Estimating accurate reddening values of LAMOST M dwarfs

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ABSTRACT

M dwarfs are the dominating type of stars in the solar neighbourhood. They serve as excellent tracers for the study of the distribution and properties of the nearby interstellar dust. In this work, we aim to obtain high accuracy reddening values of M dwarf stars from the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) Data Release 8 (DR8). Combining the LAMOST spectra with the high-quality optical photometry from the Gaia Early Data Release 3 (Gaia EDR3), we have estimated the reddening values \( E(G_{BP} - G_{RP}) \) of 641,426 M dwarfs with the machine-learning algorithm Random Forest regression. The typical reddening uncertainty is only 0.03 mag in \( E(G_{BP} - G_{RP}) \). We have obtained the reddening coefficient \( R_{0}(G_{BP} - G_{RP}) \), which is a function of the stellar intrinsic colour \( (G_{BP} - G_{RP})_0 \) and reddening value \( E(B-V) \). The values of \( E(B-V) \) are also provided for the individual stars in our catalogue. Our resultant high accuracy reddening values of M dwarfs, combined with the Gaia parallaxes, will be very powerful to map the fine structures of the dust in the solar neighbourhood.

Key words: dust, extinction – stars: low-mass – solar neighbourhood

1 INTRODUCTION

Our Sun locates in the Local Bubble, which suffers from less dust extinction compared to other places in the Galactic disk (Lallement et al. 2014; Chen et al. 2014; Chen et al. 2019a; Green et al. 2019; Leike et al. 2020). To explore the properties and fine structures of the dust nearby, high accuracy reddening values of the individual local stars are always welcome.

M dwarfs are faint stars with low mass and low surface temperature (Laughlin et al. 1997; Pecaut & Mamajek 2013). They are the most common type of stars in our solar neighbourhood (Bochanski et al. 2010; Winters et al. 2019). They can thus be utilised to study the dust properties and structures in the solar neighbourhood. Jones et al. (2011) used the Sloan Digital Sky Survey (SDSS) spectra of over 56,000 M dwarfs to map the dust distribution in the high Galactic latitudes of the local Galaxy. They compare the SDSS spectra of the target M dwarfs to a set of template M dwarf spectra from low extinction regions to derive the extinction values of the individual stars. Their resulted extinction values of the M dwarfs have a median value of 0.037 mag in \( A_V \) and an internal uncertainty of about 0.043 mag in \( A_V \). However, the size of the Jones et al. (2011) M dwarf catalogue is relatively small and most of their sources are located in high Galactic latitudes.

The ongoing Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST; Cui et al. 2012) Galactic survey (Deng et al. 2012; Zhao et al. 2012; Liu et al. 2014) have obtained more than ten million spectra of stars in the Milky Way. Zhong et al. (2015a,b) and Li et al. (2016) have developed a template-fitting pipeline to identify and classify M stars from the LAMOST spectra. Zhong et al. (2019) have provided a catalogue of 39,796 M giants and 501,152 M dwarfs based on the LAMOST Data Release 5 (DR5). Li et al. (2021) and Du et al. (2021) have developed new pipelines to calculate the atmospheric parameters, including the effective temperature \( T_{\text{eff}} \), metallicity \([\text{M/H}]\) and surface gravity log \( g \), of the LAMOST M stars. The most recently released catalogues from the LAMOST Data Release 8 (DR8; Luo et al. 2015) contains an M type star catalogue which consists of 721,947 M dwarf spectra, 44,312 M giant spectra and 4,316 M sub-dwarf spectra. In this work, we will combine the LAMOST M dwarf star catalogue with the Gaia Early Data Release 3 (Gaia EDR3; Gaia Collaboration et al. 2021) photometry to estimate the reddening values of the individual M dwarfs.

2 DATA

Our work is based on the LAMOST DR8 v1.1, which was recently published in February 2022. LAMOST DR8 v1.1 contains both the low and medium resolution spectra and catalogues obtained by the LAMOST between October 2011 and May 2020. In the current work, we adopt the M star catalogue named ’LAMOST LRS Catalog of gM, dM, and sdM stars’. The catalogued sources are selected from the low resolution survey. The LAMOST low resolution spectra have a resolution of \( R \sim 1800 \) at 5500 Å and cover the full optical wavelength ranging between 3800 and 9000 Å. The LAMOST M star catalogue contains 44,312 M giant spectra, 721,947 M dwarf spectra, and 4,316 M sub-dwarf spectra. The catalogue present values of atmospheric parameters \( T_{\text{eff}}, \log g \) and \([\text{M/H}]\); Du et al.

