The Dissolution of Clusters: What Can We Learn from Nearby, UV-bright, Overluminous Field Stars?

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Abstract

The past two decades have seen dramatic progress in our knowledge of the population of young stars of age <200 Myr that lie within 150 pc of the Sun. These nearby, young stars, most of which are found in loose, convolving groups, provide the opportunity to explore (among many other things) the dissolution of stellar clusters and their diffusion into the field star population. In the age of Gaia, this potential can now be fully exploited. We have identified, and are now investigating, a sample of nearly 400 Galex UV-selected late-type (K and early-M) field stars with Gaia-based distances <120 pc and isochronal ages ≤80 Myr (even if binaries). Only a small percentage (<10%) of stars among this (kinematically unbiased) sample can be confidently associated with established nearby, young moving groups (NYMGs). The majority display anomalous kinematics, relative to the known NYMGs. These stars may hence represent a previously unrecognized population of young stars that has recently mixed into the older field star population. We discuss the implications and caveats of such a hypothesis—including the intriguing fact that, in addition to their non-young-star-like kinematics, the majority of the UV-selected, isochronally young field stars within 50 pc appear surprisingly X-ray faint.

1 Introduction

The identification and study of stars of age <200 Myr within ~100 pc of the Sun provides crucial insight into pre-main sequence (pre-MS) stellar evolution and the formative stages of planetary systems (Kastner et al., 2016b). Such young, nearby stars provide excellent examples for direct-imaging campaigns to observe exoplanets and circumstellar discs (e.g., Kalas et al., 2004; Lagrange et al., 2008; Bowler et al., 2015; MacGregor et al., 2015; Chauvin et al., 2015), act as direct observational test-beds for early stellar evolution (e.g., Zuckerman & Song, 2004; Bell et al., 2015), and provide key evidence for the physical origins of young stars in the Solar neighbourhood (e.g., Wright & Mamajek, 2018).

The majority of these nearby, young stars can be placed in kinematically coherent ensembles known as nearby young moving groups (NYMGs). To date, at least a dozen, and perhaps as many as two dozen, NYMGs have been identified (Mamajek, 2016; Gagné et al., 2018). Since NYMGs are approximately coeval (age spreads generally < 5 Myr; Bell et al., 2015), any age determination methods for a star in a NYMG can reasonably be applied to any other star in the group; furthermore, age determinations from diverse methods can create a tight age constraint for the NYMG (e.g., Mamajek & Bell, 2014). Recent work suggests that NYMGs share similar chemical abundances (De Silva et al., 2013; Barenfeld et al., 2013), which provides evidence for their common origins and hints at the compositions of the molecular clouds from which they were born.

Over the past two decades, the identification of candidate nearby, young, late-type stars and (hence) NYMG members among the field-star population has proceeded via some combination of their signature luminous chromospheric (UV) and coronal (X-ray) emission, which result from strong surface magnetic fields (e.g., Kastner et al., 1997; Rodriguez et al., 2013, and references therein), and their common Galactic (U/V/W) space motions (e.g., Zuckerman & Song, 2004; Torres et al., 2008; Malo et al., 2013). Follow-up spectroscopy then further constrains stellar ages via determinations of Li absorption line strengths, rotation rates, and optical activity indicators (such as Hα and Na I emission lines), so as to assess the viability of candidate NYMG stars or of proposed new NYMGs (see discussions in Zuckerman & Song, 2004; Binks et al., 2015).

The fact that so many field stars, even within the nearest 100 pc, were missing parallaxes, precise proper motions, and/or radial velocity measurements presented a major difficulty for previous searches for NYMG candidates and tests of their membership status (e.g., Malo et al., 2014a). With the sudden availability of such data, in the form of the first two data releases from the Gaia space astrometry mission (Data Releases 1 and 2, hereafter DR1 and DR2; Gaia Collaboration et al., 2016, 2018), the study of nearby, young stars and NYMGs can now make major strides. This potential motivated the recent study, described in Kastner et al. (2017), in which we evaluated the distances and ages of all 19 nearby young star candidates from the sample of ∼2000 stars compiled by the Galex (UV) Nearby Young Star Survey (GAL-
NYSS: Rodriguez et al., 2013) that were included in Gaia DR1. The youth of the majority of these 19 mid-K to early-M stars was confirmed by their positions, relative to both the loci of main sequence stars and theoretical isochrones, in Gaia color-magnitude and color-color diagrams. Surprisingly few of the GALNYSS stars included in Gaia DR1 have kinematics consistent with membership in known NYMGs, however (Kastner et al., 2017).

