ESO Phase 3 Data Release Description

Data Collection	VPHASplus
Release Number	3
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Abstract

This document describes the release of the VPHAS+ DR2 Point Source Catalogue (VPHAS-DR2-PSC), which is the first band- and field-merged science catalogue to have been created from the imaging data obtained by the VST Photometric Ha Survey of the Southern Galactic Plane and Bulge (VPHAS+).

The primary goal of VPHAS+ is to collect single-epoch ugri broad-band and H-alpha narrow-band photometry across the southern Galactic Plane within the latitude range $-5^{o} < b < +5^{o}$ down to point source magnitudes of at least 21. The VPHAS+ footprint also includes the inner Galactic Bulge, defined as a 20 x 20 deg^2 box around the Galactic Centre: this assures optical coverage of the full VVV footprint. For all massive OBA stars this survey is deep enough to explore all but the most heavily obscured locations of the southern Plane, typically reaching to over 4 kpc from the Sun. These data will increase the number of known southern emission line stars by up to an order of magnitude, yielding much better statistics on important short-lived types of object. The wide-area uniform photometry obtained will also facilitate stellar population studies, capable of tracing structure over much of the southern Plane. VPHAS+ will trawl the star-formation history of the Galaxy as seen in stellar remnants of all types.

A leading survey goal is the production of a well-validated catalogue that provides 5 optical photometric data points per source at an external (systematic) precision of 0.02—0.03 magnitudes on several 100 million stars. This released data product contains the first step on the way to such a catalogue, providing PSF and aperture photometry for 319 million *detections* of point-like objects. The number of unique objects is rather lower than this, since the majority of objects are detected 2 or 3 times as a result of the survey strategy.

The catalogue presented here is derived from the calibrated images that have been released as part of the "VPHAS-DR2" collection. Accordingly it, too, covers the first 21 months of data-taking (28/12/2011 through 30/09/2013), in which 24% of the survey footprint has been observed to sufficient quality. These observations were taken under ESO programme 177.D-3023(B,C,D,E).

Overview of Observations

Since the observations are identical to those included in the "VPHAS-DR2" release of imaging data, the reader is referred to the VPHAS-DR2 release description for information on data taking and data quality statistics. The URL is

http://www.eso.org/sci/observing/phase3/data_releases/vphasplus_dr2.pdf

A map of the included pointings is shown as figure 1.

Release Content

This release provides a band-merged catalogue covering 629 deg^2 (24%) of the VPHAS+ footprint, i.e. the Southern Galactic plane. As shown in figure 1, the early survey pointings have favoured the Galactic mid-plane. Outlying islands of pointings frequently cover open clusters in common with the Gaia-ESO Survey.

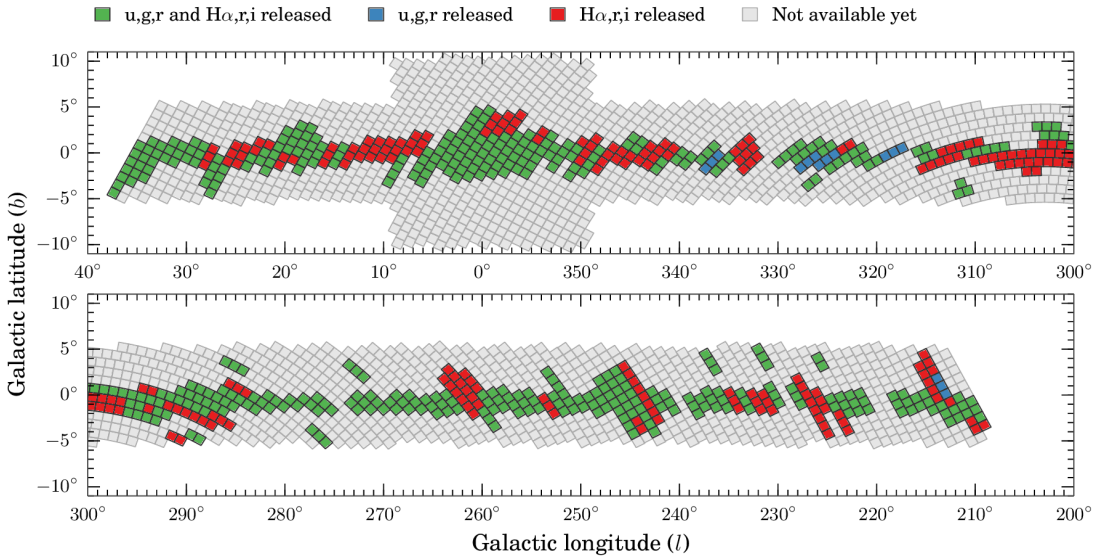

Figure 1: The VPHAS+ DR2 footprint. The 424 fields shown in green are those for which both blue and red sequences are included in the release. In addition there are 205 fields with red sequences only that are shown in red.

