Search for White Dwarfs Based on LAMOST DR8 Spectra (Postprint)

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Full Text

Preamble

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Searching for White Dwarfs Based on LAMOST DR8 Spectra

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Abstract

White dwarfs are the degenerate cores remaining at the terminal stage of evolution for low- and intermediate-mass stars, representing the evolutionary endpoint for the vast majority of stars in the universe. The observed properties of large white dwarf samples not only provide tests and constraints for stellar evolution theory but also enable investigations into the formation history and evolution of the Milky Way. By combining Gaia's high-precision photometry and annual parallax data, we searched for white dwarfs in the low-resolution spectroscopic data from LAMOST's eighth data release (DR8). Using template matching methods, we identified a total of 4,692 white dwarfs and 85 cataclysmic variables in LAMOST DR8, among which 2,876 objects had been previously confirmed as white dwarfs, while 1,854 objects represent newly discovered white dwarfs in LAMOST. Following visual confirmation, we performed detailed classifications of the white dwarf spectral types. Comparison shows that the completeness of our white dwarf sample reaches 80%, with classification accuracy achieving 99%. The final LAMOST white dwarf sample excellently reflects the distribution of different types of white dwarfs on the Gaia CMD diagram.

Keywords: white dwarfs; spectra; LAMOST

1.1 Introduction to White Dwarfs

White dwarfs are the degenerate stellar cores remaining at the end of evolution for low- and intermediate-mass stars. Stars with initial masses M $<$ 7.0 M eventually evolve into white dwarfs. Such stars, during the double-shell burning phase at the tip of the asymptotic giant branch (AGB) at the end of their evolution, eject most of their H-rich envelopes through stellar winds, leaving behind an electron-degenerate C-O core. For stars with initial masses 7.0 M $<$ M $<$ 11.0 M , depending on metallicity and mass-loss rates, different evolutionary products can result, including O-Ne white dwarfs, electron-capture supernovae, and Fe-core collapse supernovae [1].

Furthermore, white dwarfs may also be products of multiple star system evolution. Theoretically, white dwarfs with masses less than (0.3–0.45) M can only be explained as products of close binary star evolution [2], because the main-sequence lifetime of a single progenitor star for such low-mass white dwarfs would exceed the age of the universe. The formation mechanism for extremely low-mass white dwarfs (ELMWDs), defined as white dwarfs with masses less than (0.2–0.3) M [3, 4], is believed to be: after the common envelope or stable

Roche lobe mass transfer phase in a binary system, the evolving star loses its outer envelope, exposing the stellar core [5]. When the core is in a degenerate state and loses its envelope mass without triggering He fusion, an ELMWD is produced. ELMWDs have surface gravities similar to subdwarfs but typically lower effective temperatures (Teff < 20,000 K). Hot subdwarfs, by contrast, result from envelope loss after He ignition in the core, placing them on the zero-age horizontal branch (ZAHB). Additionally, it is estimated that 25%–30% of white dwarfs are produced through post-merger evolution.

White dwarfs have luminosities comparable to or even fainter than dwarf stars, but their higher temperatures make them bluer in color, locating them below and to the left of main-sequence stars on the Hertzsprung-Russell diagram. The luminosity range of white dwarfs spans more than seven orders of magnitude, with the faintest known white dwarfs having luminosities L < 10^-4.7 L , while white dwarfs that have just entered their cooling evolutionary tracks can reach luminosities of L < 10^{2-10}3 L . With nuclear fuel exhausted, white dwarfs radiate energy solely through heat stored in their non-degenerate ions and weak gravitational contraction, a process known as white dwarf cooling. The average mass of white dwarfs is approximately 0.6 M , with radii comparable to Earth's radius. Because electron degeneracy pressure is independent of temperature, white dwarfs maintain essentially constant radii during evolution. White dwarf cooling timescales are extremely long, with typical white dwarfs requiring approximately 10 Gyr to cool to 3,000 K [6]. Considering the nuclear burning history of white dwarf progenitors and the effects of gravitational settling, typical white dwarfs possess a C-O core surrounded by a thin He-rich shell, which in turn is enveloped by an H-rich shell. Although these shells are very thin, they are extremely opaque to radiation and control the outward transport of energy from white dwarfs, playing a crucial role in the cooling process. The precise masses and thicknesses of the H and He shells have become a hot research topic in this field.

