposed for the other doublets. All lines were modelled as single symmetric Gaussians, either in emission or in absorption. This might not have been the best choice for the Ly$\alpha$ line, which typically is asymmetric and sometimes even split into a blue and a red component. Therefore, after visual inspection of the spectra by four members of the team, we added a flag indicating whether the fit was good (1) or not (0) and recommend using with caution the Ly$\alpha$ parameters from the catalogue in the latter cases. In general, in the case of multi-component lines (e.g. P-Cygni profiles), only the strongest feature is fitted. We stress that slinefit, in our chosen configuration, always provides a solution. Therefore, we recommend caution when using spectral parameters when the lines are narrower than the spectral resolution (i.e. FWHM $\sim$ 460 km s$^{-1}$, corresponding to $\sigma$ $\sim$195 km s$^{-1}$), because

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\(^{3}\) https://github.com/cschreib/slinefit
Construction of the 1D mock spectra for the 
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(Fig. 2, top). The continuum was modelled as a cubic spline, 
observed V ANDELS ones. We started from a rest-frame tem-

ta set of 1D mock spectra to mimic the characteristics of the 
3.2. Mock 1D spectra and 
num_mc 
computed from the standard deviation of 
uncertainties on the spectroscopic parameters were then com-
puted from the code performance, we built a 

for the slinefit 
validation of the V ANDELS survey. They were then re-sampled 
and cut to the VANDELS dispersion and observed wavelength range.

In order to add realistic noise, we extracted 1D spectra from 
empty regions in observed 2D spectra from the VANDELS sur-

vey at different exposure times and added them to the redshifted 
templates. The final validation sample counts 270 mock spectra. In Fig. 2 (bottom), we show the comparison between three exam-

ples of mock 1D spectra and real VANDELS spectra at different redshifts and with different quality flags.

Finally, we ran the slinefit on the sample of mock 1D spectra with different sets of input parameters and checked the rela-
tive change in the measured spectral quantities with respect 
to their input values, and the pull distributions. In Fig. 3, we show 
the results from the run with the best set of parameters, which is 
summarised in Table 1. All the measured lines are included in 
the plots, but we stress that separating emission and absorption 
lines does not change the results. All distributions are consistent 
with a Gaussian with a null mean and unity sigma.

4. Direct integration

The direct integration measurements were performed using 
pylick\textsuperscript{4}, a flexible Python tool to measure spectral indices and 
associated uncertainties. The code is described in Borghi et al. 
(2022) and was extensively tested using spectra and results from 
the LEGA-C survey (van der Wel et al. 2016; Straatman et al. 
2018). Following the approach of the Lick group (Worthey 
& Ottaviani 1997), the code computes the strengths of a set of 
atomic and molecular indices and continuum breaks such as the 
D4000 (Bruzual A. 1983). Errors are evaluated following the S/N 
method by Cardiel et al. (1998).

In our catalogue, we have included 55 indices and breaks 
defined in previous works, to which we added three UV emission 
line indices (see Table 3). The new indices were defined on 
the basis of a high-S/N composite spectrum of all VAN- 
DELS sources with a high-redshift quality flag (i.e. 3 and 4). It 
was built by median stacking the de-redshifted, scaled (by the 
median flux in the wavelength range 1410–1510 Å), and rebinned 
(0.6 Å pixel\textsuperscript{−1}) spectra. In Fig. 4, we show the zoomed-in regions 
around the HeII\lambda1640+OIII\lambda1666 and CIII\lambda1909 lines, with the 
central bandpass and pseudo-continuum ranges marked in 
different colours. It should be noted that for the direct integration 
catalogue, no offset of the bandpasses is allowed with respect to 
the expected wavelength, given the redshift.

For the Ly\alpha line, we opted for a different approach. Follow-

ing Cullen et al. (2020), we applied the method by Kornei 
et al. (2010) to measure the EW of the line, which takes into 
account the line’s morphology to optimise the wavelength range 
over which the flux is integrated. The Ly\alpha line of the 1218

\textsuperscript{4} https://gitlab.com/mmoresco/pylick/

3.2. Mock 1D spectra and slinefit code validation

In order to validate the slinefit code performance, we built a 
set of 1D mock spectra to mimic the characteristics of the 
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### Table 3. pylick spectral indices.