The catalogue contains 319 million rows (the exact number is 319 126 837). Each row corresponds to the detection of an object in a sequence of 3+3 exposures taken at the same position on the sky using the ugr and riHa filters. For practical scheduling reasons, the sequence of ugr ("blue") exposures are, with very few exceptions, acquired on a different night from the sequence of riHa ("red") exposures. However, within themselves, the blue and red filter sets are contemporaneous to the extent that the elapsed time between exposing the first and last of the 3 filters is 30 – 40 minutes. The exact epoch of each magnitude included in the catalogue is provided (columns mjd_u, mjd_g, mjd_r2, etc).

Because the r band is included in both the blue and the red sequence, there are two exposures available in this filter at each telescope pointing. In the catalogue we define "r" as the r-band magnitude obtained as part of the red sequence, and "r2" as the magnitude obtained as part of the blue sequence. Each row hence contains two distinctly-labeled r magnitudes. Note however that the overall sky area so far covered by red sequences is significantly larger than that observed by blue sequences, and as a result, many rows in the catalogue show values for riHa but none for ugr2. In the absence of i band data, it has not been possible to include in this catalogue 15 fields for which only ugr sequences were collected before end September 2013 (shown in blue in figure 1).

The survey observing pattern includes offset pointings in order to account for inter-CCD gaps. As a result, each star in the footprint is typically covered by 2 or 3 different telescope pointings, which feeds through to multiple rows i.e. detections of the same star in the catalogue. To aid the user interested in only the best available detection per unique object, this is flagged in the catalogue using the "primary_source" boolean column (see the later section on field merging).

The catalogue has been created by building a single "master list" of detections for each sequence of red and blue exposures. This list is principally based on executing the DAOFIND source detec-

tion algorithm on the i-band exposure, because the i-band is the longest-wavelength filter in the survey and hence tends to show the best PSF quality and the highest star counts. To ensure the inclusion of very blue or exotic objects however, we also we also carried out the source detection in the other bands (ugrHa) in order to supplement the "master list" (see the later section on source detection).

At each of the positions in the master list, we have used DAOPHOT to obtain PSF and aperture photometry in all the filters – even those where DAOFIND did not report a detection. This strategy is sometimes referred to as "list-driven" or "forced" photometry, and is adopted here to avoid the problem of source confusion which occurs when single-band source lists are cross-matched.

Of course not all objects are detected in all bands. For this reason, the catalogue only reports PSF magnitudes when the fit was reliable (explained later) and the signal-to-noise ratio (SNR) was found to be above 3σ, where σ represents the locally measured background noise. Likewise, aperture magnitudes are only reported for objects with SNR > 3. For objects estimated to be fainter than SNR = 3 in a given band, the catalogue only reports an upper limit (magLim_u, magLim_g, etc), while leaving the magnitude columns blank.

We recommend users to apply a cut at SNR > 10 (cf. columns snr_u, snr_g, etc) and a DAOPHOT PSF fitting score of CHI < 1.5 (cf. columns chi_u, chi_g, etc), though these values may be adjusted depending on the level of accuracy and source reliability desired. For convenience, the recommended quality cuts are encoded in a set of boolean columns (cf. clean, clean_u, clean_g, clean_r2, etc). Great caution must be used for any detection for which the catalogue indicates that "clean = FALSE".

The magnitudes are reported in both the Vega (no suffix, e.g. u, g, r2) and the AB systems (suffix _ab, e.g. u_ab, g_ab, r2_ab, etc).

The catalogue's magnitude limits vary across the footprint as a function of the PSF quality and source crowding. The typical 5-sigma limits in the AB system are 22nd magnitude in ugr and 21st mag in i and Ha. More detailed evaluation is provided in the release description of the VPHAS-DR2 imaging data and single-band source lists.