The white dwarf cooling process constitutes not only a fundamental physical problem providing independent verification for dense plasma physics theory but also enables white dwarf cooling evolutionary tracks to serve as independent age and distance indicators for various stellar populations. Specifically, the theoretical luminosity function (LF) derived from differences in cooling degrees among white dwarfs of different masses, particularly its decline at the low-luminosity end, can serve as an independent indicator for constraining the ages and histories of various Milky Way populations (e.g., the Galactic disk, globular clusters, and open clusters). Using multi-color photometry and spectroscopy, one can precisely determine white dwarf effective temperatures and surface gravities, from which white dwarf masses can be obtained according to theoretical mass-radius relations. These fundamental parameters provide constraints and corrections for important issues in stellar evolution theory, such as mass-loss rates during the AGB stage, internal rotation profiles and angular momentum loss, and fundamental nuclear reaction rates. The white dwarf mass distribution can reflect the initial mass function and initial-final mass relation at different metallicities.

Moreover, the mass function can be used to study the role of binary evolution in the formation of some white dwarfs. Since over 97% of stars in the Milky Way are expected to eventually evolve into white dwarfs, the properties of the white dwarf population provide valuable information for studying the star formation history and evolution of the Milky Way. The white dwarf luminosity function can measure the death rate of local low- and intermediate-mass stars, allowing the inversion of star formation rates and star formation history (SFH) from the luminosity function, and has been used in existing studies to determine the age of the thin disk. Because white dwarf progenitors eject large amounts of C, N, and O elements during the AGB stage, white dwarfs play an important role in the chemical evolution of the Milky Way. Studying the properties of white dwarf populations requires large, well-defined white dwarf samples.

1.2 Classification of White Dwarfs

Based on the main atmospheric composition of their surface envelopes, white dwarfs are divided into two distinct primary categories. Approximately 80% of white dwarfs show only H Balmer lines, with surface atmospheres composed primarily of H, and are classified as DA-type white dwarfs. These white dwarfs have effective temperatures above 5,000 K. The remaining approximately 20% have surface atmospheric compositions dominated by He, lacking H elements in their atmospheres, and are classified as non-DA white dwarfs. Non-DA white dwarfs contain several subclasses: the hottest are called DO-type white dwarfs, with 4.5 × 10^4 K < Teff < 2 × 10^5 K, whose spectra show singly ionized He (He II) lines, while H Balmer lines and neutral He (He I) lines are also visible; the cooler ones are called DB-type white dwarfs, typically with 1.1 × 10^4 K < Teff < 3 × 10^4 K, whose spectra show only He I lines; DZ-type white dwarfs have spectra dominated by metal lines (Ca II K and Ca II H lines), with effective temperatures usually below 1.1 × 10^4 K; DQ-type white dwarfs show C2 Swan molecular bands or neutral C (C I) lines, also with effective temperatures typically below 1.1 × 10^4 K. Additionally, for a small number of ultra-cool H-atmosphere white dwarfs (Teff < 5,000 K) and ultra-cool He-atmosphere white dwarfs (Teff < 1.1 × 10^4 K), which display featureless smooth continua, they are classified as DC-type white dwarfs. Figure 1 [Figure 1: see original paper] shows typical spectra of different types of white dwarfs.