1 http://www.lamost.org/dr8/v1.1/
To obtain the precise reddening values of the LAMOST M dwarfs, we adopt the high quality photometry from Gaia EDR3, which was released in December 2020 (Gaia Collaboration et al. 2021). Gaia EDR3 contains about 1.8 billion sources with high precision celestial positions and \( G \) broad-band photometric measurements. Among them, \( \sim \) 1.5 billion sources have \( G_{\text{BP}} \) and \( G_{\text{RP}} \)-band magnitudes and five astrometric parameters (position, parallaxes and proper motions). The typical uncertainties for the Gaia EDR3 \( G \), \( G_{\text{BP}} \) and \( G_{\text{RP}} \) photometries are respectively 6, 108 and 52 mmag at \( G = 20 \) mag (Gaia Collaboration et al. 2021).

We select the M dwarfs from the LAMOST M star catalogue and cross-match them with the Gaia EDR3 using the CDS XMatch Service. We adopt a matching radius of 3\( \arcsec \) which is the diameter of the LAMOST low resolution fibre. Most (81 per cent) of our catalogued stars have total proper motions smaller than 50 mas yr\(^{-1}\) measured by Gaia. There are only 33 stars having proper motions larger than 200 mas yr\(^{-1}\). The coordinates of LAMOST stars are adopted from the photometric data such as the multiband CCD photometric survey of the Galactic Anticentre with the Xuyi 1.04/1.20 m Schmidt Telescope (XSTPS-GAC; observed during 2009 and 2011; Liu et al. 2014) and the Pan-STARRS 1 Survey (PS1; observed during 2010 and 2014; Chambers et al. 2016). The Gaia EDR3 are from the observations of Gaia during 2014 and 2017. If we assume a typical 5 yr epoch difference between the LAMOST and Gaia coordinates, the moving distances for most of our catalogued stars are smaller than \( \sim 0.25 \) arcsec. Only 33 stars have moving distances larger than 1 arcsec. Therefore, the mismatches of stars caused by the stellar proper motions can be ignored in our work. We select sources with LAMOST spectra having signal-to-noise ratios (S/N) in \( i \)-band (snri) larger than 30 and photometric uncertainties of both the Gaia EDR3 \( G_{\text{BP}} \) and \( G_{\text{RP}} \) magnitudes less than 0.01 mag.

This leads to a sample of 21,150 stars. The intrinsic colour \( (G_{\text{BP}} - G_{\text{RP}})_{0} \) of these sample stars are calculated using the reddening values from Planck Collaboration et al. (2014) dust maps and the reddening coefficients from Chen et al. (2019a), by \((G_{\text{BP}} - G_{\text{RP}})_{0} = (G_{\text{BP}} - G_{\text{RP}}) - 1.33E(B - V)\).

We randomly select 80 per cent stars from the training sample to train our Random Forest model and use the remaining 20 per cent stars to test the training accuracy. In the current work, we set the equivalent widths (EW) of the H\(\alpha\), TiO, CaH, CaOH and Na lines (ewha, tio1, tio2, tio3, tio4, cah1, cah2, caoh3, caoh and na) and the metallicity sensitive parameter (zeta) deduced from the LAMOST spectra as the input parameters. The python package scikit-learn (Pedregosa et al. 2012) is adopted to build the model. We tried different parameters with grid search to optimize the models. Finally, we adopt the number of features to consider when looking for the best split \texttt{max\_features = 'sqrt'}, the minimum number of samples required to be at a leaf node \texttt{min\_samples\_leaf = 4}, the minimum number of samples required to split an internal node \texttt{min\_samples\_split = 5} and the number of trees in the forest \texttt{n\_estimators = 581}. The best model gets a \( R^2 \) regression score

\begin{align*}
\text{Figure 1.} & \quad \text{Spatial distribution (upper panel) and the histogram of the LAMOST} \ i\text{-band S/N (bottom panel) of the } 648,220 \text{ selected M dwarf stars.}
\end{align*}
RESULTS AND DISCUSSION

We have obtained reddening values for all the catalogued LAMOST M dwarfs. As most of the M dwarfs are located nearby, they usually suffer from relatively small dust reddening effects. The intrinsic colours \((G_{BP} - G_{RP})_0\) of the sources predicted by our Random Forest model could be larger than the observed values due to uncertainties of the observations and our method, which would lead to negative values. In the current work, we keep only the sources with resulted reddening \(E(G_{BP} - G_{RP})\) values larger than \(-0.25\) mag. This leads to a final sample of 641,426 stars. The catalogue of M dwarfs with resulting reddening values is available online via "http://paperdata.china-vo.org/diskec/lstmdwarfs/table1.fits". The data format of the catalogue is described in Table 1.

