Discovery of Nine Super Li-rich Un-evolved Stars from the LAMOST Survey

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Received 2022 January 27; revised 2022 March 31; accepted 2022 April 1; published 2022 April 12

Abstract

Based on the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) medium-resolution spectroscopic survey (MRS), we report the discovery of nine super Li-rich un-evolved stars with A(Li) > 3.8 dex. These objects show unusually high levels of lithium abundances, up to three times higher than the meteoritic value of 3.3 dex, which indicates that they must have experienced a history of lithium enrichment. It is found that seven of our program stars are fast rotators with \( \sin i > 9 \text{ km s}^{-1} \), which suggests that the accretion of circumstellar matter may be the main contributor to the lithium enhancement of these un-evolved stars; however, other sources cannot be excluded.

Unified Astronomy Thesaurus concepts: Chemically peculiar stars (226); Lithium stars (927); Circumstellar matter (241); Stellar rotation (1629)

1. Introduction

Lithium (Li) is one of the key chemical elements that link cosmology to the structure and evolution of stars, and its complex evolution history remains a mystery (Delgado Mena et al. 2015; Guiglion et al. 2016; Grisoni et al. 2019; Randich et al. 2020; Matteucci 2021). Information about its evolution is of great benefit to the study of many key questions in astrophysics, such as the early universe, the formation and evolution of the Milky Way, the chemical enrichment of stellar populations, and the structure and internal processes of stars (Randich & Magrini 2021).

Li is the only element that can be produced at three extremely different astrophysical sites (Charbonnel et al. 2021). In addition to the Big Bang nucleosynthesis, the other two sites are the spallation processes of the Galactic cosmic-ray particles on interstellar matter nuclei (Prantzos 2012; Olive & Schramm 1992) and the nucleosynthesis at specific phases of the stellar evolution. Stars that have evolved to a specific stage to contribute Li include core-collapse supernovae (SNe; Woosley et al. 1990; Kusakabe et al. 2019), novae (Hernanz et al. 1996; José 2002; Tajitsu et al. 2015), red giant branch (RGB) stars (Sackmann & Boothroyd 1999), asymptotic giant branch (AGB) stars (Noll et al. 2003; Sackmann & Boothroyd 1992), and active stars (Kelly et al. 2020). The primordial Li abundance predicted by the baryon-to-photon ratio from the Planck satellite (Pitrou et al. 2018) is \( A(\text{Li})^9 \approx 2.7 \text{ dex} \), which is based on the standard Big Bang nucleosynthesis model.

It is found that there are some un-evolved stars with abnormally high Li abundance, a few of which even largely exceeds the meteoritic value of \( A(\text{Li}) = 3.3 \text{ dex} \). Deliyannis et al. (2002) discovered, for the first time, a dwarf (J37) with \( A(\text{Li}) = 4.29 \text{ dex} \) in NGC 6633 (also see Laws & Gonzalez 2003; Ashwell et al. 2005), and Koch et al. (2011) found the turnoff star J1741–5343 with \( A(\text{Li}) = 4.21 \text{ dex} \) in the old metal-poor globular cluster NGC 6397 (also see, Koch et al. 2012). Recently, Li et al. (2018) reported the discovery of two very metal-poor subgiants \( \langle \text{Fe/H} \rangle < -1.8 \text{ dex} \) with \( A(\text{Li}) = 4.55 \text{ dex} \) (J0741+2132) and 3.45 dex (J0758+4703), respectively.

The stars with unusually high Li abundance suggest that they should experience Li enrichment. However, the current models on the Li enhancement mechanism remain controversial, and none of them can explain well those stars. In the case of J37, Deliyannis et al. (2002) suggested that the action of diffusion is responsible for the enhancement of Li, while Ashwell et al. (2005) and Laws & Gonzalez (2003) proposed that the accretion of circumstellar matter is the best explanation for its abundance anomaly. For J1741–5343, the high Li abundance can be explained by the interaction with an RGB companion (Koch et al. 2011, 2012).