Release Notes

The catalogue has been prepared by the survey team at the University of Hertfordshire (UK), based on the VPHAS-DR2 imaging data which has been calibrated by the Cambridge Astronomy Surveys Unit (CASU; see the VPHAS-DR2 release notes).

The software used to transform the calibrated images into the catalogue is available and documented at

https://github.com/barentsen/surveytools

In brief, source detection was carried out using the DAOFIND algorithm, while PSF and aperture photometry was obtained using the DAOPHOT routines. A Python pipeline took care of executing the DAOFIND and DAOPHOT routines for all red+blue sequences, before merging and re-calibrating the results within a homogeneous catalogue. Details are given below.

Data Reduction and Calibration

Photometry is obtained for each sequence of blue+red exposures (or only red exposures where the blue sequence is missing) using a five-step procedure:

1. the images are corrected for VST's stray light by dividing the pixels by an additional illumination correction;

2. the “master list” of sources is generated for each sequence of 3+3 exposures;
3. for each object in the master list, PSF and aperture photometry is measured in every band;
4. the photometric zeropoints are shifted by crossmatching against the AAVSO Photometric All-Sky Survey (APASS), to bring the magnitudes onto a global calibration and to correct for the flux lost beyond the finite-sized apertures used;
5. the photometry is “field-merged” with all other red+blue sequences: duplicate detections of unique objects are identified.

We now describe each of these steps in more detail.

1. Illumination correction

All VST/OmegaCAM exposures are known to contain a significant component of stray light, which is dominated by a centrally concentrated radial pattern which causes the instrument's twilight flat-field frames to be relatively more exposed in the center of the field of view. Because twilight flat-field frames were used to calibrate the VPHAS-DR2 imaging data, all the exposures contain an artificial zeropoint gradient of up to 10–20 %, which needs to be corrected in order to obtain photometry with a constant relative calibration across the field.

The stray light issue is discussed in Sect 2.9 of the ESO OmegaCAM manual, and in a dedicated OmegaCAM commissioning report. We note that much of the data included in VPHAS-DR2 was obtained before the introduction of additional baffling to mitigate the problem, and hence the imaging data on which this catalogue is based is more strongly affected than more recent data.

Details on how the CASU performs stray-light correction is found in Sect 2.3.3 of the VPHAS+ introductory paper (Drew et al. 2014), and on the CASU website. In brief, the APASS survey is used to derive an additional flat field, called the “illumination correction”. To create the present catalogue, we have followed the same procedure by dividing the VPHAS-DR2 imaging data by a reworked and improved illumination correction (provided by CASU, personal communication).

2. Source detection

Having obtained more accurately flat-fielded images, we then generate the master list of point sources in the region of the sky covered by the sequence of red(+blue) exposures. This is achieved using the DAOFIND algorithm as implemented in IRAF v2.16.1 and accessed using PyRAF v2.1.8.

First, the source detection is carried out on the i-band image using a DAOFIND detection threshold of 2.5σ, which forms the heart of the master list. Subsequently, source detection is also carried out in the other bands, using a detection threshold of 5σ, picking up objects which are not already in the master list. To be accepted as new and distinct sources, these additions must lie no closer than 2 arcsec to already included detections. This is a conservative value which may be lowered in future releases.

Standard DAOFIND quality cuts are applied during source detection to ensure that the vast majority of detections are genuine point sources, namely: we require that the “ROUNDNESS” parameter must lie between -0.75 and +0.75, and the “SHARPNESS” parameter must lie between 0.2 and 0.9.

3. Photometry

Having obtained a master source list, PSF and aperture photometry is then carried out using the DAOPHOT algorithms. Both the circular PSF fitting radius and the aperture radius were set equal to the PSF Full-Width-at-Half-Maximum (FWHM) as measured from the data in each CCD frame separately. The choice for radius=FWHM is the value recommended by the DAOPHOT manual,

and has the added benefit that the correction required to correct for the flux lost outside of the aperture will be close to constant across the survey, assuming a constant PSF shape.