4.1 Converting \(E(G_{BP} - G_{RP})\) to \(E(B - V)\)

In addition to the \(E(G_{BP} - G_{RP})\) values, we also provide the mostly used \(E(B - V)\) reddening values for the individual stars in our catalogue. In the current work, we have adopted a reddening coefficient of \(R(G_{BP} - G_{RP}) = 1.33\) from Chen et al. (2019a) to convert the Planck \(E(B - V)\) to \(E(G_{BP} - G_{RP})\) for the stars in the training data set. The reddening coefficient \(R(G_{BP} - G_{RP})\) should vary for the individual stars, due to: 1) the variation of the extinction curves in different environments (Jones et al. 2011; Schlafly et al. 2016), 2) the wide wavelength ranges of the Gaia \(G_{BP}\) and \(G_{RP}\) bands, and 3) the variation of the stellar spectral energy distributions (SEDs). Stars in the training sample are all located in very low extinction regions, with line-of-sight reddening \(E(B - V)\) < 0.02 mag. The variation of the reddening coefficient \(R(G_{BP} - G_{RP})\) would not affect our results. However, to convert \(E(G_{BP} - G_{RP})\) to \(E(B - V)\) for all our catalogued stars accurately, we should consider the variation of the \(R(G_{BP} - G_{RP})\).
We adopt the following criteria: from the Planck Collaboration et al. (2014) dust map are reliable. We choose stars that are out of the Galactic dust disk and we assume their distances to the Galactic plane ($R_0$) and Galactic latitude ($|b|$) > 15°. Distance to the Galactic plane ($|Z|$) > 300 pc, (v) matching distances between the LAMOST and Gaia positions $< 1"$. This leads to a sample of 62,905 stars. We note that stars with very red colours ($(G_{BP} - G_{RP}) > 2.5$ mag) are not included in this selected sample, since they are too faint to be observed at $|Z| > 300$ pc. The reddening coefficients $R(G_{BP} - G_{RP})$ of the selected stars are calculated by $R(G_{BP} - G_{RP}) = E(G_{BP} - G_{RP})/E(B - V)$, where $E(G_{BP} - G_{RP})$ are calculated in the current work and $E(B - V)$ are adopted from the Planck Collaboration et al. (2014) dust map. The selected stars are divided into 10 × 10 pixels in the $(G_{BP} - G_{RP})_0$ and $E(B - V)$ space. We obtain the averaged $R(G_{BP} - G_{RP})$ value of each pixel and fit $R(G_{BP} - G_{RP})$ as a function of $(G_{BP} - G_{RP})_0$ and $E(B - V)$. As a result, we obtain,

$$R(G_{BP} - G_{RP}) = 1.148 - 0.014E(B - V) - 4.418E(B - V)^2 + 0.239(G_{BP} - G_{RP}) - 0.158(G_{BP} - G_{RP})_0^2 + 1.195E(B - V)(G_{BP} - G_{RP})_0.$$

In Fig. 3 we show the fitting results. Our derived correlations between $R(G_{BP} - G_{RP})$ and $(G_{BP} - G_{RP})_0, E(B - V)$ are very similar as those derived from Sun et al. (2022), see their Fig. 1), which increase our confidence that both relations are robust. We have converted our resulted $E(G_{BP} - G_{RP})$ values to $E(B - V)$ for all the stars. For stars with colours redder than 2.325 mag, we adopt the reddening coefficients calculated with the colour $(G_{BP} - G_{RP})_0 = 2.325$ mag. The derived $E(B - V)$ values are also listed in our catalogue.