In the present work, we further investigate the ability of Gaia data to identify nearby, young stars and to assess their NYMG memberships — or lack thereof. Guided by the Kastner et al. (2017) study, we have used Gaia DR1 to select a sample consisting of a few hundred bright (7 < V < 12.5) stars with Galex UV counterparts that are isochronally young (ages ~80 Myr). We then used Gaia DR2 data to assess these stars’ kinematics. For subsamples of these Gaia/Galex-selected nearby young star candidates, additional archival data (e.g., X-ray emission and Li absorption) have been compiled with which we can assess diagnostics of youth. Here, we discuss the main characteristics of this isochronally and UV-selected sample of candidate nearby, young stars. The details, including tables listing (Gaia/Galex/2MASS) astrometric, photometric, and kinematic data for the full sample, will be included in a forthcoming paper (Chalifour et al. 2019, in prep.).

2 Selecting Candidate Nearby, Young Stars from Galex and Gaia Data

Expanding on Kastner et al. (2017), our initial selection of stars for the present study was based on crossmatching Gaia DR1 catalog entries with the Galex All-sky Imaging Survey (AIS) point source catalog, but without the additional proper motion constraints used by Rodriguez et al. (2013) to assemble the GALNYSS catalog. We adopted a cross-matching radius of 3″ to associate Gaia DR1 entries with NUV photometry from the Galex AIS and, subsequently, near-IR (JHK_s) and mid-IR (W1–W4) photometry from 2MASS and WISE, respectively, using the Vizier crossmatch service. This cross-matching exercise generated a catalog with 715,773 objects.

We then selected stars within 125 pc (i.e., parallaxes π ≥ 8 mas) that lie significantly above the main sequence (MS) according the models of Tognelli et al. (2011, hereafter T11). Specifically, the T11 isochrones were used to select the subset of stars that appear younger than 80 Myr — even if equal-components binaries (see, e.g., Kastner et al., 2017) — in a M_K vs G – K_s color-magnitude diagram (Fig. 1). The evolutionary models of Baraffe et al. (2015) and those of T11 agree to within a few tenths of a magnitude at 80 Myr for K and early-M type stars, with the T11 models consistently predicting older ages for low-mass stars (Kastner et al., 2017). For this reason, the T11 models are a more conservative choice for selecting stars younger than 80 Myr. To further limit the sample size, we then selected only stars lying below (less luminous than) and redward of the T11 1.0 M⊙ evolutionary track. No lower limit on mass was imposed, although the use of the Tycho catalogue to construct the DR1 catalog imposes a magnitude limit of V ~ 9, which should result in a sample dominated by young K and early M dwarfs (§3.1).

Figure 1: Top: K_s vs. G – K_s color-magnitude diagram (density plot) of Galex UV-selected DR1 stars, with positions of our 376 young star candidates indicated as green circles. Theoretical pre-MS isochrones from T11 for ages of 10 and 20 Myr as well as 80 Myr “binary stars” are overlaid; i.e., the 80 Myr isochrone has been adjusted upwards by 0.75 mag, to simulate the positions of equal-components binaries of that age. Bottom: zoomed-in view of the same CMD, centered on the positions of the candidates.

The foregoing selection criteria resulted in the sample of 376 stars highlighted in Fig. 1. These candidate young stars are more or less uniformly distributed across the sky, with the exception of the Galex Galactic plane avoidance zone. The candidate sample includes a small number of previously identified NYMG members (§3.3.2) — including TW Hya, the namesake of the ~10 Myr-old association whose identifica-

1Preliminary versions of these tables can be obtained, on request, from the authors.

