The Galactic spiral structure as revealed by O- and early B-type stars

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ABSTRACT

We investigate the morphology and kinematics of the Galactic spiral structure based on a new sample of O- and early B-type stars. We select 6,858 highly confident OB star candidates from the combined data of the VST Photometric Hα Survey Data Release 2 (VPHAS+ DR2) and the Gaia Data Release 2 (Gaia DR2). Together with the O-B2 stars from the literature, we build a sample consisting of 14,880 O- and early B-type stars, all with Gaia parallax uncertainties smaller than 20 per cent. The new sample, hitherto the largest one of O- and early B-type stars with robust distance and proper motion estimates, covers the Galactic plane of distances up to \(6\) kpc from the Sun. The sample allows us to examine the morphology of the Scutum, Sagittarius, Local and Perseus Arms in great detail. The spiral structure of the Milky Way as traced by O- and early B-type stars shows flocculent patterns. Accurate structure parameters, as well as the means and dispersions of the vertical velocity distributions of the individual spiral arms are presented.

Key words: stars: early-type – Galaxy: disk – Galaxy: structure

1 INTRODUCTION

The Galactic spiral structure is an important feature when studying the characteristics and properties of the Milky Way disk. However, we still do not know its exact structure, due to the difficulties of obtaining accurate distances of the tracers (Vallée 2017; Xu et al. 2018b).

Most of the current Galactic spiral models are based on the kinematic distances of ionized H II regions (Georgelin & Georgelin 1976; Downes et al. 1980; Caswell & Haynes 1987; Russell 2003; Hou et al. 2009), HI neutral gas (Kerr 1969; Weaver 1970; McClure-Griffiths et al. 2004; Kalberla & Kerp 2009; Koo et al. 2017) and CO molecular clouds (Solomon & Rivolo 1989; May et al. 1997; Heyer et al. 2001; Dame & Thaddeus 2011; Hou & Han 2014; Sun et al. 2015; 2017). However, due to the large errors of those kinematic distances, the identification of the spiral arms suffers from inevitable large ambiguity. Up to now, there is still no consensus on the number of arms, their locations and properties.

Precise distance is of paramount importance for tracing the structure of the Galactic spiral arms. The accurate distance measurements of masers from the Very Long Baseline Interferometry (VLBI) have been vital to disentangle the spiral arms, spurs and arm branches (Xu et al. 2006; Honma et al. 2007; Reid et al. 2014). However, there are accurate trigonometric parallax observations for only about 100 masers, mostly in the first and second quadrants of the disk.

The second Gaia data release (Gaia DR2; Gaia Collaboration et al. 2018) has provided unprecedented high quality astrometric data for over one billion stars. The uncertainties of Gaia parallaxes vary between 0.04 and 0.1 mas for sources of \(G\) magnitudes between 8 and 18 mag, yielding parallaxes accurate to 20 per cent out to distances of \(\sim 5\) kpc (Lindegren et al. 2018). Based on the Gaia DR2 parallaxes, Xu et al. (2018b) and Xu et al. (2018a) have studied the morphology of the Galactic spiral arm structure within 3 kpc of the Sun using a sample of OB stars from Reed (2003). They find that the nearby spiral structure unraveled by this sample agrees well with that revealed by the VLBI masers and extends to the fourth quadrant. They also find new spur-like structures between the major arms.
The new OB star candidates are selected from the VPHAS+2 VPHAS+ which are discussed and summarized in Section 5. In Section 4, we present our main results.

Deng et al. (2012) and Liu et al. (2014, Yuan et al. 2015). However, most of them are late B-type (B4 or later) stars and there are only about 300 O-B2 stars.

The VPHAS+ data release 2 (VPHAS+ DR2; Drew et al. 2014) have presented u, g, r, i and Hα photometry of over 300 million objects covering 629 deg² of the Galactic plane. Together with the Gaia DR2, they provide us a great opportunity to select a new sample of O- and early B-type stars and explore the Galactic spiral structure up to ~ 6 kpc from the Sun. In this paper, we have selected a deep sample of OB-star candidates from the VPHAS+ DR2 and Gaia DR2 catalogues. Combined with the O-B2 stars available from the literature, we examine the Galactic spiral structure in unprecedented detail.

The paper is structured as following. In Section 2, we present the relevant VPHAS+ DR2 and Gaia DR2 data. Section 3 describes the new OB-star sample. In Section 4, we present our main results which are discussed and summarized in Section 5.