Observational evidence indicates that the spectral type of a single white dwarf may evolve with the cooling process, meaning the dominant element in the spectrum changes. This suggests that white dwarf surface atmospheric composition may be affected by convection, mass loss, accretion, radiative levitation, and gravitational settling. As cooling proceeds, DO-type white dwarf spectra transition from being dominated by He II lines to He I lines, transforming from DO to DB type. However, only a small number of H-deficient white dwarfs have been observed in the transition temperature range (3 × 10^4 < Teff < 4.5 × 10^4 K) between DO and DB types, a phenomenon known as the DB gap. This interval contains some mixed-atmosphere white dwarfs, “hot DQ” white dwarfs

dominated by C II lines, and a few O-rich atmosphere white dwarfs (DS type). The known ratio of DA to non-DA white dwarfs is a function of effective temperature [6], suggesting that convection or gravitational settling may cause small amounts of H originally present in the atmospheres of some hot H-deficient white dwarfs (PG 1159 stars or DO types) to gradually reach the surface and float atop the He envelope, forming an H-rich atmosphere [7, 8]. At the lower edge of the DB gap, the development of larger mass convective He envelopes may dilute the thin H radiative layer, transforming the H-dominated atmosphere back to He-dominated. Over half of DB-type white dwarfs are DBA types showing weak H lines, indicating that DA white dwarfs with thin H envelopes may begin transitioning to DB types due to convection at lower temperatures.

Approximately 3% of white dwarfs show metal pollution (primarily Ca II K and Ca II H lines), which can only be explained by accretion of interstellar or circumstellar material (such as asteroids) onto cool white dwarfs [9]. Except for very hot objects (Teff $> 5 \times 10$^4 K), radiative levitation remains important for the appearance of metal lines [10]. In rare cases, the convective zone beneath the He envelope is deep enough to dredge C to the surface, causing these white dwarfs to show C2 molecular bands or C atomic lines, forming DQ-type white dwarfs. Even rarer are white dwarfs with O-rich atmospheres containing small amounts of Ne and Mg, showing O lines without H or He lines, classified as DS-type white dwarfs.

1.3 Observation and Search for White Dwarfs

In early times, due to the lack of large-aperture, high-precision survey telescopes, the number of observed and confirmed white dwarfs was very limited. White dwarf search efforts included observing blue faint stars in proper motion catalogs and searching for ultraviolet-excess objects. McCook and Sion [11] published the first spectroscopically confirmed white dwarf catalog in 1977. Due to equipment and technological limitations at the time, discovered white dwarfs were biased toward hot stars, fast-moving stars, and stars with larger radii and smaller masses [12].

Over the past two decades, thanks to large-area, high-precision survey projects such as SDSS (Sloan Digital Sky Survey), GALEX (Galaxy Evolution Explorer), Gaia (Global astrometric interferometer for astrophysics), and LAMOST (Large Sky Area Multi-Object Fiber Spectroscopy Telescope), efficient searches for large samples of white dwarfs have become possible.

The largest spectroscopically confirmed white dwarf catalog to date comes from SDSS. The SDSS project uses a 2.5 m telescope located at Apache Observatory in New Mexico, USA, aiming to obtain photometric and spectroscopic data for vast numbers of celestial objects to deepen understanding of galaxy formation and evolution, large-scale cosmic structure, and other fields. SDSS spectroscopy employs different spectrographs: the SDSS-I/II spectrograph covers 3,800–9,200 Å with resolution 1,850–2,200; the BOSS spectrograph covers 3,650–10,400 Å

with resolution 1,500 at 3,800 Å and 2,200 at 9,000 Å. The latest SDSS white dwarf catalog was established by Kepler et al. [13]. Based on SDSS DR14 data, they performed initial screening of white dwarf candidates using color ranges selected by Eisenstein et al. [14], proper motions greater than 20 mas yr^-1 at 3σ, and hot stars classified by the SDSS Pipeline software. They then examined all candidate spectra to confirm line features, ultimately obtaining a master catalog of 37,053 sources, including 20,088 white dwarfs. In addition to white dwarfs, the catalog contains hot subdwarfs (sdOs, sdOBs, sdBs), cataclysmic variables (CVs), narrow hydrogen-line objects (sdAs), and carbon stars (dCs). Based on SDSS DR16, they reported 2,410 newly identified objects containing white dwarfs and spectral classifications [15]. Kepler et al. [13, 15] used Koester's [16] atmospheric models to fit all white dwarfs and hot subdwarfs with S/N > 10 in their catalog, measured Teff and log g values, and finally estimated masses for DA, DB, DC, and DZ white dwarfs.