At the moment, only a few super Li-rich un-evolved stars have been found; therefore, more such stars are needed to investigate the mechanism of Li enhancement, especially from a large spectroscopic survey as pointed out by Koch et al. (2012). The Large Sky Area Multi-Object Fiber Spectroscopic Telescope survey (LAMOST, Cui et al. 2012; Deng et al. 2012; Zhao et al. 2012; Yan et al. 2022) can play an important role in this area due to its unparalleled ability in gathering spectra. In
this letter, we report nine unevolved stars from the LAMOST medium-resolution spectroscopic survey (MRS). In Section 2, we describe the selection of super Li-rich candidates. The determination of the Li abundances and the rotation velocities is presented in Section 3. The mechanisms of Li enrichment are discussed in Section 4, while the conclusions are given in Section 5.

2. Selection of the Super Li-rich Candidates

The LAMOST spectroscopic survey has provided us with massive medium-resolution spectra, which are collected by the innovative active reflecting Schmidt telescope located in Xinglong Observatory, China (Cui et al. 2012). The optical system has an effective aperture of 3.6 m–4.9 m with a wide field of view of ∼5°. The spectroscopic system contains 16 spectrographs with 32 integrated 4K × 4K CCD cameras, and a total of 4000 spectra can be obtained simultaneously via 4000 fibers. The LAMOST-MRS survey includes blue and red fields. The LAMOST-MRS survey includes blue and red fields. The LAMOST-LRS, a consistent result can be found for the four fields.

Combining the information of the stellar atmospheric parameters provided by the LAMOST data release 7 (DR7) (LRS, Luo et al. 2015) and the Li abundances derived from the LAMOST medium-resolution spectra by Gao et al. (2021), we pick out nine unevolved stars with very strong Li lines in their spectra as the super Li-rich candidates from 125,436 objects with surface gravity log g ≥ 3.5 dex.

3. Stellar Parameters and Li Abundances

3.1. Stellar Atmospheric Parameters

The stellar atmospheric parameters (effective temperature $T_{\text{eff}}$, log g, and metallicity [Fe/H]) used in this analysis are taken from the LAMOST-LRS (Luo et al. 2015), while the microturbulent velocities ($\xi$) are adopted based on a relation to the effective temperature (see Gao et al. 2021). All the information is presented in Table 1.

It is known that Li abundance is sensitive to $T_{\text{eff}}$ (Spite & Spite 1982); therefore, it is necessary to evaluate the reliability of $T_{\text{eff}}$. To verify this, we also estimate $T_{\text{eff}}$ from the color index ($V − K_\alpha$) using the temperature scales of Ramírez & Meléndez (2005) and Casagrande et al. (2010). The magnitudes of V and $K_\alpha$ are taken from UCAC4 (Zacharias et al. 2013) and 2MASS (Cutri et al. 2003), respectively, while the reddening corrections are obtained from the online 3D dust map10 provided by Green et al. (2019) using the geometric distances of Bailer-Jones et al. (2021). The effective temperatures derived from the color index are shown in Table 1.

Comparing to the effective temperatures derived from LAMOST-LRS, a consistent result can be found for the four fields. The other five stars, i.e., UCAC 440–009448, 441–011058, 451–011087, 569–010383, and 606–009417, show lower $T_{\text{eff}}$ estimated from the color index; especially for UCAC 460–009417, the difference is as large as 1,000 K. This star is identified as a young stellar object (YSO) and is located in the Perseus OB2 association (Azimul et al. 2015). In addition, UCAC 440–009448, 441–011058, and 451–011087 have been identified as YSOs, and all of them are in the Orion Star-forming Complex region (Nakano et al. 1999; Kounkel et al. 2018; Zari et al. 2018). UCAC 569–010383, according to its position and distance, is located in the Taurus– Auriga complex region (Krolikowski et al. 2021). As noted by Xiang et al. (2021), such stars should suffer larger reddening than those of the 3D “average” dust map of Green et al. (2019). For example, Kunder et al. (2017) noted that the effective temperature of UCAC 441–011058 derived from LAMOST-LRS is 300 K higher than that estimated by the infrared flux method. UCAC 606–009417 has an $E(V − K_\alpha)$ of 1.83 from Green et al. (2019), while Schlafly et al. (2014) and Schlegel et al. (1998) suggested that its reddening is $E(V − K_\alpha)$ < 2.62 and >2.91, respectively. Thus, we instead adopt the $T_{\text{eff}}$ from LAMOST-LRS.