<table>
<thead>
<tr>
<th>Index</th>
<th>Central bandpass</th>
<th>Blue continuum</th>
<th>Red continuum</th>
<th>Units</th>
<th>Type</th>
<th>Ref.</th>
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<tbody>
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<td>BL4302</td>
<td>1292.000–1312.000</td>
<td>1270.000–1290.000</td>
<td>1345.000–1365.000</td>
<td>Å</td>
<td>atomic</td>
<td>3</td>
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<td>OI+SiII1303</td>
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<td>1268.000–1286.000</td>
<td>1308.000–1324.000</td>
<td>Å</td>
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</tr>
<tr>
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<td>1308.000–1324.000</td>
<td>1348.000–1378.000</td>
<td>Å</td>
<td>atomic</td>
<td>9</td>
</tr>
<tr>
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<td>1348.000–1378.000</td>
<td>1433.000–1460.000</td>
<td>Å</td>
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<td>3</td>
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<td>1475.000–1495.000</td>
<td>Å</td>
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<tr>
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<td>9</td>
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<td>Å</td>
<td>atomic</td>
<td>3</td>
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<td>2675.000–2925.000</td>
<td>Å</td>
<td>atomic</td>
<td>3</td>
</tr>
<tr>
<td>Be(2400)</td>
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<td>2720.000–2782.000</td>
<td>2818.000–2838.000</td>
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<td>2525.000–2572.000</td>
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<tr>
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<td>2562.000–2588.000</td>
<td>2647.000–2673.000</td>
<td>Å</td>
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<td>3</td>
</tr>
<tr>
<td>Hβ</td>
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<td>3805.000–3845.000</td>
<td>3845.000–3900.000</td>
<td>Å</td>
<td>atomic</td>
<td>3</td>
</tr>
<tr>
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<td>2784.000–2814.000</td>
<td>2762.000–2782.000</td>
<td>2818.000–2838.000</td>
<td>Å</td>
<td>atomic</td>
<td>3</td>
</tr>
<tr>
<td>MgII3086</td>
<td>2600.000–2630.000</td>
<td>2645.000–2675.000</td>
<td>2675.000–2925.000</td>
<td>Å</td>
<td>atomic</td>
<td>3</td>
</tr>
<tr>
<td>MgII</td>
<td>2839.000–2865.000</td>
<td>2818.000–2838.000</td>
<td>2906.000–2936.000</td>
<td>Å</td>
<td>atomic</td>
<td>3</td>
</tr>
<tr>
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<td>3941.600–4079.750</td>
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<td>Å</td>
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</tr>
<tr>
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<td>4057.250–4088.500</td>
<td>4114.750–4137.250</td>
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<td>atomic</td>
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</tr>
<tr>
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<td>408.125–417.625</td>
<td>424.125–428.125</td>
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</tr>
<tr>
<td>CaII</td>
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<td>421.000–421.750</td>
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</tr>
<tr>
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<td>426.375–428.250</td>
<td>431.875–435.375</td>
<td>Å</td>
<td>atomic</td>
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</tr>
<tr>
<td>Hα</td>
<td>6562.800–6584.250</td>
<td>6541.000–6601.000</td>
<td>6678.500–6840.000</td>
<td>Å</td>
<td>atomic</td>
<td>1</td>
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<tr>
<td>Hβ</td>
<td>4861.375–4897.250</td>
<td>4827.875–4947.875</td>
<td>4987.625–5091.625</td>
<td>Å</td>
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<td>5054.000–5065.250</td>
<td>Å</td>
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</tr>
<tr>
<td>MgII</td>
<td>5069.125–5134.125</td>
<td>4985.125–4957.625</td>
<td>5301.125–5366.125</td>
<td>Å</td>
<td>atomic</td>
<td>1</td>
</tr>
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<td>5154.125–5196.625</td>
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<tr>
<td>MgII</td>
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<td>5191.375–5206.375</td>
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<tr>
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<td>5353.375–5363.375</td>
<td>Å</td>
<td>atomic</td>
<td>1</td>
</tr>
</tbody>
</table>