LAMOST surveys have become another important source for white dwarf searches due to their advantage in efficiently obtaining massive spectroscopic data. Several white dwarf search works based on LAMOST low-resolution spectroscopic data have been published. Zhang et al. [17] discovered 230 DA white dwarfs from the pilot survey by fitting S´ersic profiles to Balmer lines combined with visual confirmation. Using LAMOST Pipeline spectral types, fitting S´ersic profiles to Balmer lines, performing color-color cuts, and final visual confirmation, Guo et al. [18] discovered 1,056 DA, 34 DB, and 276 white dwarf-main-sequence binaries in DR2. Kong et al. [19] identified 287 DB white dwarfs in DR5 using machine learning methods of LASSO and Support Vector Machine (SVM). The same method is being applied to subsequent LAMOST data releases. Additionally, searches for white dwarf-main-sequence binaries in LAMOST have continued. Ren et al. [21] developed an algorithm based on wavelet transforms that can detect Balmer lines at the blue end and molecular absorption bands at the red end, identifying 876 white dwarf-main-sequence binaries in DR5. With the continuous release of LAMOST spectroscopic data, white dwarf searches and identifications require further development.

2 Data Sources

We used low-resolution spectroscopic data from LAMOST's pilot survey and the first eight years of formal surveys, combined with Gaia EDR3 astrometric and photometric data, to search for white dwarfs in the LAMOST spectral database and expand the LAMOST white dwarf sample.

2.1 Gaia Data

Gaia is the European Space Agency's follow-up mission to HIPPARCOS, designed to precisely measure the three-dimensional spatial and velocity distributions of over one billion stars and determine their astrophysical properties, such as surface gravity and effective temperature, to create precise three-dimensional

maps of stars in the Milky Way and understand the structure, formation, and evolution of our Galaxy.

Gaia's imaging relies on two telescopes with apertures of 1.45 m × 0.5 m, equipped with three terminal instruments: an astrometric instrument, a photometer, and a radial velocity spectrometer, for measuring stellar positions, proper motions, parallaxes, brightness, and spectra. Its parallax measurement precision reaches microarcsecond levels for the first time, with a G-band limiting magnitude of 20 mag. The Gaia satellite was launched in December 2013 and operates at the Sun-Earth Lagrange L2 point. After half a year of commissioning and performance verification, formal scientific operations began in summer 2014. The first data release (DR1) and second data release (DR2) were made in 2016 and 2018, respectively. This work uses the third early data release, EDR3, published in 2020. It is part of the complete DR3 dataset, based on 34 months of data collected between July 25, 2014 and May 28, 2017, covering over 1.8 billion targets. EDR3 includes updated source lists, right ascension, declination, parallax, proper motions, G, GBp, GRp broadband photometric magnitudes, and an updated radial velocity list from DR2. Among these, 882 million sources have six astrometric parameters (right ascension, declination, parallax, proper motion in right ascension, proper motion in declination, and pseudo-color), 585 million sources have five astrometric parameters (without pseudo-color), and 344 million sources have only mean positions (mostly faint objects).

Compared with DR2, EDR3's parallax measurement precision has improved by an average of 20%–30%, and proper motion measurement precision has doubled. Additionally, photometric measurements are more uniform not only in sky distribution but also in target magnitude and color distributions. The catalog also includes new diagnostic parameters to facilitate more reliable quality cuts.