### 4.2 Reddening uncertainties

For the uncertainties of our derived reddening $E(G_{BP} - G_{RP})$, we first consider the random errors, which are estimated from the dispersions of reddening differences (divided by $\sqrt{2}$) yielded by duplicate observations. We have found 96,118 unique stars in our catalogue that have more than one spectra. We select stars with duplicate spectra that have similar $i$-band S/N and compare their resulted reddening values. Fig. 4 shows the difference dispersions divided by $\sqrt{2}$, i.e. the random errors, as a function of the $i$-band S/N of the LAMOST spectra and the photometric errors of the Gaia $(G_{BP} - G_{RP})$ colours $\sigma(G_{BP} - G_{RP})$ computed by adding the photometric errors in quadrature. For stars of LAMOST S/N of 10, the random errors are about 0.10 mag. The random errors decrease to ~0.03 mag for stars with S/N of about 50 and becomes better than ~0.02 mag at S/N values larger than 100. We fit the random errors as a function of the S/N and $\sigma(G_{BP} - G_{RP})$ values. As a result, we obtain,

$$\sigma(E(G_{BP} - G_{RP})) = 0.003 + 0.357\sigma(G_{BP} - G_{RP}) - 3.882\sigma(G_{BP} - G_{RP})^2 + \frac{0.602}{S/N^{0.854}},$$

![Table 1. Description of the M dwarfs reddening catalogue.](image)

| Column | Name | Description |
|--------|------|-------------|
| 1 spec_id | Unique spectral ID of LAMOST sources, in format of 'date-plateid-spectrographid-fibreid' |
| 2 sourceid | Gaia EDR3 sourceid |
| 3 ra | Right ascension ($^\circ$) |
| 4 dec | Declination ($^\circ$) |
| 5 snr | LAMOST S/N in $i$-band |
| 6 bp | Gaia EDR3 $G_{BP}$ magnitude |
| 7 bp_err | Gaia EDR3 $G_{BP}$ magnitude uncertainty |
| 8 rp | Gaia EDR3 $G_{RP}$ magnitude |
| 9 rp_err | Gaia EDR3 $G_{RP}$ magnitude uncertainty |
| 10 ebpp | Reddening $E(G_{BP} - G_{RP})$ values resulted in the current work |
| 11 ebpp_err | Error of $E(G_{BP} - G_{RP})$ |
| 12 ebv | Reddening $E(B - V)$ values, converted from $E(G_{BP} - G_{RP})$ |

![Figure 4. Random uncertainties of reddening $\sigma(E(G_{BP} - G_{RP}))$, estimated by comparing results of duplicate observations of similar S/N values, as a function of the S/N and $\sigma(G_{BP} - G_{RP})$ values. The dots and curves are respectively the measured and fitted values. Different colours denote different $\sigma(G_{BP} - G_{RP})$ bins, which are labeled in the diagram.](image)
which are used to calculate the random errors of the individual stars in our catalogue. For stars of S/N better than 200, their random errors are assigned to be values of those at S/N = 200. The typical random error of our catalogued stars is about 0.03 mag in $E(B - V)$. In addition to the random errors described above, the uncertainties of our derived reddening values also contain systematic errors which arise from the fact that our training data set are not from perfectly extinction-free lines of sight. Our training sample stars were chosen from regions of integrated reddening of up to 0.02 mag in $E(B - V)$. The median line-of-sight reddening of our training sample stars is $E(B - V) = 0.016$ mag. Since most of the training sample stars are located at high Galactic latitudes ($b > 15^\circ$) and large distances to the Galactic plane ($|Z| > 300$ pc), the deviation between their actual reddening values and those from the Planck Collaboration et al. (2014) dust map should be negligible. Because of this, we have ignored the systematical uncertainties in the current work and adopted only the random errors as the final reddening uncertainties. An alternative method is to obtain the intrinsic reddening values of the training sample star from a synthetic spectral library. However, it would result in additional errors from the uncertainties of the synthetic stellar models (Yuan et al. 2015).
with a negligible averaged di
tour catalogue and we have obtained 173,603 common stars. Our re-
small than 0.08 mag. The selected stars are cross-matched with
\[ \chi \]
smaller than 0.05 mag; 2) the goodness-of-fit (maximum-likelihood
stars from the Anders et al. catalogue by the following criteria: 1)
their catalogue, which yields 99,273 common stars. The
agreement of our results with those from
Anders et al. (2022) is good. The average difference is negligible and
the dispersion is 0.075 mag in \( E(G_{BP} - G_{RP}) \).