VPHAS+ AND GAIA

The new OB star candidates are selected from the VPHAS+ DR2 and Gaia DR2 catalogues.

The VPHAS+ Survey (Drew et al. 2014) collected images in the SDSS u, g, r, i broad bands and the Hα narrow band using the OmegaCAM imager (Kuijken 2011) on the VLT Survey Telescope (VST). The survey is designed to cover ~ 2000 deg² of the Galactic plane in the southern hemisphere of Galactic latitude |b| < 5° and Galactic longitude −150° < l < 40°, and a Galactic bulge extension of |b| < 10° near the Galactic centre. The VPHAS+ DR2 (Drew et al. 2014), released in 2016, contains PSF and aperture photometry of ~ 319 million point-like sources covering 629 deg² of the planned VPHAS+ footprint. Typically, a signal-to-noise ratio S/N = 5 cut corresponds to a limiting magnitude of about 22 mag in the u, g and r bands. The photometric calibration of VPHAS+ DR2 is consistent with that of the SDSS within an accuracy of 0.05 mag (r.m.s. error) for g and r bands.

To exclude contaminations of sub- and over-luminous OB stars and stars of spectral types B4 and later, we combine the VPHAS+ photometry with the Gaia DR2 data (Gaia Collaboration et al. 2018). Gaia DR2 provides high precision photometric measurements of over 1.4 billion sources in G, G_{BP} and G_{RP} bands. The Gaia G band covers the entire optical wavelength ranging between 330 and 1050 nm. The G_{BP} (330 - 680 nm) and G_{RP} (630 - 1050 nm) magnitudes are derived from the Gaia low resolution spectrophotometric measurements. The internal validation shows that the Gaia DR2 calibration uncertainties for the G, G_{BP} and G_{RP} bands are 2.5 and 3 mmag, respectively. Gaia DR2 also releases high-quality parallax and proper motion measurements of 1.3 billion sources. The parallax uncertainties are around 0.04 mas for bright sources of G < 14 mag and around 0.1 mas for sources of G ~ 18 mag.

3 THE OB-STAR SAMPLE

3.1 OB star candidates from VPHAS+ and Gaia

Similarly to Mohr-Smith et al. (2015) and Mohr-Smith et al. (2017), we first select OB star candidates with the (u − g, g − r) colour-colour diagram. In the diagram, the reddened OB stars of spectral types earlier than B3 are easily identifiable as they are located above and away from the main stellar locus. We select sources in the VPHAS+ DR2 catalogue with cuts g < 20 mag, g-band photometric errors smaller than 0.05 mag, u and r detections and photometric uncertainties smaller than 0.05 mag. In Fig. 1 we plot the distribution of all stars thus selected in the (u − g, g − r) colour-colour diagram. We adopt the reddening vector for the B3V stars from Drew et al. (2014). In total, 91,668 unique stars are found located above the B3V-star reddening curve.

Our aim is to select a sample of young and luminous OB stars to trace the Galactic spiral arms. The candidates selected from the (u − g, g − r) diagram includes all types of OB stars. One thus needs to identify and reject stars amongst those candidates that actually belong to the old populations, such as sub-dwarfs and white dwarfs. In addition, the sample selected from the VPHAS+ colour-colour

![Figure 1. Distribution of stars selected from the VPHAS+ DR2 catalogue in the (u − g) versus (g − r) plane. The blue curve represents the stellar locus from the PARSEC isochrones (Marigo et al. 2017) and the red line shows the reddening curve of the B3V stars from Drew et al. (2014). Pink dots are O-B2 candidates from Mohr-Smith et al. (2017).](image-url)
diagram is also contaminated by a significant number of stars of B4- and later-types due to the relative large photometric uncertainties of $u$-band (see also Mohr-Smith et al. 2017). To exclude those contaminators, Mohr-Smith et al. (2017) carried out a SED analysis based on the multi-band photometry of VPHAS+ and 2MASS. In the current work, we adopt the high precision photometric data and parallaxes from the Gaia DR2 to exclude all the contaminators. We cross-match the candidates with the Gaia DR2 catalogue. We adopt only stars of Gaia parallax errors smaller than 20 per cent, reddening correction in the Gaia colour-$'absolute'$ magnitude diagram, without reddening corrections, is also contaminated by a significant number of stars of B4- and later-types due to the large photometric uncertainty of $u$-band (see also Mohr-Smith et al. 2017). To exclude those contaminators, Mohr-Smith et al. (2017) carried out a SED analysis based on the multi-band photometry of VPHAS+ and 2MASS. In the current work, we adopt the high precision photometric data and parallaxes from the Gaia DR2 to exclude all the contaminators.
Figure 3. Spatial distribution of the combined OB sample stars in the XY plane. Black, blue, orange and green dots correspond to OB star candidates selected in this work, those from Skiff (2014), Maiz Apellániz et al. (2013) and Huang et al. (in prep.), respectively. The Sun, assumed to be at 8.34 kpc from the Galactic center, is located at the centre of the plot (\(X = 0\) kpc and \(Y = 8.34\) kpc). The directions of \(l = 0^\circ, 45^\circ, 90^\circ, 135^\circ, 180^\circ, 225^\circ, 270^\circ\) and \(315^\circ\) are also marked in the plot.