**Notes.**

1. Borghi et al. (2022) Eq. (1); 2. Borghi et al. (2022) Eq. (2); 3. Borghi et al. (2022) Eq. (4); 4. As Borghi et al. (2022) Eq. (4), but integrating over F(λ) dλ, instead of F(ν) dν; 5. These indices were firstly defined by Leitherer et al. (2011), but here we present a slightly modified version.

**References.**

Fig. 3. Comparison between slinefit results and input values for the sample of 270 mock spectra. In the top panels, we plotted the pull distributions. As a reference, we marked with a grey curve a Gaussian with a null mean and unity sigma. In the bottom panels, we plotted the relative change of the measured spectral quantities, with respect to their input values, as a function of the peak S/N of the lines. Black squares represent the median values of the relative change in bins of the S/N; error bars are the semi-interquartile range (SIQR). The line parameters are, starting clockwise from the top left figure: line centroid, EW, FWHM, and flux.

Individual galaxies at \( z \gtrsim 2.95 \) (i.e. the redshift limit for the Ly\( \alpha \) to be in the VIMOS wavelength range) was visually classified as either emission, absorption, combination, or noise; examples are shown in Fig. 5. The emission spectra are clearly dominated by a Ly\( \alpha \) emission feature. The absorption spectra are dominated by an extended through around the Ly\( \alpha \) position. In the combination case, the spectrum contain superimposed emission and absorption features. Finally, the noise category include spectra where no clear feature could be identified at the Ly\( \alpha \) position (see Kornei et al. 2010, for a detailed description). In the first three cases, after the peak of the emission and absorption, the integration window is defined by the wavelength values on either side of the peak where the flux intersects the average continuum level. The blue and red continua are defined as the median flux values in the range \( \lambda = [1120–1180] \text{ Å} \) and \( [1228–1255] \text{ Å} \), respectively. In the case of absorption and combination sources, the spectra were first smoothed with a boxcar function of six pixels in width to minimise the possibility of noise spikes affecting the determination of the boundaries of the integration range. For noise sources, the Ly\( \alpha \) flux is simply defined as the integrated flux in the range \( \lambda = [1200–1228] \text{ Å} \). In all cases the line flux was divided by the red continuum value to obtain the EW.
average. We performed several tests on 2D and 1D spectra; our procedures (Garilli et al. 2021), and should reflect the noise level of the continuum bandpasses, as indicated in Table 3, are marked in black, while the two local continuum windows are marked in blue and red. The green points and dashed lines indicate the mean flux in the continuum bandpasses and the linear pseudo-continuum.

Fig. 4. Median composite spectrum of VANDELS sources (grey). The upper and lower panels show zoomed-in regions around the HeII]λ4686+OIII]λ4959 and CIII]λ1909 lines, respectively. The central bandpasses, as indicated in Table 3, are marked in black, while the two local continuum windows are marked in blue and red. The green points and dashed lines indicate the mean flux in the continuum bandpasses and the linear pseudo-continuum.

Fig. 5. Examples illustrating the four Lyα categories from Kornei et al. (2010). Clockwise, from the top left: emission, combination, absorption, and noise.

5 This is the extension NOISE in the multi-extension FITS files distributed through the VANDELS collaboration website and the column ERR in the FITS binary tables downloadable from the ESO archive.