For a magnitude measurement to be included in the catalogue, it must meet the following criteria:

- The imaging data does not contain bad, saturated, or missing pixels within the aperture or sky annulus. This requirement results in magnitudes brighter than the typical saturation limit (13-14th magnitude), or measures of stars near the edges of a CCD being excluded. The magnitude columns are left blank for each filter that is affected.
- The DAOPHOT PSF fitting score, CHI, is less than 3. This criterion was found to be effective at removing spurious sources that deviate too far from the expected PSF template, which is estimated on a CCD-by-CCD basis from the data. However, genuine point sources which happen to be affected by the wings or artefacts of a nearby bright star may also be rejected on this criterion.
- During PSF-fitting, the x/y pixel position of each object's centroid is treated as a free parameter. However, if the centroid moved by more than one pixel (0.218 arcsec) from the reference position listed in the master source list, then the PSF fit is considered "bad" and its magnitude is left blank in the catalogue.

When a magnitude is left blank in the catalogue, the "warning" column will indicate which of these issues occurred (cf. columns warning_u, warning_g, warning_r2, etc).

4. Uniform photometric calibration

After the photometry for all sources has been gathered into the master list, the magnitudes are brought onto an interim global calibration in g, r and i, by computing offsets relative to the AAVSO Photometric All-Sky Survey (APASS). A single offset is computed for all magnitudes that originate from a single OmegaCAM exposure, hence the uniformity of calibration is expected to be best over ~1 deg^2 sky areas. The u and Ha magnitude scales are fixed relative to g and r following the same approach as described in section 6 of Drew et al (2014). This step also ensures that the photometry is corrected for the flux lost outside of the circular aperture used.

5. Field-merging

The last step is to merge the set of red+blue sequences into the final catalogue product. During this step we cross-match all the overlapping pointings to identify duplicate detections of unique objects, using a cross-matching radius of 0.5 arcsec. These duplicates are identified in the catalogue by sharing the same "primaryID", which specifically identifies the "objectID" of the best (primary) detection.

The primary detection is defined as the one for which the magnitude could be measured successfully in the largest number of filters, giving priority to magnitudes measured with SNR > 10. If multiple sequences offer data in the same number of filters, then the sequence with the best i-band PSF FWHM (ie. the best i-band seeing) is chosen. The primary detection has the "primary_source" boolean column set to TRUE in the catalogue.

Data Quality

This is the first band-merged science catalogue to have been created for the VPHAS+ survey. As a result, this product and its creation strategy has so far received limited, in-house vetting. An initial appraisal of the photometric calibration suggests that it is consistent with SDSS to an accuracy of 0.05 mag (rms error).

Feedback (via www.vphas.eu) from users in the community on issues encountered in the catalogue will be very welcome and help shape future editions encompassing more of the survey footprint.

Known issues

1) The pointing of the VST occasionally deviates from request enough to cause blue+red sequences to be misaligned by up to ~10%. This complicates the pattern of overlap but should not lead to much source loss.
2) OmegaCAM CCD extension number 10 (formal name “ESO_CCD_82”) is known to have suffered from significant gain variations from the start of VST operations up until 2 June 2012. We have excluded all data from this CCD for the period affected.
3) The calibration is known to show systematic errors exceeding 0.1 mag in isolated patches. These are either inherited from APASS, the current calibration reference, or due to patchy cloud not deemed sufficiently pronounced to fail quality control.
4) Of order 1% of the sky area covered by DR2 proved to fail catalogue generation, for a mix of reasons, ranging from instances of doubled sources due to pointing glitches through to more subtle problems linked to features of the algorithm used. The most seriously affected locations are rectangular regions centred on Galactic co-ordinates (l,b):
(358.49, -1.43); (0.52 + 4.43); (1.05, +3.62); (238.56, -1.19)
In each case, the catalogue reports no data across a box approximately 0.75 degrees on a side, oriented N-S. The other data drop-outs are more limited in impact, amounting to occasional smaller holes, or loss of second detections.

In view of item 4) above, and given the present limited Plane coverage of DR2, an important general recommendation to the user is to always plot up the spatial distribution of catalogue sources to understand the sky area limits of the available photometry before embarking on exploitation.

Previous Releases

N/A

Data Format

File Types

The catalogue was prepared as a set of 1075 binary FITS tables in the multi-tile science catalogue format, following the guidelines described in ESO's Phase 3 Data Products Standards document. The total data volume is 182 GB.