Based on the above exercise, 6,858 OB candidates have been selected above the B3V-star extinction curve. A catalogue of these OB-star candidates is available in electronic form in the online version of this manuscript. Table 2 describes the data format of the catalogue. In order to check if any objects in our catalogue have known spectral types, we cross-match our candidates with the SIMBAD database with a match radius of 1 arcsec. We find 139 objects that have been spectroscopically classified in the SIMBAD. Table 3 summarises the numbers and fractions of those stars in different spectroscopically confirmed spectral types. The majority of them are indeed OB stars as expected, with a contamination at the level of \(\sim 10\) percent from Wolf-Rayet (WR) stars, and later A, F and M stars. A very positive feature of Table 3 is the high success-rate that we are able to place stars correctly into the O and early B spectral types. Most of the OB stars are of early types (B3 and earlier), with only about 9 percent contamination of B4 and later types. We have also checked our OB-star candidates against data from large-scale spectroscopic surveys, and find 27 common stars with the LAMOST surveys. There are 25 stars that have effective temperatures higher than \(\sim 12,000\) K in the value-added catalogue of the LAMOST Spectroscopic Survey of the Galactic Anti-centre Data Release 2 (LSS-GAC DR2; Xiang et al. 2017).

3.2 OB stars from the literature

In addition to the new OB candidates selected from the VPHAS+ DR2 catalogue, we have also made use of the OB stars available in the literature. In the current work, we adopt three catalogues, the GOSC catalogue (Maiz Apellániz et al. 2013), the OB star cata-

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2 The catalogue is also available online via [http://paperdata.china-vo.org/diskec/obsamp/table2.fits](http://paperdata.china-vo.org/diskec/obsamp/table2.fits).
Table 2. Description of the OB-star candidate catalogue selected from the VPHAS+ DR2.

| Column | Name | Description |
|--------|------|-------------|
| 1      | id   | Index of the star in the catalogue |
| 2      | RA   | Right Ascension (J2000) |
| 3      | Dec  | Declination (J2000) |
| 4      | u    | VPHAS+ u-band magnitude |
| 5      | uerr | VPHAS+ u-band photometric uncertainty |
| 6      | g    | VPHAS+ g-band magnitude |
| 7      | gerr | VPHAS+ g-band photometric uncertainty |
| 8      | r    | VPHAS+ r-band magnitude |
| 9      | rerr | VPHAS+ r-band photometric uncertainty |
| 10     | i    | VPHAS+ i-band magnitude |
| 11     | ierr | VPHAS+ i-band photometric uncertainty |
| 12     | Hα  | VPHAS+ Hα-band magnitude |
| 13     | Hoerr| VPHAS+ Hα-band photometric uncertainty |
| 14     | G    | Gaia G-band magnitude |
| 15     | Gα   | Gaia G-band photometric uncertainty |
| 16     | BP   | Gaia Gα-band magnitude |
| 17     | BPerr| Gaia Gα-band photometric uncertainty |
| 18     | RP   | Gaia Gα-band magnitude |
| 19     | RPerr| Gaia Gα-band photometric uncertainty |
| 20     | dis  | Distance of object estimated from Eq. (1) |
| 21     | para | Gaia parallax |
| 22     | paraerr| Gaia parallax uncertainty |
| 23     | pmra | Gaia proper motion in Right Ascension |
| 24     | pmraerr| Uncertainty of proper motion in Right Ascension |
| 25     | pmdec| Gaia proper motion in Declination |
| 26     | pmdecerr| Uncertainty of proper motion in Declination |
| 27     | ref  | The reference if the star is already present in the literature |

Notes: 1 Of OB spectral type but without subclasses available.