5. Scaling of the error spectra

The spectra distributed as part of the VANDELS public data release include the 1D noise estimate \( \sigma \) in erg cm\(^{-2}\) s\(^{-1}\) Å\(^{-1}\). The error spectrum is a direct product of the data reduction procedures (Garilli et al. 2021), and should reflect the noise level of the corresponding object spectrum. However, the comparison between the error spectra and the noise r.m.s. of the object spectra, measured in line-free regions, shows a discrepancy, with the error spectra underestimating the noise level by a factor of \(~2\), on average. We performed several tests on 2D and 1D spectra: our hypothesis is that the discrepancy is caused by the fact that the data reduction pipeline does not take the full covariance matrix into account. We opted for an a posteriori statistical correction of the error spectra (e.g. van der Wel et al. 2021). In particular, for each object, we computed a scaling factor to be applied to the error spectrum. The scaling factor is defined as the standard deviation of the fit residuals, divided by the error spectrum:

\[
1.482 \times \text{MAD} \left( \text{object}_{\text{spectrum}} - \text{model}_{\text{spectrum}} \right) / \text{error}_{\text{spectrum}},
\]

where \( \text{model}_{\text{spectrum}} \) is the output of \( \text{slinefit} \) and MAD is the median absolute deviation. If the error spectrum is an accurate representation of the noise in the object spectrum, the above quantity should be close to 1; if the error spectrum underestimates the noise, then the above quantity can be used as a scaling factor. We computed it in five wavelength windows, free of strong sky lines, and then defined the scaling factor as the mean of the five values. The associated uncertainty is the error on the mean, which takes into account a slight wavelength dependence of the ratio between the noise r.m.s. of the object spectrum and the error spectrum (i.e. the ratio is on average \(~10\%\) lower close to the spectral edges than in the central region). Figure 6 shows the distribution of the scaling factor.

The \text{slinefit} code can actually perform the scaling of the error spectrum internally. If the appropriate keyword (\text{residual_rescale}) is switched on, the previously defined scaling factor is computed locally for each line; then, the whole error spectrum is normalised by interpolating between the scaling factors of the chosen lines, and the whole fit is performed a second time. The measurements in the official catalogue were instead performed by applying a single scaling factor to each error spectrum before running \text{slinefit} with the \text{residual_rescale} keyword switched off. This choice allowed us to provide a set of measurements that could be easily reproduced by other codes that do not include a scaling feature. The direct integration measurements were also performed after scaling the error spectra.

The scaling factors and their uncertainties are included in both catalogues. We stress that the error spectra in the VANDELS data release (i.e. NOISE extension or ERR column) are not scaled: they have to be multiplied by the scaling factor in order to obtain reliable errors on the spectroscopic measurements.
6. The catalogues

We have produced a total of four catalogues: two (one for each field) for the Gaussian fit measurements performed with slinefit and two (again, one for each field) for the direct integration measurements performed with pyl1ck plus Lyα following the Kornei et al. (2010) method. The contents of the catalogues are summarised in Table 4, while in Fig. 7, we show the distributions of the EW of some notable lines and, for the passive galaxies’ sample at $z < 2$, the D4000 break. As already

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Fig. 7. Distributions of the D4000 break and the EW of some notable lines. In each panel we show the distributions at $S/N ≥ 1$ (light grey) and $S/N ≥ 3$ (green). For the lines from the ‘Gaussian fit’ catalogues, the cut is in S/N flux. Top left: Lyα EW (direct integration). Top right: D4000 (direct integration). Middle left: [OIII]1509 Å EW (Gaussian fit). Middle right: [OII]3727 Å EW (Gaussian fit). Bottom left: OI+SiII1303 Å EW (Gaussian fit). Bottom right: OI+SiII1303 Å EW (Gaussian fit). In the last two panels, we also show the distribution at $S/N ≥ 2$ (dark grey).
Table 4. Legend of catalogue content.

<table>
<thead>
<tr>
<th>#</th>
<th>Column name</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gaussian fit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>objID</td>
<td>Object identification</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>z</td>
<td>Spectroscopic redshift</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>zQfl</td>
<td>Redshift confidence flag (Sect. 2)</td>
<td></td>
</tr>
<tr>
<td>4-5</td>
<td>scaling_factor, e_scaling_factor</td>
<td>Scaling factor (Sect. 5) (and error)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>lya_fl</td>
<td>Goodness-of-fit flag for Lyα (Sect. 3)</td>
<td></td>
</tr>
<tr>
<td>7-406</td>
<td>wave, ewave, flux, eflux, cont, econt, ew, eew, sigma, esigma</td>
<td>Lines parameters from slinefit; observed centroid wavelength (and error); lines flux (and error); continuum flux (and error); rest-frame EW; line width (and error)</td>
<td>microns, erg s⁻¹ cm⁻², erg s⁻¹ cm⁻² Å⁻¹, Å, km s⁻¹</td>
</tr>
</tbody>
</table>