To further demonstrate that the adopted $T_{\text{eff}}$ is reliable, we fit the Hα absorption lines for five objects (the remaining four stars are YSOs, two of which show Hα emission lines, and the other two show weak Hα absorption lines; Table 2). As an example, in Figure 1, we show the fitting result for UCAC 677–057614, and it can be seen that the observed Hα line wing can be well fitted.

We also calculate the log g based on the parallax from Gaia EDR3 (Gaia Collaboration et al. 2021) and present them in Table 1 (log g$_{\text{phot}}$). The discrepancy between the log g obtained from LAMOST-LRS and those from the parallax is less than 0.5 dex, which has no obvious impact on the derived Li abundances.

3.2. Li Abundances

The Li abundances of all our program stars are derived with the spectrum synthesis method; we adopt the MAFAGS-OS model atmospheres (Grupp 2004; Grupp et al. 2009) and the atomic line data near the Li resonance line at 6708 Å from Carlberg et al. (2012) to calculate the theoretical profiles with an interactive IDL code, Spectrum Investigation Utility (SIU;
Reetz 1991). For the NLTE calculation, we adopt the Li atomic model from Shi et al. (2007).

It is noted that the non-local thermodynamic equilibrium (NLTE) effects of the Li resonance line cannot be ignored for Li-rich stars, and it can be larger than 0.2 dex (Li et al. 2018; Yan et al. 2018). Recently, Wang et al. (2021) noted that the 3D-NLTE corrections of the Li resonance line can be up to \( \sim 0.15 \) dex more negative with respect to previous estimates. Both LTE and NLTE Li abundances are derived with the predicted ionization equilibrium of the Li resonance line. We note that the NLTE effects are very large for our program stars, with the largest one reaching \( \sim 0.5 \) dex.

The uncertainties of Li abundances are mostly due to the errors in the temperature; thus, we estimate this effect by increasing \( T_{\text{eff}} \) by 200 K (two times the typical uncertainties; Luo et al. 2015) and show them in Table 2. The equivalent widths (EWs) of Li resonance lines are also shown in Table 2. For each object, we derive EW by the theoretical line profile synthesized from its Li abundance.

3.3. Projected Rotation Velocities

Projected rotation velocity (\( v \sin i \)) is an important indicator for diagnosing the mechanism of Li enrichment. We take the FWHM of the arc lamp line near 6708 Å as the width of the instrumental profile, and the macro-turbulence velocity is derived from the empirical relation to \( T_{\text{eff}} \) from Gray (1984). The derived \( v \sin i \) are presented in Table 2.

3.4. TESS Light Curves

We extract the light curves of nine program stars from the Transiting Exoplanet Survey Satellite (TESS; Ricker et al. 2014) full-frame images (FFIs). We cross-match our program stars with the TESS Input Catalog (TIC) and download the time series FFIs of \( 15 \times 15 \) pixels around each target using the TESSCut service11 on the MAST archive. We perform simple aperture photometry with either \( 3 \times 3 \) or \( 5 \times 5 \) pixels (depending on the \( T \) magnitude) centered on each target and subtract the background light determined from the pixels outside a certain radius for any known sources in the field. We find that all the nine stars are covered by at least one sector in TESS, and four of them show obvious periodic or semiregular brightness changes. The sector-by-sector light curves are plotted in Figure 1, and the periods range from 1.6 to 4.0 days with amplitudes between 5% and 10%. The flux variations are most likely caused by the rotational modulation of stellar spots for three of them. Therefore, we derive their rotational periods \( (P_{\text{rot}}) \) by finding the peaks on the generalized Lomb–Scargle periodogram (Zechmeister & Kürster 2009) of the light curves. The results are shown in Table 2. We further derive the rotational speed \( (v_{\text{rot}}) \) using the relation of \( v_{\text{rot}} = 50.58(R_*/R_\odot)/P_{\text{rot}} \), where \( R_\odot \) is the stellar radius, \( P_{\text{rot}} \) is the rotational period in units of days, and \( v_{\text{rot}} \) is in units of km s\(^{-1}\). Considering the upper limit of projected rotational velocities \( v \sin i \) derived from LAMOST-MRS, we find all the values of \( v \sin i \) are smaller or agree well with the \( v_{\text{rot}} \) from light curves, which meets our expectation. The stellar radii \( (R_*) \) and masses \( (M_*) \) are derived by interpolating the Yale evolution tracks (Spada et al. 2017).