Table 3. Numbers and fractions of stars in different spectral types, for a sample of 139 OB star candidates that have spectroscopic classifications available from the SIMBAD database.

| Type           | Number | Fraction |
|----------------|--------|----------|
| O stars        | 19     | 14 per cent |
| B0-B2 stars    | 54     | 39 per cent |
| B3 stars       | 9      | 6 per cent |
| B4-B8 stars    | 13     | 9 per cent |
| Other OB stars | 30     | 22 per cent |
| WR stars       | 5      | 4 per cent |
| A/F/M stars    | 9      | 6 per cent |

3.3 The combined sample of OB stars and candidates

Combining our newly selected VPHAS+ OB-star candidates with those from the literature, we obtain a catalogue of 14,880 unique OB stars and candidates, all with Gaia parallax uncertainties smaller than 20 per cent. Distances of all stars in the catalogue are calculated from the Gaia parallaxes using Eq. (1). We have compared our distance estimates with those of Bailer-Jones et al. (2018) and found no systematics between them and the dispersion is very small (about 1 per cent). In Fig. 3 we show the distribution of those stars.

The catalogue is also available online via http://paperdata.china-vo.org/diskec/obsamp/table4.fits.
OB stars and candidates in the Galactic X-Y plane. This new combined sample spans from $X = -8$ to 5 kpc and $Y = 2$ to 15 kpc in the Galactic plane. The VPHAS+ and the literature samples complement with each other in the spatial coverage. The Skiff and Maíz Apellániz et al. sample stars are mainly distributed at distances $d < 4$ kpc from the Sun, while those of Huang et al. and those newly selected from the VPHAS+ fall between 2 $< d < 6$ kpc from the Sun. Stars from Huang et al. are mainly in the Galactic outer disk while those of the VPHAS+ are in the Galactic inner disk.

4 THE GALACTIC SPIRAL ARMS

4.1 Morphology of the Galactic spiral structure

As Fig. 3 shows, the OB stars fall in clumps and strips, and trace clearly the structure of the Galactic spiral arms. The gaps between the arms are quite visible. Comparing with previous work (Reid et al. 2014, Xu et al. 2018a), our data have a larger spatial coverage and probe much further distances from the Sun. Thanks to the deep limiting magnitudes of the VPHAS+ and LAMOST data, we are now able to explore the disk area of distances between 4 and 6 kpc from the Sun for the first time.

In Fig. 4, we plot the spatial and density distributions of the OB stars in the X-Y plane. The distance is calculated using a Kernel Density Estimation (KDE) of a Gaussian Kernel of bandwidth 0.2 kpc. The masers from the literature (Table 2 of Xu et al. 2018b) are over-plotted in the diagram. The similarity in the distributions of these two types of tracers is clearly visible. This is not surprising as masers and young OB associations are both good tracers of massive star forming regions. Overall, the spiral pattern revealed by the OB stars and the masers consists of four spiral arm segments.

In the top parts of the two panels of Fig. 4 (Galactocentric distance $R > 12$ kpc), there are two masers (purple circles), probably the sign posts of the position of the Outer Arm. Limited by the Gaia parallax uncertainties, only a few OB stars are found in this region in the current work. Nevertheless, several OB stars are indeed found around one of the two masers ($l \sim 135^\circ$). Two strips of OB stars, one at $(X, Y) \sim (2.5$ kpc, 12 kpc) and another at $(X, Y) \sim (-2$ kpc, 12 kpc), are visible, and they could belong to the Outer Arm, or to the bridge that connects the Outer and the Perseus Arms.

The Perseus Arm is well constrained by both the OB stars and the masers from $l = 90^\circ$ to $270^\circ$. In the regions of $l$ between 135° and 170° and $l$ between 190° and 220°, there are two ‘holes’ without masers or few OB stars. The holes are probably true as these regions are well covered by the VPHAS+ and LAMOST data. OB stars are clearly found in the same directions at either nearer or further distances from the Sun. Thus it is unlikely that we miss the OB stars in the holes should they exist. It is interesting to note that the two possible bridges that connect the Outer and the Perseus Arms fall in those two directions. On the near side of the two holes ($X = -1.5$ to 1.5 kpc and $Y \sim 9$ kpc), several groups of OB stars as well as some masers are found between the Perseus and the Local Arms.