2The present study was initiated before the release of Gaia DR2, and so relies entirely on DR1 for sample selection. However, for the analysis described in §3, we use DR2 astrometric and photometric data. This substitution is justified by the fact that, for our final sample of 376 objects, the absolute difference between DR1 and DR2 parallaxes is less than twice the combined error bar from DR1 and DR2 for 95% of the sample stars, and this difference is never larger than 5.0 pc.

3http://cdsxmatch.u-strasbg.fr/xmatch
tion spawned the wider search for NYMGs and their members (Kastner et al., 1997; Zuckerman & Song, 2004; Torres et al., 2008).

3 Properties of the Candidate Stars

3.1 Spectral types

We assigned spectral types to the sample stars either on the basis of the stars’ entries in the SIMBAD astronomical database (152 stars; Wenger et al., 2000) or via optical/near-IR colors. For the latter stars, we used the average of a linear interpolation of $V - K_s$ and $G - K_s$ vs. spectral type using online tables provided by E. Mamajek. For stars with spectral types available in SIMBAD, we find agreement with the color-based interpolation within $\sim 2$ spectral subtypes. As expected, the vast majority of the stars have spectral types between mid-K and early-M, a result of the combination of the range of $G - K_s$ over which they were selected and Gaia DR1 magnitude limits (see Kastner et al., 2017).

3.2 Age diagnostics

3.2.1 UV excesses

In Kastner et al. (2017) it was demonstrated that UV-selected nearby young stars generally appear below the locus of main sequence stars in a $NUV - G$ vs $G - K_s$ color-color diagram, due to their enhanced levels of chromospheric activity and (hence) near-UV excesses. Figure 2 confirms that the larger sample considered here adheres to this trend; the majority of the selected stars indeed appear to lie below the main sequence locus.

![Figure 2: $NUV - G$ vs. $G - K$ color-color diagram for all Galex-selected stars in Gaia DR1, highlighting the positions of the 376 candidate stars (green symbols; yellow symbols for stars within 50 pc) as well as the sample of (19) stars from Kastner et al. (2017, purple symbols) and previously identified nearby, young stars (red symbols). The green line indicates the locus of main sequence stars; the displacement of a star to the right of this line is indicative of the presence and strength of its NUV excess.](image)

In Fig. 3, we plot $NUV - G$ vs. isochronal age (and distance) for the 376 candidate stars. For reference, we overplot the means and standard deviations for K stars in the β Pic Moving Group (age $21 \pm 26$ Myr; Binks & Jeffries, 2014; Malo et al., 2014b), AB Dor Moving Group (age $\sim 150$ Myr; Bell et al., 2015) and Hyades (age $650 \pm 70$ Myr; Martin et al., 2018). All three groups lie within $1 \sigma$ of one another in $NUV - G$. Furthermore, the mean and standard deviation in $NUV - G$ for 217 K-type field-stars in the Gliese-Jahreiss catalog (Gliese & Jahreiß, 1991) is $8.40 \pm 1.07$, only slightly larger than (within $1 \sigma$ of) the presumably younger NYMG samples. These statistics, along with Fig. 3, suggest that $NUV - G$ (or, by extension, UV excess) is of limited utility in isolating young stars from the field population.

3.2.2 X-ray emission

Strength of X-ray emission (due to coronal activity) is another indicator of stellar youth; it has long been recognized that pre-main sequence stars generally have measured values of $log L_X/L_{bol}$ in the range $-4.0$ to $-3.0$ (e.g., Kastner et al., 1997, 2016a; Binks & Kastner 2019, in prep; and references therein). Of the 376 candidate young stars, only 103 (27.6%) have ROSAT X-ray count rates listed in either the 1RXP, 2RXS or 2RXP (ROSAT All-Sky Survey; RASS) catalogs (Voges et al., 1999, 2000; Boller et al., 2016). While the ROSAT non-detection of the majority of candidate stars more distant than 50 pc may partially reflect the RASS sensitivity limits (Rodriguez et al., 2013), the low RASS detection rate of the candidate stars within 50 pc may provide contrary evidence for youth (see below).