Catalogue Columns

Column	Type	Unit	Description
name	string		Position-based source name in the sexagesimal form: "VPHAS-DR2 JHHMMSS.ss+DDMMSS.s". VPHAS-DR2 indicates the survey and data release, while J indicates that the position is J2000 equatorial.
RAJ2000	double	deg	Right Ascension in decimal degrees (J2000) with respect to the 2MASS PSC reference frame, which is consistent with ICRS to within 0.1 arcsec. The coordinate given is obtained from the astrometric measurement in the i-band exposure. If the source is undetected in i, then the r, r2, g, ha, or u coordinate is given (bands are listed in order of preference).
DEJ2000	double	deg	Declination in decimal degrees (J2000). See comments above.

Column	Type	Unit	Description
sourceID	string		Unique VPHAS source identifier in the format "#field-#extension-#number", e.g. "1679b-8-5386", is composed of the VPHAS field offset identifier, the CCD extension number, and a unique object number.
primaryID	string		sourceID of the preferred catalogue entry for this source. If equal to “sourceID”, then this entry is the preferred observation of a unique source. If it is different from sourceID, then the entry is a duplicate observation of a source and this column points to the preferred alternative.
primary_source	boolean		True if the entry is the preferred observation of a unique source. Use is_primary = True if you only want one row per source.
nObs	short		Number of observations of this source in the survey.
clean	boolean		True if clean_g, clean_r2, clean_r, clean_i, and clean_ha are all True. Note that clean_u is not required, in view of the more limited number of detections in this extreme band.
u_g	float	mag	(u - g) colour index, formed by subtracting columns u and g. To obtain the uncertainty, take the root of the sum of the squares of columns err_u and err_g.
g_r2	float	mag	(g - r2) colour index, formed by subtracting columns g and r2. See comments above.
r_i	float	mag	(r - i) colour index, formed by subtracting columns r and i. See comments above.
r_ha	float	mag	(r - Halpha) colour index, formed by subtracting columns r and ha. See comments above.
clean_u	boolean		True if the u-band detection was significant and the PSF fit reliable (snr_u > 10 & chi_u < 1.5).
u	float	mag	Default u-band magnitude obtained using PSF fitting. Calibrated in the Vega system.
u_AB	float	mag	Default u-band magnitude obtained using PSF fitting. Calibrated in the AB system.
err_u	float	mag	Statistical uncertainty for u as determined by DAOPHOT's PSF-fitting routine. Does not include systematics such as flat-fielding or zeropoint calibration errors.
chi_u	float		Goodness of the PSF fit in u, as determined by DAOPHOT's ALLSTAR PSF-fitting routine. A value close to one is good.
warning_u	string		Flags problems encountered while fitting the PSF, if any. Possible values include 'No_error', 'Off_image', 'Too_faint', and 'Bad_fit'. The magnitude values are left empty when an error occurred in catalogue generation. This column is for information only.
aperMag_u	float	mag	u-band VEGA magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMag_u_AB	float	mag	u-band AB magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMagErr_u	float	mag	Uncertainty in aperMag_u. Does not include systematics

Column	Type	Unit	Description
			such as flat-fielding and zeropoint calibration errors, or any errors due to crowding.
snr_u	float		Signal-to-noise ratio of the flux in the aperture, relative to the local background
magLim_u	float	mag	The Vega magnitude a SNR=3 source would have at this position.
psffwhm_u	float	arcsec	Typical Full Width at Half Maximum (FWHM) of the Point Spread Function (PSF) in the CCD frame.
mjd_u	double	days	Modified Julian Date at the start of the u-band exposure.
detectionID_u	string		Unique identifier of the detection in the format "#night-#exposure-#extension-#number", for example "20120429-00089-8-5386".
clean_g	boolean		True if the g-band detection was significant and the PSF fit reliable (snr_g > 10 & chi_g < 1.5).
g	float	mag	Default g-band magnitude obtained using PSF fitting. Calibrated in the Vega system.
g_AB	float	mag	Default g-band magnitude obtained using PSF fitting. Calibrated in the AB system.
err_g	float	mag	Statistical uncertainty for g as determined by DAOPHOT's PSF-fitting routine. Does not include systematics such as flat-fielding or zeropoint calibration errors.
chi_g	float		Goodness of the PSF fit in g, as determined by DAOPHOT's ALLSTAR PSF-fitting routine. A value close to one is good.
warning_g	string		Flags problems encountered while fitting the PSF, if any. Possible values include 'No_error', 'Off_image', 'Too_faint', and 'Bad_fit'. The magnitude values are left empty when an error occurred in catalogue generation. This columns is for information only.
aperMag_g	float	mag	g-band VEGA magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMag_g_AB	float	mag	g-band AB magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMagErr_g	float	mag	Uncertainty in aperMag_g. Does not include systematics such as flat-fielding and zeropoint calibration errors, or any errors due to crowding.
snr_g	float		Signal-to-noise ratio of the flux in the aperture, relative to the local background
magLim_g	float	mag	The Vega magnitude a SNR=3 source would have at this position.
psffwhm_g	float	arcsec	Typical Full Width at Half Maximum (FWHM) of the Point Spread Function (PSF) in the CCD frame.
mjd_g	double	days	Modified Julian Date at the start of the g-band exposure.
detectionID_g	string		Unique identifier of the detection in the format "#night-#exposure-#extension-#number", for example "20120429-00089-8-5386".