The light curve of UCAC4 606-009417 has a complicated pattern, which is different from those of the other three stars. This star shows clear periodic flux variations most of the time during TESS Sector 18, whereas it exhibits some irregular dips in brightness with a timescale of \( \sim 1 \) day and depths of 3%–12%. We search the Gaia EDR3 data set to check any common proper-motion (CPM) companions closed to this star and find that it has a CPM companion with a projected separation of 4.4'' and \( \Delta G = 4.55 \). The similar proper motions indicate they are moving along nearly the same direction in the sky, and their parallaxes \( (\varpi = 3.3925 \pm 0.0185 \text{ mas and } 3.2477 \pm 0.0982 \text{ mas}) \) are consistent within 1.5\( \sigma \). Therefore, they are probably gravitationally bounded.

Table 2

| UCAC4 | \( A_{\text{Li}} \) (dex) | \( A_{\text{Li NLTE}} \) (dex) | EW (mÅ) | \( v \sin i \) (km s\(^{-1}\)) | \( M/M_\odot \) | \( R/R_\odot \) | \( P_{\text{rot}} \) (days) | \( v_{\text{rot}} \) (km s\(^{-1}\)) | Class |
|-------|-----------------|-----------------|---------|------------------|-----------|-----------|-----------------|-----------------|-------|
| 440-009448 | 4.63 ± 0.27 | 4.39 ± 0.24 | 496.6 | 18 | 0.78 | 0.89 | 1.69 | 26.6 | YSO |
| 441-011058 | 4.18 ± 0.24 | 3.80 ± 0.21 | 317.7 | 20 | 1.38 | 2.51 | 3.55 | 35.8 | YSO |
| 451-011087 | 4.12 ± 0.24 | 3.82 ± 0.20 | 324.2 | 20 | 1.04 | 1.50 | 3.70 | 20.5 | YSO |
| 569-010383 | 4.75 ± 0.23 | 4.34 ± 0.22 | 372.3 | 9 | 1.16 | 1.56 | ... | ... | ... |
| 596-052739 | 4.82 ± 0.15 | 4.46 ± 0.20 | 427.5 | 8 | 0.96 | 1.67 | ... | ... | ... |
| 606-009417 | 4.17 ± 0.24 | 3.82 ± 0.21 | 330.0 | 25 | 1.00 | 0.90 | ... | ... | YSO |
| 629-030411 | 4.09 ± 0.16 | 3.94 ± 0.15 | 163.7 | 45 | 1.60 | 1.89 | ... | ... | ... |
| 646-050572 | 5.04 ± 0.24 | 4.59 ± 0.20 | 435.0 | 11 | 0.82 | 1.58 | ... | ... | ... |
| 677-057614 | 4.44 ± 0.23 | 3.96 ± 0.27 | 327.2 | <6 | 1.03 | 1.71 | ... | ... | ... |

11 https://mast.stsci.edu/tesscut/
Figure 2. The observed spectra (black dots) around the Li line at 6707.8 Å, superimposed on the synthetic spectra under LTE (solid green lines) and NLTE assumptions (solid red lines).
to 1240 ± 37 au, suggesting the system is a wide binary with G7V+M1V components.

4. Discussion

We present the distribution of the nine super Li-rich unevolved stars in the metallicity−$T_{\text{eff}}$ plane color-coded according to their NLTE Li abundances in Figure 4. Eight of them are located within a small range of the solar metallicity (−0.4 dex < [Fe/H] < +0.4 dex), while the most metal-poor one is UCAC4 460–05072 with [Fe/H] of −0.69 dex. Except for the hottest star UCAC4 629–030411 with $T_{\text{eff}}$ of 6807 K, the effective temperatures of others are between 5100 K to 5800 K.