ROSAT count rates were converted to $f_X$ as described in Kastner et al. (2016a), and bolometric fluxes ($f_{bol}$) were estimated from the stars’ spectral types and $J$ magnitudes using bolometric corrections listed in Pecaut & Mamajek (2013). The resulting plot of $log f_X/f_{bol}$ vs. age (and distance) for the 103 candidate stars with ROSAT X-ray detections is presented in Fig. 4, overlaid with the means and standard deviations of $log L_X/L_{bol}$ for K stars in three nearby young star clusters (NGC 2547, Pleiades, and Hyades), to illustrate the decline of $log L_X/L_{bol}$ over the age range 30 Myr to 650 Myr (see also Kastner et al., 1997). Comparison

![Figure 3: $NUV - G$ vs. isochronal age for the 376 candidate stars, with symbol color coding indicating distances to individual stars. The vertical line segments indicate the means and standard deviations of $NUV - G$ for the β Pic Moving Group (BPMG), AB Dor Moving Group (ABDMG) and Hyades.](image)
of Figs. 3 and 4 provides tentative evidence that NUV emission remains elevated for K stars even after X-ray emission begins to decline, and that both the X-ray and UV distributions may broaden after K stars arrive on the main sequence. These results are consistent with those of Stelzer et al. (2013), who found a similar relationship for UV and X-ray emission for M stars in NYMGs and in the field.

Notably, the majority of our 103 candidate stars that were detected in X-rays by the RASS lie between the Pleiades and Hyades in $L_X/L_{bol}$, and many of the stars within $\sim 70$ pc lie at or below the $L_X/L_{bol}$ level of the Hyades. Furthermore, of the 36 candidates within 50 pc, only 13 (36%) were detected in the RASS. Hence, on the basis of X-ray emission characteristics, we would conclude that the majority of our 376 candidate young stars are very likely much older than their Gaia-based isochronal ages.

![Figure 4](image.png)

**Figure 4:** As in Fig. 3, but here we display $\log f_X/f_{bol}$ (= $\log L_X/L_{bol}$) vs. isochronal age and distance for the 103 candidate stars with RASS X-ray detections. The vertical line segments indicate the means and standard deviations of three young clusters (N2547 = NGC 2547).

### 3.3 Kinematics

#### 3.3.1 Space velocity distribution

Galactic space velocities ($UVW$) and their errors were calculated from each star’s position, proper motion, radial velocity (RV), and parallax (and their associated errors) following the prescription in Johnson & Soderblom (1987). All 376 Gaia DR1-selected objects in our candidate young star sample have position, proper motion, and parallax data available in the Gaia DR2 catalog. The median errors are 0.04095 mas, 0.0805 mas yr$^{-1}$ and 0.05230 mas, respectively, where the positional and proper motion errors are the means of the RA and declination components. Distances are acquired from the Bayesian inference technique described in Bailer-Jones et al. (2018). The RVs were sourced from the literature for the 285 stars with available measurements, using the VizieR online database.

The resulting $UVW$ space velocities are displayed in Fig. 5, overlaid with the centroid positions and approximate $UVW$ extents of 8 well-established NYMGs with ages up to $\sim 150$ Myr (selected from Gagné et al., 2018). It is immediately apparent that the vast majority of the 376 candidate nearby young stars have space velocities that place them far outside the individual and collective $UVW$ domains of these NYMGs. Thus, as in the case of the X-ray emission strengths of our candidates (§3.2.2), their kinematics strongly suggest that the majority of these candidates are older than 150 Myr. This conundrum is further explored in §4.