|     | Direct integration           |                                                  |                      |
| 1   | objID                        | Object identification                            |                      |
| 2   | z                            | Spectroscopic redshift                           |                      |
| 3   | zQfl                         | Redshift confidence flag (Sect. 2)               |                      |
| 4-5 | err_scaling_factor, eerr_scaling_factor | Error scaling factor (Sect. 5) (and error) |                      |
| 6   | lya_class                     | Lyα visual classification (Sect. 4); 1=emission; 2=combination; 3=absorption; 4=noise | Å                    |
| 7-8 | LyA_EW0_K10, LyA_EW0_K10_err | Lyα EW following Kornei et al. (2010) (and error) err flags | Å                    |
| 9-182 | index name, err, cont       | Rest-frame EW (atomic indices); Pseudo-continuum flux | Å, erg s⁻¹ cm⁻² Å⁻¹ |

Notes. (a) EW sign convention: positive for emission lines; negative for absorption lines. (b) We stress that in the catalogue the Gaussian σ of each line is provided, not the FWHM.

Fig. 8. Examples of EW comparison between Gaussian fit and direct integration methods for a single line (SiII1526 Å; red triangles) and an unresolved group of lines (OII+SiII1303 Å; green squares). Only measurements at S/N ≥ 3 are shown. The 1-to-1 relation is also indicated in black.

mentioned, we computed spectral properties only for galaxies with a reliable redshift, namely those with a quality flag = 2, 3, 4, 9. In the slinefit catalogue, we have not included the measurements for the three BLAGN whose emission line fits require two components⁶. Dedicated spectral measurements for these objects will be presented in Bongiorno et al. (in prep.).

The EW of some lines was measured using both the Gaussian fit and direct integration methods. The agreement between the two measurements is very good in the case of single lines, as shown in Fig. 8 for the SiII1526 Å, as an example: on average, the linear correlation coefficient is r ≳ 0.9 and the root-mean-square error (RMSE) is ∼0.5–0.6 Å. A systematic small offset of ∼0.5 Å is attributable to the different ways of determining the continuum level in the two methods. In the case of unresolved groups of lines, where a single-Gaussian model was assumed (e.g. OII+SiII1303 Å), the correlation coefficient between the two methods is still high (r ≳ 0.8, on average, with an RMSE of ∼0.7–0.8 Å), but the Gaussian fit tends to systematically underestimate the flux, more than what would be expected by accounting only for the differences in the continuum. The EW ratio between the two methods is on average between 0.6 and 0.8, depending on the group of lines.

Finally, as an additional validation, in Fig. 9 we compare subsets of measurements from our catalogues to independent and previously published measurements performed with different codes and methods by VANDiLS team members. For the Gaussian fit catalogue, we compared our measurements of the CIII]1909 Å flux and of the centroids of four absorption lines