The Local Arm is the nearest spiral arm to our Sun and the most well defined in the plot. All the OB clumps (or strips) of the other arms show significant linear patterns (“fingers”) that point toward the Sun, which are possibly the results of the discontinuous distribution of the VPHAS+ and LAMOST fields, and have relatively large distance dispersions of about 1 kpc, which are likely mainly caused by the relatively large errors in the distances. The Local Arm are well resolved into several small OB clumps, with our Sun located near one of them. The presence of OB stars near $(X, Y) = (-6$ kpc, 7.5 kpc) suggests that the Local Arm may extend into the fourth quadrant at $l \sim 280^\circ$, indicating that the Local Arm might well be a major spiral arm, rather than a spur structure.

The Sagittarius Arm is well constrained by the OB clumps from $l = 290^\circ$ ($X = -7$ kpc and $Y = 5.5$ kpc) to $30^\circ$ ($X = 2$ kpc and $Y = 6$ kpc). A possible ‘hole’ pattern is visible in the directions of $l$ between 320° and 350°. Similar to the ‘holes’ in the Perseus Arm, there are several OB clumps found at both the nearer and further sides of the ‘hole’, connecting the Sagittarius Arm with the Local and the Scutum Arms, respectively. There are a lot more OB stars falling along the Sagittarius Arm than those on the Local and the Perseus Arms, suggesting that the star-forming activities are much stronger in the inner disk than those in the outer disk.

The gap between the Scutum and the Sagittarius Arms is not significant in the first quadrant. Due to the large distance uncertainties of stars in that region, we are not able to distinguish whether this small gap is largely caused by the effects of the large distance errors or the two Arms actually merge into one in this region. The gap between the two Arms in the fourth quadrant is clearly visible.

In general, all the Spiral Arms discussed above are well traced by the discrete OB clumps and masers. In addition to ‘holes’, many more possible patterns, such as branches, spurs and bridges be-
Figure 4. Spatial (bottom panel) and density (upper panel) distributions of the combined sample of OB stars and candidates in the X-Y plane. Solid and dashed orange, red, blue and pink lines delineate respectively the best-fit spiral arm models of the Scutum, Sagittarius, Local and Perseus Arms presented in the current work and those of Xu et al. (2018b). Circles of the above colours are the masers from Xu et al. (2018b) probably associated with the individual Arms. The purple circles are the masers from Xu et al. (2018b) that may trace the Outer Arm. Three black dashed circles mark the positions of possible ‘hole’ patterns in the Sagittarius and Perseus Arms. The Sun, assumed to be at 8.34 kpc from the Galactic center, is located at the centre of the plot. The directions of \( l = 0^\circ, 45^\circ, 90^\circ, 135^\circ, 180^\circ, 225^\circ, 270^\circ \) and \( 315^\circ \) are also marked in the plot.
The best-fitted models of the individual arms are plotted in Fig. 4 and the corresponding parameters are listed in Table 5. Our models connect most of the OB clumps and masers. The resulted values of distance $R_0$ of the four spiral arms are very similar to those from Xu et al. (2018b), who obtain the structure parameters of the four arms using O stars from Reed (2003) and the masers. Our current sample of traces covers a larger range in the X-Y space than that of Xu et al. (2018b). And this yields the pitch angles of the individual arms that differ slightly from those of Xu et al. (2018b) but match better with the new data.

### Table 5. Spiral arm characteristics

| Arm           | $R_0$ (kpc) | $\psi$ (°) | $\langle V_Z \rangle$ (km s$^{-1}$) | $\sigma_{V_Z}$ km s$^{-1}$ |
|---------------|-------------|------------|-----------------------------------|--------------------------|
| Scutum Arm    | 5.89±0.02   | 15.1±0.7   | −3.5                              | 6.5                      |
| Sagittarius Arm | 6.95±0.01 | 17.4±0.2   | −4.1                              | 6.8                      |
| Local Arm     | 8.51±0.01   | 10.2±0.2   | −2.0                              | 7.1                      |
| Perseus Arm   | 10.35±0.01  | 7.0±0.3    | −3.9                              | 6.9                      |

where $W$ is the weight, $x$ and $y$ the Cartesian coordinates, $i$ and $t$ the indexes of tracers and model positions closest to the tracers. In the current work, we simply adopt a weight $W_{OB} = 1$ for all the OB stars and candidates and $W_m = 10$ for all the masers (Xu et al. 2018b). The errors of the derived parameters are calculated using the bootstrap method (Wall & Jenkins 2003). We randomly re-sampled the combined OB sample 1000 times and obtain the best-fit parameters for each sample. The r.m.s scatters of the resulted parameters give the uncertainties of our results.