#### 3.3.2 NYMG membership

To establish whether there exists a subset of our 376 candidate stars that are possible or established NYMG members, we applied a suite of kinematic membership tests: (1) a $\chi^2_{MG}$ test on $UVW$ and associated errors — with $\chi^2_{MG}$ as defined in Shkolnik et al. (2012) and Binks et al. (2015) — wherein we require $\chi^2_{MG} < 3.78$, corresponding to 95% probability of membership; (2) a kinematic distance test, in which the measured distance and the distance expected were the object a member of a given NYMG (with NYMG distances defined via galactic position data provided in Gagné et al., 2018), $\Delta D$, must agree to within 10 pc; and (3) an RV test, in which the difference between the measured RV and the RV expected were the object a member of a given NYMG, $\Delta RV$, must be less than 5 km s$^{-1}$. These criteria are applicable for all objects in the candidate young star list, regardless of whether there is an RV measurement or not; for stars lacking an RV, $\chi^2_{MG}$ was calculated over a range of RVs to determine whether any plausible value provides a potential match to a known NYMG. In addition to these kinematic criteria, one must ensure that the isochronal age of the star is consistent with the age range of the NYMG membership that is implicated kinematically, and — in cases where the implicated NYMG has a compact footprint in RA and declination (e.g., Gagné et al., 2018, their Fig. 1) — that the candidate’s position on the sky does not obviously disqualify it from membership.

Table 1 summarizes the key results of applying the foregoing criteria to the 376 candidate stars. Among the 285 candidates with RV measurements, we find 19 stars satisfy the $\chi^2_{MG}$ test, and 14 of these pass all further kinematic and sky position tests. Six of these 14 stars (2MASS J 04392545+3322446, 09503676−2933278,

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Figure 5: UVW space velocities of the nearby young star candidates selected as described in §2, with centroid positions and extents of 8 well-established NYMGs (Gagné et al., 2018) indicated. The axis ranges of the top row of panels are set so as to display all 376 candidates, while the bottom panels provide zoomed-in views centered on $U = V = W = 0$ and encompassing the NYMG centroids.

Our UV- and Gaia-DR1-based search for nearby ($D \leq 120$ pc), young (age $<100$ Myr) stars has yielded the potential identification of 6–8 new candidate members of NYMGs and the recovery of another dozen or so previously known NYMG members (§3.3.2; Table 1). While these identifications demonstrate the potential of the methods described here, the rather low yield — roughly 20 known or new NYMG members among 376 candidates — is surprising, given that our 376 candidates were selected on the basis of Gaia-based isochronal ages $\leq 80$ Myr (Fig. 1) as well as large UV fluxes (Fig. 2). Similarly, Figs. 4 and 5 provide strong evidence that our sample of nearby young star candidates is in fact dominated by stars with ages $>150$ Myr, despite the fact that these stars lie high above the locus of MS stars in a Gaia/2MASS color-magnitude diagram (Fig. 1).

These results have far-reaching implications for the use of Gaia-based isochronal ages to select candidate young stars for purposes of imaging giant exoplanets, as well as for models of the manifestation and evolution of stellar magnetic activity. Before further considering these implications, we mention three somewhat unlikely explanations for the non-young-star-like X-ray and kinematic properties of the majority of the candidates.

1. Contamination by first-ascent giant stars. This explanation would appear to be at odds both with the CMD distribution of the candidates (Fig. 1) and with the frequency of UV excesses among the candidate stars (Fig. 2).

2. Binaries with a narrow range of separations. Binary stars with separations such that both stars are included in 2MASS photometry ($\sim 2''$ PSF), but only the primary is measured by Gaia at $G$ band, would shift an apparently single star upwards and to the right in Fig. 1. However, such confusion should only apply to a highly specific subsample of binary stars with separations around $\sim 1''$.

3. MS stars with white dwarf (WD) companions. A subset of our candidates may be MS stars that have been spun up and/or inflated by accretion of mass lost by the asymptotic giant branch antecedent of a companion WD (Jeffries & Smalley, 1996), such that the WD is in fact a contributor to (or dominates) the UV detected by Galex. But it seems highly improbable that such systems would dominate our sample.