⁶ There are entries in the catalogue for these objects, but all cells in the table were set to --99.0.
Fig. 9. Comparison between the measurements presented in this work and previously published VANDELS results. In all plots we also show the one-to-one relation (dashed red line). Top left: CIII\(\lambda 1909\) Å flux from Calabrò et al. (2022b; Gaussian fit). Top right: interstellar medium absorption line centroids from Calabrò et al. (2022b; Gaussian fit; the points for the different ions have been shifted by 0.01 for visualisation purposes). Middle left: Lyα flux from Guaita et al. (2022b; Gaussian fit). Middle right: Lyα flux from Calabrò et al. (2022b; Gaussian fit). Top right: interstellar medium absorption line centroids from Calabrò et al. (2022b; Gaussian fit; the points for the different ions have been shifted by 0.01 for visualisation purposes). Middle left: Lyα flux from Guaita et al. (2022b; Gaussian fit). Middle right: AGN emission line flux from Bongiorno et al. (in prep.; Gaussian fit). Bottom: \(D_{\lambda 4000}\) from Hamadouche et al. (2022; direct integration).
to those by Calabrò et al. (2022b), which were obtained by fitting each line profile with a Gaussian function using the Python version of the MPFITT routine (Markwardt 2009). The continuum was parameterised as a straight line and fitted simultaneously with the lines. We find a good agreement between the two sets of measurements (no S/N cut applied): for the CIII\(^4\) we find a good agreement between the two sets of measurements, which were parameterised as a straight line and fitted simultaneously with an offset with respect to the 1-to-1 relation. On the other hand, for the absorption lines’ centroids we find a good agreement between the two sets of measurements, with an\(r\) of 0.9 and RMSE of \(0.3 \times 10^{-17}\) erg s\(^{-1}\) cm\(^{-2}\).

We compared our flux measurements for different emission lines in the VANDELS AGN sample (excluding BLAGN) to the ones obtained with a custom Python code from Bongiorno et al. (in prep.), the line fluxes are the mean of a Gaussian and a Lorentzian profile fit, plus a polynomial continuum. The\(r\) and RMSE range from 0.7 to 0.9 and from 2.0 \(\times 10^{-17}\) to 4.0 \(\times 10^{-17}\) erg s\(^{-1}\) cm\(^{-2}\), respectively, depending on the line. Finally, we checked the D\(r\) break in the VANDELS subsample of quiescent galaxies from our direct integration catalogue against the independent measurements by Hamadouche et al. (2022) and we found an excellent agreement (\(r\) = 1.0 and RMSE = \(3.0 \times 10^{-2}\)).

7. Summary

In this paper, we present the public release of the spectroscopic measurements of the VANDELS survey (Pentericci et al. 2018a; McLure et al. 2018; Garilli et al. 2021). We built two catalogues: one containing line properties from Gaussian fit measurements performed with the slinefit code, the other including line indices and continuum breaks measured with the pylick code, plus Ly\(\alpha\) EWs following the Kornei et al. (2010) method. We created a set of mock spectra to mimic observed VANDELS sources in order to validate the slinefit code, while the pylick code was already tested in a previous work (Borghii et al. 2022). As a further check of the accuracy of our catalogues, we compared subsets of measurements to previous results obtained with different codes and methods. We have also found that the error spectra included in the VANDELS data release underestimate the noise level when compared to the r.m.s. of the object spectra and computed a correction that we provide in the catalogues. The full spectroscopic catalogues, together with the spectra, redshift catalogues, complementary photometric information, and SED fitting derived quantities, are publicly available from the VANDELS survey databaseootnote{http://vandels.inaf.it} and at the CDS.

Acknowledgements. This paper is dedicated to the memory of Olivier Le Fèvre. We would like to thank the anonymous referee for their constructive comments. The VANDELS Data Release 4 (DR4), including the catalogues presented in this paper, is publicly available and can be accessed using the VANDELS database at http://vandels.inaf.it/dr4.html, or through the ESO archives. The data published in this paper have been obtained using the pando.rla ez software developed by INAF IASF-Milano. MT, LPoz and ACim acknowledge the support from grant PRIN MIUR 2017 (grant 2017ZFKRSJ), LPoz acknowledges the support from "fondi premiali" MITIC (Mining The Cosmos Big Data and Innovative Italian Technology for Frontier Astrophysics and Cosmology), LPen, ACal and MC acknowledge support from the Mainstream Grant VANDELS. The Cosmic Dawn Center (DAWN) is funded by the Danish National Research Foundation under grant no.40. JPUD acknowledges support from the Carlsberg Foundation. RA acknowledges support from ANID Fondecyt Regular 1200207. ACC thanks the Leverhulme Trust for their support via a Leverhulme Early Career Fellowship. MLH acknowledges the support of the UK Science and Technology Facilities Council. ASL acknowledges support from Swiss National Science Foundation.

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