Column	Type	Unit	Description
clean_r2	boolean		True if the r2-band detection was significant and the PSF fit reliable (snr_r2 > 10 & chi_r2 < 1.5).
r2	float	mag	Second r-band magnitude obtained using PSF fitting. Calibrated in the Vega system.
r2_AB	float	mag	Second r-band magnitude obtained using PSF fitting. Calibrated in the AB system.
err_r2	float	mag	Uncertainty for r2 as determined by DAOPHOT's PSF-fitting routine. Does not include systematics such as flat-fielding or zeropoint calibration errors.
chi_r2	float		Goodness of the PSF fit in r2, as determined by DAOPHOT's ALLSTAR PSF-fitting routine. A value close to one is good.
warning_r2	string		Flags problems encountered while fitting the PSF, if any. Possible values include 'No_error', 'Off_image', 'Too_faint', and 'Bad_fit'. The magnitude values are left empty when an error occurred in catalogue generation. This column is for information only.
aperMag_r2	float	mag	r2-band VEGA magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMag_r2_AB	float	mag	r2-band AB magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMagErr_r2	float	mag	Uncertainty in aperMag_r2. Does not include systematics such as flat-fielding and zeropoint calibration errors, or any errors due to crowding.
snr_r2	float		Signal-to-noise ratio of the flux in the aperture, relative to the local background
magLim_r2	float	mag	The Vega magnitude a SNR=3 source would have at this position.
psffwhm_r2	float	arcsec	Typical Full Width at Half Maximum (FWHM) of the Point Spread Function (PSF) in the CCD frame.
mjd_r2	double	days	Modified Julian Date at the start of the r2-band exposure.
detectionID_r2	string		Unique identifier of the detection in the format "#night-#exposure-#extension-#number", for example "20120429-00089-8-5386".
clean_ha	boolean		True if the H-alpha detection is significant and the PSF fit reliable (snr_ha > 10 & chi_ha < 1.5)
ha	float	mag	Default H-alpha magnitude obtained using PSF fitting. Calibrated in the Vega system.
err_ha	float	mag	Uncertainty for ha as determined by DAOPHOT's PSF-fitting routine. Does not include systematics such as flat-fielding or zeropoint calibration errors.
chi_ha	float		Goodness of the PSF fit in H-alpha, as determined by DAOPHOT's ALLSTAR PSF-fitting routine. A value close to one is good.
warning_ha	string		Flags problems encountered while fitting the PSF, if any. Possible values include 'No_error', 'Off_image',