We check the variation of radial velocities (RVs) of each object from its consecutively observed spectra and the light curves from TESS of all our program stars and find no obvious evidence of binaries except UCAC4 606–009417.

Although the mechanisms of Li enrichment for the super Li-rich unevolved stars have been discussed widely (Deliyannis et al. 2002; Laws & Gonzalez 2003; Ashwell et al. 2005; Koch et al. 2011, 2012), they are still unclear. In addition to the complex origin of Li (Randich et al. 2020), another major factor is that such peculiar objects are so rare. Therefore, it is important to discuss the origin of these super Li-rich unevolved stars:

Four program stars, i.e., UCAC4 440–009448, 441–011058, 451–011087, and 606–009417, are YSOs (Azimlu et al. 2015; Nakano et al. 1999; Kounkel et al. 2018; Zari et al. 2018). The H$\alpha$ lines of four objects show emission or weak absorption. It is suggested by Romano et al. (2021) that in the inner Galaxy, $R_{\text{GC}}$ ∼ 4 kpc, the Li abundances can reach as high as 4.0 dex at the current time; however, the observed upper envelope Li abundance for the young star formation regions is around 3.3 dex. The NLTE Li abundances of the four young stars are higher than 3.8 dex, which is about three times higher than that of the upper envelope value for the young stars in Romano

Figure 3. Light curves of the four sample stars that exhibit periodic or semiregular brightness changes. Light curves are extracted using simple aperture photometry from the TESS full-frame images. Each sector covers ~27 days.
et al. (2021). As discussed above, only UCAC4 606-009417 is a wide binary system with an M1V component; therefore, it is not possible that these four stars enhance their Li by accreting the Li-rich material from its companion, such as AGB and RGB stars or novae. Considering all of them are fast rotators \((v\sin i > 15 \text{ km s}^{-1})\), the most likely possibility is the accretion of circumstellar Li-rich matter.

There are three program stars with \(v\sin i\) less than 10 \text{ km s}^{-1}, i.e., UCAC4 569-010383, 596-052739, and 677–057614, and they have similar effective temperatures and metallicities. All of them have very high Li abundances \((A_{\text{Li}})_{\text{NLTE}} > 3.9 \text{ dex})\), and there is no obvious evidence that the three stars are binaries based on the variation of their RVs and light curves from TESS. Koch et al. (2011, 2012) suggested when a star engulfs a planet, the surface abundances of some of its elements, including Li, can increase. More recently, Soares-Furtado et al. (2021) found that the most compelling strengths and survival times of engulfment-derived enrichment are the host stars near the main-sequence turnoff of mass between 1.4 and 1.6 \(M_\odot\). However, the composition of the gaseous giant planet is similar to that of its host star, thus we cannot expect this mechanism to enhance the Li abundance to their observed levels. Meanwhile, their Li enrichment by accreting the circumstellar Li-rich matter cannot be ruled out.

UCAC4 629–030411 has a very fast rotation \((v\sin i = 45 \text{ km s}^{-1})\). Its Li is more likely enriched by the accretion of circumstellar matter. However, this star has the highest temperature. It is suggested by Richer & Michaud (1993) and Richard et al. (2005) that Li from deeper regions can be radiatively accelerated outward to enrich the surface convection zone (diffusion) for stars in the temperature ranges of 6900 K and 7100 K. Considering the temperature of this star is only slightly lower than the above range, the possibility of diffusion enrichment cannot be ruled out.

UCAC4 646–050572 is the most metal-poor star in our sample. The kinematic information of \((U, V, W) = (−96, −120, −1) \text{ (km s}^{-1}\) indicates that it belongs to the thick disk (Bensby & Lind 2018). Considering its rotation velocity is around 11 \text{ km s}^{-1} and no evidence of binary, the Li enrichment is most likely due to the accretion of circumstellar matter as well.