2.2 LAMOST Data

The "Large Sky Area Multi-Object Fiber Spectroscopy Telescope" (LAMOST), also known as the Guo Shoujing Telescope, is a meridian-reflection Schmidt telescope with an effective aperture of 3.6–4.9 m, located at the Xinglong Observatory of the National Astronomical Observatories, Chinese Academy of Sciences, in Xinglong County, Chengde City, Hebei Province. The main body consists of a reflective Schmidt corrector mirror Ma in the north, a spherical primary mirror Mb in the south, and a focal plane in between. During observations, the spherical primary mirror and focal plane remain fixed on the ground, while the corrector mirror tracks targets as they pass near the meridian. Because the corrector mirror innovatively employs active optics technology, overcoming the technical bottleneck that large aperture and wide field of view cannot be simultaneously achieved, it is currently the largest wide-field survey telescope in operation. The focal plane has a diameter of 1.75 m and uses parallel controllable fiber positioning technology to simultaneously control the real-time positions of 4,000 fibers. These technologies enable LAMOST to have a large field of view of 20 square degrees, capable of simultaneously obtaining spectra for 4,000 targets

in both red and blue bands in a single exposure, making it the telescope with the highest spectral acquisition rate in the world. LAMOST's low-resolution survey has 16 spectrographs, each connected to 250 fibers and 2 CCD cameras. The red wavelength coverage is 5,700–9,000 Å, the blue wavelength coverage is 3,700–5,900 Å, with a resolution of approximately 1,800. The average exposure time per target is 1.5 hours, reaching a limiting magnitude of 17.8 mag. The two-dimensional spectral images produced after the spectrographs disperse starlight through gratings undergo extraction, flat-fielding, calibration, sky subtraction, and red-blue data merging through the LAMOST 2D Pipeline software to obtain one-dimensional spectra. After processing through the LAMOST 1D Pipeline software for template matching, analysis, spectral classification, redshift measurement, parameter measurement, and packaging, catalog data products are produced. The main scientific objectives of LAMOST's low-resolution spectral survey include the structure and evolution of the Milky Way, stellar population census, searches for special objects (Li-rich giants, metal-poor stars, hypervelocity stars, white dwarfs, etc.), exoplanet searches, star formation, formation and evolution of nearby galaxies, and quasar searches.

3 Data Processing

We cross-matched LAMOST DR7 and low-resolution spectroscopic data from the eighth year of formal surveys with the Gaia EDR3 catalog. LAMOST uses fibers with a diameter of 3 , and fiber pointing errors average no more than 1.5 . Considering these factors, we adopted a cross-matching radius of 3 . This yielded 10.45 million LAMOST spectra with Gaia photometric data, for which the absolute magnitudes of the targets can be obtained from:

$$G_{\mathrm{abs}} = g_{\mathrm{mm}} - 5\log_{10}\left(\frac{1}{p}\right) + 5$$

where G_{abs} is the absolute magnitude in Gaia's g band, g_{mm} is the mean photometric magnitude in Gaia's g band, and p is Gaia's annual parallax in units of milliarcseconds.

After retrieving GBp–GRp colors for all LAMOST spectra, we plotted their distribution in the Gaia CMD diagram, as shown in Figure 2 [Figure 2: see original paper]. To determine the distribution of white dwarfs and contaminating objects in the CMD, we cross-matched the catalog of white dwarfs and contaminants identified from SDSS DR14 by Kepler et al. [13] with the Gaia EDR3 catalog. After obtaining Gaia photometric data for SDSS objects, we plotted them together with all LAMOST objects in the same CMD diagram, as shown in Figure 3 [Figure 3: see original paper]. In Figure 3, the large region where LAMOST objects (gray points) are concentrated corresponds to the edge of the main-sequence region, while white dwarfs (blue points) are mainly concentrated in the region separated from the main sequence at 6.5 < G_{abs} < 15 mag and –0.6 < GBp–GRp < 1.5 mag. As seen in Figure 3, the white dwarf-dominated