Column	Type	Unit	Description
			'Too_faint', and 'Bad_fit'. The magnitude values are left empty when an error occurred during catalogue generation. This column is for information only.
aperMag_ha	float	mag	H-alpha VEGA magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMagErr_ha	float	mag	Uncertainty in aperMag_ha. Does not include systematics such as flat-fielding and zeropoint calibration errors, or any errors due to crowding.
snr_ha	float		Signal-to-noise ratio of the flux in the aperture, relative to the local background
magLim_ha	float	mag	The Vega magnitude a SNR=3 source would have at this position.
psffwhm_ha	float	arcsec	Typical Full Width at Half Maximum (FWHM) of the Point Spread Function (PSF) in the CCD frame.
mjd_ha	double	days	Modified Julian Date at the start of the H-alpha exposure.
detectionID_ha	string		Unique identifier of the detection in the format "#night-#exposure-#extension-#number", for example "20120429-00089-8-5386".
clean_r	boolean		True if the r-band detection was significant and the PSF fit good (snr_r > 10 & chi_r < 1.5).
r	float	mag	Default r-band magnitude obtained using PSF fitting. Calibrated in the Vega system.
r_AB	float	mag	Default r-band magnitude obtained using PSF fitting. Calibrated in the AB system.
err_r	float	mag	Statistical uncertainty for r as determined by DAOPHOT's PSF-fitting routine. Does not include systematics such as flat-fielding or zeropoint calibration errors.
chi_r	float		Goodness of the PSF fit in r, as determined by DAOPHOT's ALLSTAR PSF-fitting routine. A value close to one is good.
warning_r	string		Flags problems encountered while fitting the PSF, if any. Possible values include 'No_error', 'Off_image', 'Too_faint', and 'Bad_fit'. The magnitude values are left empty when an error occurred in catalogue generation. This column is for information only.
aperMag_r	float	mag	r-band VEGA magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMag_r_AB	float	mag	r-band AB magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMagErr_r	float	mag	Uncertainty in aperMag_r. Does not include systematics such as flat-fielding and zeropoint calibration errors, or any errors due to crowding.
snr_r	float		Signal-to-noise ratio of the flux in the aperture, relative to the local background
magLim_r	float	mag	The Vega magnitude a SNR=3 source would have at this

Column	Type	Unit	Description
			position.
psffwhm_r	float	arcsec	Typical Full Width at Half Maximum (FWHM) of the Point Spread Function (PSF) in the CCD frame.
mjd_r	double	days	Modified Julian Date at the start of the r-band exposure.
detectionID_r	string		Unique identifier of the detection in the format "#night-#exposure-#extension-#number", for example "20120429-00089-8-5386".
clean_i	boolean		True if the i-band detection was significant and the PSF fit reliable (snr_i > 10 & chi_i < 1.5).
i	float	mag	Default i-band magnitude obtained using PSF fitting. Calibrated in the Vega system.
i_AB	float	mag	Default i-band magnitude obtained using PSF fitting. Calibrated in the AB system.
err_i	float	mag	Statistical uncertainty for i as determined by DAOPHOT's PSF-fitting routine. Does not include systematics such as flat-fielding or zeropoint calibration errors.
chi_i	float		Goodness of the PSF fit in i, as determined by DAOPHOT's ALLSTAR PSF-fitting routine. A value close to one is good.
warning_i	string		Flags problems encountered while fitting the PSF, if any. Possible values include 'No_error', 'Off_image', 'Too_faint', and 'Bad_fit'. The magnitude values are left empty when an error occurred in catalogue generation. This column is for information only.
aperMag_i	float	mag	i-band VEGA magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMag_i_AB	float	mag	i-band AB magnitude obtained using aperture photometry. In crowded fields, this magnitude is prone to contamination from nearby sources.
aperMagErr_i	float	mag	Uncertainty in aperMag_i. Does not include systematics such as flat-fielding and zeropoint calibration errors, or any errors due to crowding.
snr_i	float		Signal-to-noise ratio of the flux in the aperture, relative to the local background
magLim_i	float	mag	The Vega magnitude a SNR=3 source would have at this position.
psffwhm_i	float	arcsec	Typical Full Width at Half Maximum (FWHM) of the Point Spread Function (PSF) in the CCD frame.
mjd_i	double	days	Modified Julian Date at the start of the i-band exposure.
detectionID_i	string		Unique identifier of the detection in the format "#night-#exposure-#extension-#number", for example "20120429-00089-8-5386".
field	string		Survey-specific identifier of the telescope pointing, e.g. "0001a".
ext	short		OmegaCAM CCD used, identified by the extension number in the FITS files that the instrument produces.
l	float	deg	Galactic longitude in decimal degrees (IAU 1958 system).

Column	Type	Unit	Description
b	float	deg	Galactic latitude in decimal degrees (IAU 1958 system).
nbDist	float	arcsec	Angular distance to the nearest neighbour detected in the same exposure.

Acknowledgements

The general journal reference for VPHAS+ is: Drew et al, 2014, MNRAS, 440, 2036.

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