5. Conclusions

We discover nine super Li-rich unevolved stars with NLTE Li abundance \(A_{\text{Li}}\) higher than 3.8 \text{ dex} from the LAMOST-MRS, which is the largest sample of such type stars. It is found that the NLTE effects are as large as \(\sim 0.5 \text{ dex}\) for these stars. We note that most of our program stars are fast rotators. Therefore, the accretion of circumstellar matter may be the main contributor to the Li enhancement in these stars; however, other sources cannot be ruled out.

The LAMOST-MRS is ongoing and will continue to provide a great opportunity to study such chemically peculiar stars.

The authors are grateful to Guang-Wei Li for helpful discussions about the peculiar star. Our research is supported by the National Key R&D Program of China No. 2019YFA0405502, the National Natural Science Foundation of China under grant Nos. 12090040, 12090044, 11833006, 12022304, 11973052, 11973042, U2031144, and U1931102. H.-L.Y. acknowledges support from the Youth Innovation Promotion Association of the Chinese Academy of Sciences (id. 2019060) and NAOC Nebula Talents Program. We acknowledge the science research grants from the China Manned Space Project with No. CMS-CSST-2021-B05. Guoshoujing Telescope (the Large Sky Area Multi-Object Fiber Spectroscopic Telescope LAMOST) is a National Major Scientific Project built by the Chinese Academy of Sciences. Funding for the project has been provided by the National Development and Reform Commission. LAMOST is operated and managed by the National Astronomical Observatories, Chinese Academy of Sciences. This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement. This paper includes data collected by the TESS mission, which are publicly available from the Mikulski Archive for Space Telescopes (MAST). Funding for the TESS mission is provided by NASA’s Science Mission directorate.