4.3 Comparison with previous work

The typical error of our resultant reddening values is estimated to be
\( \sim 0.03 \) mag. To verify the robustness of our reddening values,
we have compared our results with those from previous works. The
comparisons are shown in Fig. 5. Chen et al. (2014) obtained \( r \-
band extinction values for over 13 million stars in the Galactic an-
ticentre from the SED fits to the multi-band photometric measures-
tments of the Xuyi Schmidt Telescope Photometric Survey of the
Galactic Anticentre (XSTPS-GAC), the Two Micron All Sky Sur-
vey (2MASS) and Wide-Field Infrared Survey Explorer (WISE). We
cross-matched our catalogue with that from Chen et al. (2014) with a
radius of 3”, which yields 112,621 common stars. The Chen et al.
estinction values are converted to reddening values by the extinc-
tion coefficients from Yuan et al. (2013): \( E(B - V) = 0.43A_v \). Our
resulted reddening values are in good agreement with those from
Chen et al. (2014). The mean difference is 0.014 mag and the disper-
sion is 0.061 mag.

Based on Gaia parallaxes and stellar photometry from Pan-
STARRS 1 (PS1) and 2MASS, Green et al. (2019) obtained reddening
values of 799 million stars in the northern sky. To compare the
Green et al. results with our values, we have selected stars in the
Green et al. catalogue by the following criteria: 1) stars been de-
mained in all the eight PS1 and 2MASS passbands (\( g_{P1}, r_{P1}, i_{P1}, z_{P1},
\gamma_{P1}, J, H \) and \( K_S \)) and the photometric errors in all the eight bands
smaller than 0.05 mag; 2) the goodness-of-fit (maximum-likelihood
\( \chi^2/\text{passband} \) smaller than 5; and 3) the uncertainties of reddening
smaller than 0.08 mag. The selected stars are cross-matched with
our catalogue and we have obtained 173,603 common stars. Our re-
sults agree well with those selected from the Green et al. catalogue,
with a negligible averaged difference and a small dispersion of only
0.058 mag.

Anders et al. (2022) presented a catalogue of 362 million stars.
Their reddening values are derived from the photometric catalogues of
Gaia EDR3, PS1, SkyMapper, 2MASS, and WISE. We select stars from
the Anders et al. catalogue by the following criteria: 1)

\[ \frac{C_\lambda}{\sigma_\lambda} < 0.5; \text{ Rybizki et al. 2022} \]

\[ \text{and good } G_{BP} - G_{RP} \text{ photomet-
tries ([C_\lambda]/\sigma_\lambda < 0.5)} \]

\[ \text{where } C_\lambda \text{ and } \sigma_\lambda \text{ are respectively the bp rp excess corr value and a simple function of the Gaia } G \text{ m-
gitude defined in Riello et al. 2021} \]; 2) stars been detected in all
the Gaia \( GG_{BP}G_{RP} \), the 2MASS \( JHK_s \), the WISE \( W1W2 \) and the
PS1/SkyMapper \( griz \) bands; 3) stars with good fitting models (the
first number of the flag \( 'sh\_outflag' = 0 \) ) and small fitting errors (the
third number of \( 'sh\_outflag' = 0 \)). The selected stars are then cross-
matched with our catalogue, which yields 99,273 common stars.

4.4 The Hertzsprung–Russell diagram

Based on the stars for which we measured accurate reddening val-
ues, we have plotted the Hertzsprung–Russell diagram (HRD) of
the LAMOST M dwarfs (Fig. 6). We have selected 528,368 stars
in our catalogue that have Gaia EDR3 parallax errors smaller than
20 per cent. The distances of the selected stars \( d \) are calculated
from the Gaia EDR3 parallaxes \( \epsilon \) by a simple Bayesian algorithm
(Bailer-Jones et al. 2018; Chen et al. 2019b). We adopt a posterior
probability given by

\[ p(d|\epsilon) = d^2 \exp(-\frac{1}{2\sigma_\epsilon^2}(\epsilon - \epsilon_0 - \frac{1}{d}))p(d), \]

where \( \sigma_\epsilon \) is the Gaia parallaxes uncertainties, \( \epsilon_0 \) the global paral-
lax zero point and \( p(d) \) the space density distribution prior for the
M dwarfs. In the current work, we adopt \( \epsilon_0 = -0.026 \) mas from
Huang et al. (2021) and the Galactic disk model derived from the
late type stars \( (1.0 < r - i < 1.4 \text{mag}) \) by Jurić et al. (2008).