Following Hou & Han (2014) and Xu et al. (2018b), we derive the parameters of the arm structures, including the Scutum, Sagittarius, Local and Perseus Arms, based on the current sample of OB stars candidates, as well as masers. We adopt the simple, logarithmic model of a spiral arm (Kennicutt 1981), i.e.,

$$\ln(R/R_0) = -\beta \tan \psi,$$

where $R$ is the Galactocentric distance, $\beta$ the Galactocentric azimuth that has a value of 0 in the direction toward the Sun and increases clockwise, $R_0$ the radius of the arm at reference azimuth $\beta_0 = 0$° and $\psi$ the pitch angle of the arm. We perform an MCMC analysis to find the optimized value of each of the parameters by minimising a factor defined as,

$$Z = \frac{\sum W_i \sqrt{(x_i - x_t)^2 + (y_i - y_t)^2}}{\sum W_i},$$

and $W_{OB}$ for all the OB stars and candidates and $W_m = 10$ for all the masers (Xu et al. 2018b). The errors of the derived parameters are calculated using the bootstrap method (Wall & Jenkins 2003). We randomly re-sampled the combined OB sample 1000 times and obtain the best-fit parameters for each sample. The r.m.s scatters of the resulted parameters give the uncertainties of our results.

The best-fitted models of the individual arms are plotted in Fig. 4 and the corresponding parameters are listed in Table 5. Our models connect most of the OB clumps and masers. The resulted values of distance $R_0$ of the four spiral arms are very similar to those from Xu et al. (2018b), who obtain the structure parameters of the four arms using O stars from Reed (2003) and the masers. Our current sample of traces covers a larger range in the X-Y space than that of Xu et al. (2018b). And this yields the pitch angles of the individual arms that differ slightly from those of Xu et al. (2018b) but match better with the new data.
In this paper, we have identified 6,858 new O- and early B-type star candidates from the VPHAS+ DR2 and Gaia DR2 catalogues. Combined with the O-B2 candidates available in the literature, we have built a sample of 14,880 O- and early B-type stars and candidates with Gaia parallax errors smaller than 20 per cent. This is hitherto the largest sample of O- and early B-type stars and candidates with accurate distance and proper motion estimates. Based on the catalogue, we have explored the morphology and kinematics of the Galactic spiral structure. Our sample reveal clearly four spiral arm segments, i.e., the Scutum, Sagittarius, Local and Perseus Arms. We have obtained accurate structure parameters of those Arms. The data show three possible ‘hole’ patterns along the Galactic spiral arms, in addition to abundant other substructures. The Galactic spiral structures as traced by the young OB stars are more likely flocculent spirals.

The size and the spatial distribution of our sample are mainly limited by the parallax uncertainties of the Gaia DR2. If we loose the Gaia parallax uncertainties up to 30 per cent, the number of the selected VPHAS+ OB candidates would be doubled and the sample will extend to a distance of ~10 kpc from the Sun. However, the increased distance errors will lead to a larger fraction of contamination of the sub-dwarfs. Meanwhile the distance uncertainty might become comparable to or even larger than the gaps between the spiral arms. The future Gaia releases are expected to improve our work by enlarging the sample size and also the spatial coverage. On the other hand, VPHAS+ DR2, that we used in the current work, covers only 20 per cent of the full footprint of the VPHAS+ survey. The future VPHAS+ data release would also help enlarge our data set and extend to higher Galactic latitudes. Other ongoing and future u-band photometric surveys, such as the SkyMapper, the Large Synoptic Survey Telescope (LSST) and the Multi-channel Photometric Survey Telescope (Mephisto) surveys, will aid in the construction of samples of more O- and early B-type stars that cover larger areas of the Galactic plane.

5 DISCUSSION AND SUMMARY

In Fig. 6 we compare the spatial distribution of our OB stars and candidates with that of the interstellar dust reddening for \(|b| < 0.5^\circ\) of the Galactic plane [Chen et al. 2019]. Due to the heavy extinction in the Galactic plane, the extinction map of [Chen et al. 2019] is only completed to ~3 kpc. Overall, there is a good correlation between the distribution of the OB stars and candidates and that of the interstellar dust at large scales. The Sagittarius, Local and Perseus arms are discernible in both the interstellar dust extinction map and in the OB star distribution. The dust clouds are very likely to be spatially associated with the Galactic spiral arm models delineated in the current work.
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