region partially overlaps with other contaminating objects such as hot subdwarfs, post-AGB stars, and sdA stars, so selecting white dwarfs based on the Gaia CMD inevitably introduces additional objects. To make our selection more efficient—that is, to select white dwarfs in LAMOST as completely as possible while excluding large numbers of main-sequence stars—we defined a set of cuts along the edge of the main sequence in the diagram:

$$
\begin{aligned}
G_{\rm abs} &> -1.387 \\
5G_{\rm abs} &> 7.5 \times ((GBp - GRp) + 0.1)^3 + 20 \times ((GBp - GRp) + 0.1)^2 + 20.8 \times ((GBp - GRp) + 0.1) + 0. \\
GBp - GRp &< 4.5 \\
G_{\rm abs} &> 1.6 \times (GBp - GRp) + 7.607
\end{aligned}
$$

The selected white dwarf candidates, shown as black points in Figure 2, contain 14,851 spectra. For white dwarf identification, we used template matching supplemented by visual inspection. We selected known white dwarf spectra of various types (including DA, DB, DO, DC, DZ, DQ, DS, DA+M, CV) with S/N $>$ 50 from SDSS DR14 and degraded their resolution to that of LAMOST spectra to serve as templates. For white dwarf candidates with S/N $>$ 10, we matched their spectra with template spectra in wavelength ranges where white dwarf spectral features are concentrated (mainly in the blue end). Finally, we performed visual confirmation and classification for spectra matched as white dwarfs. For candidates with S/N $<$ 10, we conducted direct visual inspection; if the spectrum showed white dwarf characteristics within visual inspection range, it was classified as a high-confidence white dwarf candidate.

Before visual confirmation, we performed one-to-one correspondence between SDSS DR14 white dwarf spectra and homologous spectra in LAMOST DR8, visually learning the characteristics of different white dwarf types in both SDSS and LAMOST.

Observationally, white dwarf classification is based on characteristic spectral lines. The characteristic lines of different white dwarf types reflect physical parameters including surface atmospheric structure and chemical composition, effective temperature, surface gravity, and magnetic field strength. After becoming familiar with various white dwarf spectra, we adopted the following criteria for visual confirmation and classification of all white dwarf candidates in LAMOST DR8: (1) H I Balmer lines are typically broad with strong Balmer decrement (DA, DAB, DBA, DZA, and subdwarfs); (2) He I line at 4,471 Å (DB, subdwarfs); (3) He II line at 4,686 Å (DO, PG 1159, sdO); (4) C2 Swan bands or atomic C I lines (DQ); (5) Ca II H&K lines (DZ, DAZ, DBZ); (6) C II line at 4,367 Å (hot DQ); (7) Zeeman splitting (magnetic white dwarfs, marked with H); (8) Featureless spectra with significant proper motion (DC); (9) Increased flux at the red end (binaries, likely M dwarfs); (10) O I lines at 6,158 Å, 7,774 Å, 8,448 Å (DS, O-dominated); (11) H and He emission lines (cataclysmic variables or M dwarfs).

Additionally, some extra markers were added to the above main white dwarf types to assist or refine classification: (1) E: presence of emission lines; (2) ?: indicates uncertain classification, also denoted by colon (:); (3) X: peculiar or unclassifiable spectra; (4) V: optional symbol indicating variable stars; (5) d: presence of circumstellar dust.

White dwarf spectra are generally simpler than those of other stellar types, containing only a few elemental lines specific to the white dwarf type (H, He, Ca, C, O), reflecting the simple atmospheric composition with at most a few mixed spectral features. Our classification principle was: if characteristic lines of any white dwarf type dominate the spectrum, that type is assigned as the primary type; if other type features appear but are weaker than the primary lines relative to the spectrum, the corresponding type marker is added after the primary type as a subtype.