With the resultant distances, the Gaia \( G \)-band absolute magni-
tudes are then calculated by \( M_G = G - 5 \log d + 5 - A_G \). In the current
work, we adopted the \( G \)-band extinction coefficient from Chen et al.
(2019a) to obtain the \( G \)-band extinction, by \( A_G = 1.91E(B - V) \).
We show the dust-corrected colour and absolute magnitude diagram
for the selected 528,368 stars in Fig. 6. A PARSEC isochrone with the
Solar metallicity and age of 10 Gyr (Bressan et al. 2012) is over-
plotted in the diagram. The distribution of our catalogued stars is in
good agreement with the theoretic isochrone, which suggests the
robustness of our resulted reddening values. Most of our catalogued
stars have intrinsic colours \( (G_{BP} - G_{RP})_0 \) between 1.6 and 3.2 mag
and absolute magnitudes \( M_G \) between 7 and 12 mag. According to
the PARSEC isochrone, our catalogued stars have masses between
0.2 and 0.65 \( M_\odot \).

4.5 The reddening distribution

Finally, we plot the \( E(G_{BP} - G_{RP}) \) reddening maps in the Galactic
longitude \( l \) and latitude \( b \) coordinates and the Galactocentric coor-
dinates based on our catalogued M dwarfs. In Fig. 7, we show the
reddening map in the Galactic longitude \( l \) and latitude \( b \). We use the
HEALPix pixelization scheme (Görski et al. 2005) to bin the sample
stars into individual pixels. We adopt a resolution of 27 arcmin (with
HEALPix nside = 128) and average the reddening values of stars
in the individual pixels. Fig. 7 presents a nice local dust reddening
map, which show very similar features to the nearest distance slice
of Galactic three-dimensional (3D) dust maps, such as the Green
et al. (2019) 3D extinction map with distance \( 0 < d < 0.5 \text{kpc} \)
(their Fig. 1) and the Guo et al. (2021) map with \( 0 < d < 0.4 \text{kpc} \)
(their Fig. 14). The famous nearby giant molecular clouds, such as
the Orion (l, b ~ -160°, -15°), the Taurus (l, b ~ 170°, -15°), the Perseus (l, b ~ 155°, -20°), the Aries (l, b ~ 160°, -30°), the Eridanus (l, b ~ 190°, -35°), the Aquila Rift (l, b ~ 30°, 10°) and the Pegasus (l, b ~ 90°, -35°), are clearly visible in the map.

We have also created averaged $E(B - V) - G_{BP}$ maps in the Galactic cylindrical coordinates based on the 528,368 stars with Gaia EDR3 parallaxes errors smaller than 20 per cent. The maps are presented in Fig. 8. In the left panel of Fig. 8, we show the distribution of reddening $E(B - V) - G_{BP}$ values in the Galactic $X$-$Y$ plane for stars with distances to the Galactic plane within 50 pc. The most significant feature in the Figure is the Local Bubble, which are marked by the $E(B - V) - G_{BP} = 0.15$ mag contour lines. The shape of the Local Bubble is in good agreement with those derived from the previous 3D extinction maps (e.g. Fig. 12 from Chen et al. 2019a and Fig. 4 from Lalllement et al. 2022). In the right panel of Fig. 8 we show the averaged reddening $E(G_{BP} - G_{RP})$ maps in the Galactic coordinates $R$ and $Z$. The Figure displays a remarkable shape of the Galactic dust disc. Based on our catalogue M dwarfs with accurate reddening values, we will be able to investigate the large and small scales dust structure in the solar neighbourhood. More quantitative analysis will be presented in future works.

5 CONCLUSIONS

By combining the LAMOST DR8 M dwarf star catalogue and Gaia EDR3, we have presented a catalogue containing accurate reddening values $E(G_{BP} - G_{RP})$ of 641,426 M dwarfs, which are estimated by the Random Forest regression. With the benefit of the LAMOST spectral information and the Gaia accurate photometric observations of the M dwarfs, we are able to obtain reddening values of the individual stars with very high accuracy. The typical uncertainty of our resultant reddening values is only 0.03 mag in $E(G_{BP} - G_{RP})$. We have also derived the reddening coefficient $R(E_{BP} - G_{RP})$, as a function of the stellar intrinsic colour $(G_{BP} - G_{RP})$, and the reddening values $E(B - V)$. Values of $E(B - V)$, converted from $E(G_{BP} - G_{RP})$, are also listed in our catalogue. Our derived reddening values are in good agreement with those deduced from the previous works.

Our catalogue contains high precision reddening values of a large sample of stars in the solar neighbourhood. The catalogue, combined with the robust distances from the Gaia parallaxes, will be important basic data for us to study the fine structure and properties of the interstellar dust nearby.
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DATA AVAILABILITY

The data underlying this article is available online via “http://paperdata.china-vo.org/diskec/lstmdwarfs/table1.fits”.

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