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References
Ashwell, J. F., Jeffries, R. D., Smalley, B., et al. 2005, MNRAS, 363, L81
Azimio, M., Martínez-Galarza, J. R., & Muench, A. A. 2015, AJ, 150, 95
Bailer-Jones, C. A. L., Rybizki, J., Fouesneau, M., Demleitner, M., & Andrae, R. 2021, AJ, 161, 147
Bensby, T., & Lind, K. 2018, A&A, 615, A151
Carlberg, J. K., Cunha, K., Smith, V. V., & Majewski, S. R. 2012, ApJ, 757, 109
Casagrande, L., Ramírez, I., Meléndez, J., Bessell, M., & Asplund, M. 2010, A&A, 512, A54
Charbonnel, C., Borisov, S., de Laverny, P., & Prantzos, N. 2021, A&A, 649, L10
Cui, X.-Q., Zhao, Y.-H., Chu, Y.-Q., et al. 2012, RAA, 12, 1197
Cutri, R. M., Skrutskie, M. F., van Dyk, S., et al. 2003, yCat, II/246
Delgado Mená, E., Bertrán de Lis, S., Adibekyan, V. Z., et al. 2015, A&A, 576, A69
Deliyannis, C. P., Steinhauer, A., & Jeffries, R. D. 2002, ApJL, 577, L39
Deng, L.-C., Newberg, H. J., Liu, C., et al. 2012, RAA, 12, 735
Gaia Collaboration, Brown, A. G. A., Vallenari, A., et al. 2021, A&A, 649, A1
Gao, Q., Shi, J.-R., Yan, H.-L., et al. 2021, ApJ, 914, 116
Green, G. M., Schlaufy, E., Zucker, C., Speagle, J. S., & Finkbeiner, D. 2019, ApJ, 887, 93
Grupp, F. 2004, A&A, 420, 289
Grupp, F., Kurucz, R. L., & Tan, K. 2009, A&A, 503, 177
Guiglion, G., de Laverny, P., Recio-Blanco, A., et al. 2016, A&A, 595, A18
Hernanz, M., Jose, J., Coc, A., & Isern, J. 1996, ApJL, 465, L27
José, J. 2002, in AIP Conference Proceedings, Volume 637, CLASSICAL NOVA EXPLOSIONS: International Conference on Classical Nova Explosions, ed. M. Hernanz & J. José (New York: AIP), 104
Kelly, D. E., Christian, D. J., Mathioudakis, M., & Jevremović, D. 2020, RAA, 20, 104
Koch, A., Lind, K., & Rich, R. M. 2011, ApJL, 738, L29
Koch, A., Lind, K., Thompson, I. B., & Rich, R. M. 2012, MSAIS, 22, 79
Kounkel, M., Covey, K., Suárez, G., et al. 2018, AJ, 156, 84
Krolikowski, D. M., Kraus, A. L., & Rizzuto, A. C. 2021, AJ, 162, 110
Kunder, A., Kordopatis, G., Steinmetz, M., et al. 2017, AJ, 153, 75
Kusakabe, M., Cheoun, M.-K., Kim, K. S., et al. 2019, ApJ, 872, 164
Laws, C., & Gonzalez, G. 2003, ApJ, 595, 1498
Li, H., Aoki, W., Matsuno, T., et al. 2018, ApJL, 852, L31
Luo, A. L., Zhao, Y.-H., Zhao, G., et al. 2015, RAA, 15, 1095
Matteucci, F. 2021, A&ARv, 29, 5
Nakano, M., Yamauchi, S., Sugitani, K., Ogura, K., & Kogure, T. 1999, PASJ, 51, 1
Nollett, K. M., Busso, M., & Wasserburg, G. J. 2003, ApJ, 582, 1036
Olive, K. A., & Schramm, D. N. 1992, Natur, 360, 439
Pitrou, C., Coc, A., Uzan, J.-P., & Vangioni, E. 2018, Phil, 754, 1
Prantzos, N. 2012, A&A, 542, A67
Ramírez, I., & Meléndez, J. 2005, ApJ, 626, 446
Randich, S., & Magrini, L. 2021, FrASS, 8, 6
Randich, S., Pasquini, L., Franciosini, E., et al. 2020, A&A, 640, L1
Reetz, J. K. 1991, PhD Thesis, LMU Munich
Richard, O., Michaud, G., & Richer, J. 2005, ApJ, 619, 538
Richer, J., & Michaud, G. 1993, ApJ, 416, 312
Ricker, G. R., Winn, J. N., Vanderspek, R., et al. 2014, Proc. SPIE, 9143, 914320
Romano, D., Magrini, L., Randich, S., et al. 2021, A&A, 653, A72
Sackmann, I. J., & Boothroyd, A. I. 1992, ApJL, 392, L71
Sackmann, I. J., & Boothroyd, A. I. 1999, ApJ, 510, 217
Schlaufy, E. F., Green, G., Finkbeiner, D. P., et al. 2014, ApJ, 789, 15
Schlegel, D. J., Finkbeiner, D. P., & Davis, M. 1998, ApJ, 500, 525
Shi, J. R., Gehren, T., Zhang, H. W., Zeng, J. L., & Zhao, G. 2007, A&A, 465, 587
Soares-Furtado, M., Cantado, M., MacLeod, M., & Ness, M. K. 2021, AJ, 162, 273
Spada, F., Demarque, P., Kim, Y. C., Boyajian, T. S., & Breuer, J. M. 2017, ApJ, 838, 161
Spite, F., & Spite, M. 1982, A&A, 115, 357
Tajitsu, A., Sadakane, K., Naito, H., Araź, A., & Aoki, W. 2015, Natur, 518, 381
Wang, E. X., Nordlander, T., Asplund, M., et al. 2021, MNRAS, 500, 2159
Woosley, S. E., Hartmann, D. H., Hoffman, R. D., & Haxton, W. C. 1990, ApJ, 356, 272
Xiang, M., Rix, H.-W., Ting, Y.-S., et al. 2021, ApJS, 253, 22
Yan, H., Li, H., Wang, S., et al. 2022, The Innovation, 3, 100224
Yan, H.-L., Shi, J.-R., Zhou, Y.-T., et al. 2018, NatAs, 2, 790
Zacharias, N., Finch, C. T., Girard, T. M., et al. 2013, AJ, 145, 44
Zari, E., Hashemi, H., Brown, A. G. A., Jardine, K., & de Zeeuw, P. T. 2018, A&A, 620, A172
Zechmeister, M., & Kürster, M. 2009, A&A, 496, 577
Zhao, G., Zhao, Y.-H., Chu, Y.-Q., Jing, Y.-P., & Deng, L.-C. 2012, RAA, 12, 723