The surprising "bifurcation" of our UV- and isochronally-selected nearby young star candidates into X-ray-bright and X-ray-faint subsamples (Fig. 4) raises a set of particularly vexing questions. Namely: If the large (apparently dominant) fraction of X-ray-faint stars among our candidates are
in fact not pre-MS stars, then why are they as “overlumin-
ous” (in terms of their bolometric luminosities) as the X-
ray-bright stars? Are they “imposters” — zero-age (or even
older) main sequence (MS) stars that are “puffed up” via high
levels of magnetic activity to fast rotation rates, as ap-
ppears to be the case for, e.g., the subset of overluminous late-
type Pleiades stars (Somers & Stassun, 2017)? If so, why do
so many of our magnetically active, presumably radically in-
fated young MS field stars have such weak coronae relative to
“normal” young stars, despite their apparently similar levels
of chromospheric UV excess? Could some or all of these stars
be rotationally inflated yet X-ray faint due to centrifugally
induced “coronal stripping” (Jardine, 2004)?

Addressing these questions will require a dedicated ob-
serving campaign targeting our candidate stars in the optical
through UV to X-ray regimes, so as to access diagnostics of
chromospheric and coronal activity and relate these prop-
ties to stellar age indicators and rotation rates. To that
end, we have been obtaining moderate- to high-resolution
optical spectra of a representative sample of the candidates
(Chalifour et al. 2019, in prep.). Ultraviolet spectroscopy with
HST, as well as Chandra and XMM X-ray spectroscopy, rep-
resent the additional, essential puzzle pieces necessary to un-
derstand the natures of the class of isochronally young and
UV-bright yet X-ray faint and kinematically “old” stars un-
covered by this work. Regardless, the preliminary work pre-
sented here, like that of Wright & Mamajek (2018), hints at the
power of Gaia astrometric and photometric data for pur-
poses of isolating the population of young MS stars that orig-
inated in young moving groups and have relatively recently
mixed into the field star population.

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### Table 1: Candidate NYMG Members

| Name          | Isochronal Age (2MASS J) | Distance (pc) | NYMG<sup>a</sup> | \(\Delta v\) (km s\(^{-1}\)) | \(\Delta D\) (pc) | NYMG<sub>1st</sub> ref(s)<sup>b</sup> | BANYAN<sup>c</sup> |
|---------------|--------------------------|---------------|-------------------|-------------------------------|-----------------|-----------------------------------|-------------------|
| 00565546−5152319 | < 10 − 50                | 37.036<sup>−0.749</sup> | ARG > 100         | −3.683                        | 23.599          | ARG abc                           |
| 03315564−4359135 | 25 − 80                 | 45.216 ± 0.071  | THA 9.169          | +1.196                        | 1.919            | THA abc                           |
| 04480066−5041255 | 20 − 60                 | 59.499<sup>−0.269</sup> | THA 33.464         | +6.042                        | 43.723          | THA abc                           |
| 04524951−1955016 | 10 − 60                 | 61.576<sup>−0.976</sup> | THA 87.503         | +44.000                       | 14.899          | THA abc                           |
| 12151838−2037283 | 25 − 80                 | 51.515<sup>−0.219</sup> | ABD 3.833          | +1.627                        | 3.955            | ABD a                             |
| 23002791−2618431 | 10 − 25                 | 31.830<sup>−0.050</sup> | ABD 5.253          | +3.471                        | 1.450            | ABD abc ABD(98.8)                 |
| 020414683−5259523 | < 10 − 30               | 43.756 ± 0.072  | THA 1.629          | −1.987                        | 1.117            | THA abcd TWA(99.9)                |
| 04090973+2901306 | < 10 − 40               | 109.965<sup>−0.508</sup> | (TWA)<sup>d</sup> | 0.809                         | ...              | TAU(13.7)                         |
| 04392545+3332446 | 20 − 60                 | 89.859<sup>−0.307</sup> | THA 1.949          | −2.167                        | 2.528            | BPM abcd BPM(99.9)                |
| 05008741−5715255 | 20 − 60                 | 26.880 ± 0.020  | BPM 0.461          | +0.552                        | 2.034            | BPM abcd BPM(99.9)                |
| 05214684+2400444 | 10 − 50                 | 88.044<sup>−0.321</sup> | THA 3.360          | −1.511                        | 25.403           |                                 |
| 09503676−2939278 | 15 − 70                 | 120.645<sup>−0.531</sup> | BPM 1.017          | −1.533                        | 8.202            |                                 |
| 10182870−3150029 | 25 − 70                 | 65.520 ± 0.139  | TWA 2.082          | +3.543                        | 4.676            | TWA abd                           |
| 10374731−0623225 | 15 − 60                 | 37.824 ± 0.059  | OCT 1.672          | −1.482                        | 5.663            |                                 |
| 11015191−3442170<sup>e</sup> | < 10 − 20 | 59.980<sup>−0.150</sup> | TWA 0.479          | −0.326                        | 1.741            | TWA abcd TWA(99.9)                |
| 11212188−4736028 | < 10 − 40               | 70.579 ± 0.160  | BPM 3.609          | +3.037                        | 17.407           |                                 |
| 11315526−3436272 | < 10 − 10               | 49.309<sup>−0.144</sup> | TWA 0.021          | +0.099                        | 0.418            | TWA abcd TWA(99.9)                |
| 11594226−7601260 | < 10 − 30               | 99.460<sup>−0.236</sup> | EPS 0.047          | −0.102                        | 0.094            | CAN d EPS(99.9)                   |
| 13065028−4609561 | 20 − 60                 | 98.621<sup>−0.504</sup> | TWA 0.468          | −3.802                        | 5.261            | LCC(28.7)                         |
| 14015830+1925296 | 10 − 40                 | 64.077<sup>−0.133</sup> | (OCT)<sup>f</sup> | 2.294                         | +6.030           | 55.606                           |
| 14590325−2406318 | 20 − 80                 | 113.447<sup>−0.456</sup> | TWA 2.737          | +4.294                        | 24.248           | UCL(92.0)                         |
| 21351099+3402313 | 15 − 70                 | 75.599<sup>−0.183</sup> | (OCT)<sup>f</sup> | 0.972                         | ...              |                                 |
| 22424884+1303532 | < 10 − 20               | 67.620<sup>−0.383</sup> | COL 3.345          | +2.006                        | 7.162            |                                 |
| 23230835−1215513 | 25 − 70                 | 27.352 ± 0.044  | BPM 0.499          | +0.600                        | 0.020            | BPM ab d BPM(99.9)                |