4 Results and Discussion

After template matching and visual confirmation of all spectra, we discovered 4,777 independent targets corresponding to 6,032 spectra in LAMOST DR8 data, of which 4,692 targets are white dwarfs and the remaining 85 targets are cataclysmic variable systems. Comparing with previously published LAMOST white dwarf catalogs, 2,876 objects in our catalog had been previously identified as white dwarfs, while 1,854 objects are newly identified as white dwarfs in LAMOST.

After visually inspecting all 14,851 spectra, the final classification results are shown in Table 1 . During classification, we marked all visually identifiable spectral features and added weaker features as subtypes following the primary white dwarf type. The classifications in the table represent the sum of all targets with the same primary type.

Table 1: White dwarf identification and classification results for 14,851 candidate spectra in LAMOST DR8

Type	Number
DA	3,805
DA+dC	257
PG1159	3
DB+M	8

Comparing the white dwarf catalog identified in LAMOST DR8 with the SDSS DR14 white dwarf catalog, we found that DC-type white dwarfs constitute up to 9% of all white dwarfs in SDSS, while in our LAMOST DR8 data, DC-type white dwarfs account for only 2%. We analyze that this may be because DC-type white dwarfs have lower luminosities, and LAMOST's limiting magnitude is fainter than SDSS, so LAMOST can only observe a very small number of

nearby cool white dwarfs. Moreover, most DC-type white dwarfs in SDSS DR14 have signal-to-noise ratios below 10, and such distant cool white dwarfs have extremely low spectral signal-to-noise ratios in LAMOST, preventing us from resolving spectral profiles, so we cannot confirm those cool white dwarfs with signal-to-noise ratios below 10.

Plotting the white dwarfs identified in LAMOST DR8 together with recently released SDSS DR16 white dwarfs on the Gaia CMD diagram allows us to study the distribution of different white dwarf types, as shown in Figure 4 [Figure 4: see original paper]. Panel (a) shows the distribution of white dwarfs identified using LAMOST DR8 data on the Gaia CMD diagram; panel (b) shows the distribution of SDSS DR16 white dwarfs on the Gaia CMD diagram.

As shown in Figure 4, DA-type white dwarfs, represented by black dots, have the widest distribution range, while other types of white dwarfs show clustered distributions only in specific regions. DO-type white dwarfs are distributed in the upper-left part of the dense white dwarf region, i.e., the starting point of the white dwarf cooling sequence, while DB-type white dwarfs are distributed in regions with redder colors and larger absolute magnitude values. There exists a discontinuous distribution region of H-deficient white dwarfs between DO and DB types, known as the DB gap. The distributions of DQ, DZ, and DC-type white dwarfs overlap to some extent, but DQ white dwarfs show distinct additional "structures." For cool white dwarfs, our method can only identify objects in LAMOST data down to GBp–GRp = 0.9 mag, while SDSS can identify white dwarfs at the low-temperature end down to GBp–GRp 1.5 mag. It can be seen that the distribution of LAMOST DR8 white dwarfs identified by our method is basically consistent with that of SDSS white dwarfs. After cross-matching our white dwarf catalog with the SDSS DR16 white dwarf catalog, 20 out of 2,571 common targets showed inconsistent classifications for primary white dwarf type and white dwarf-main-sequence binary classification, giving a classification accuracy of 99% for this catalog. Table 2 presents partial data from the LAMOST DR8 white dwarf catalog.

To determine the completeness of this white dwarf sample, we cross-matched it with the Gaia EDR3 white dwarf catalog [22] containing 359,073 high-confidence white dwarf candidates (P_{WD} > 0.75), retrieving our identified white dwarfs among the common sources. The resulting completeness of the white dwarf sample is 80%.

The white dwarf catalog data from this paper (DOI: 10.57760/sciencedb.08123) can be accessed and obtained from the Chinese Academy of Sciences Science Data Bank (https://www.scidb.cn/s/3MFFzy) for open use by astronomers.

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Note: Figure translations are in progress. See original paper for figures.