**Candidates assigned as NYMG members in literature but rejected/omitted by our criteria**

| Name          | Isochronal Age (2MASS J) | Distance (pc) | NYMG<sup>a</sup> | \(\Delta v\) (km s\(^{-1}\)) | \(\Delta D\) (pc) | NYMG<sub>1st</sub> ref(s)<sup>b</sup> | BANYAN<sup>c</sup> |
|---------------|--------------------------|---------------|-------------------|-------------------------------|-----------------|-----------------------------------|-------------------|
| 02052739+5020228 | 15 − 70                 | 117.742<sup>−0.704</sup> | ABD (−13.0, −10.0)<sup>6</sup> | 0.243                         |                 |                                 |
| 04310860+6445082 | 20 − 80                 | 43.807<sup>−0.166</sup> | ABD (+10.0, +12.5)<sup>6</sup> | 0.502                         |                 |                                 |

**Candidates with a measured RV and with \(\chi^2 < 3.78\)**

NOTES:

a) ABD = AB Doradus MG, ARG = Argus, BPM = Beta Pictoris MG, COL = Columbia MG, EPS = epsilon Cha LCC = Lower Centaurus Crux, OCT = Octans-Near MG, TAU = Taurus, THA = Tucana-Horologium Association, THO = 32 Ori MG, TWA = TW Hydrae Assoc., UCL = Upper Centaurus Crux.

b) References: a = Bell et al. (2015); b = Malo et al. (2013); c = Torres et al. (2008); d = Zuckerman & Song (2004).

c) BANYAN \(\Sigma\) probability of membership (Gagné et al., 2014).

d) Kinematic \(\chi^2\) match to TWA, but sky position incompatible with TWA membership. The star 04090973+2901306 is most likely associated with the Taurus cloud.

e) TW Hya.

f) Kinematic \(\chi^2\) match to OCT, but sky position incompatible with OCT membership.

g) Viable RV range for membership.

Zenodo, 2018