Monthly Notices of the ROYAL ASTRONOMICAL SOCIETY

Mon. Not. R. Astron. Soc. **411,** 117–123 (2011) doi:10.1111/j.1365-2966.2010.17660.x

A search for new members of the β Pictoris, Tucana–Horologium and ϵ Cha moving groups in the RAVE data base

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Accepted 2010 September 7. Received 2010 September 6; in original form 2010 July 6

ABSTRACT

We report on the discovery of new members of nearby young moving groups, exploiting the full power of combining the Radial Velocity Experiment (RAVE) survey with several stellar age diagnostic methods and follow-up high-resolution optical spectroscopy. The results include the identification of one new and five likely members of the β Pictoris moving group, ranging from spectral types F9 to M4 with the majority being M dwarfs, one K7 likely member of the ϵ Cha group and two stars in the Tucana–Horologium association. Based on the positive identifications, we foreshadow a great potential of the RAVE data base in progressing towards a full census of young moving groups in the solar neighbourhood.

Key words: stars: kinematics and dynamics – open clusters and associations: individual: β Pictoris moving group – open clusters and associations: individual: Tucana–Horologium association – open clusters and associations: individual: ϵ Cha association.

1 INTRODUCTION

In the last decade, many young (<100 Myr) stars have been identified in the solar neighbourhood. Most of them belong to different moving groups, in which stars share common age and motion

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through the Galaxy (for review, see Zuckerman & Song 2004). Up to now, nine such kinematic assemblages have been revealed within 150 pc of our Solar system with ages ranging from 8 to 70 Myr (Torres et al. 2008), most of them situated in the Southern hemisphere far from known star-forming regions. However, tracing back their space trajectories shows that the birthplace of some of them may have been close to the nearest sites of massive star formation, the Sco–Cen region (Fernández, Figueras & Torra 2008).

Young moving groups are rich in debris discs, which implies very active planetesimal formation around these stars (Moór et al. 2006; Rebull et al. 2008). Since the epochs of several key events in the early Solar system (e.g. formation of terrestrial planets, Apai 2009) overlap well with the age of these groups, discs around the members are favourable and so present nearby and well-dated sites for investigations of planet formation and evolution. The members are also ideal targets when one would like to detect substellar objects via direct imaging, since giant gas planets are thought to fade significantly during their evolution (e.g. Kasper et al. 2007).

Most of the known young stellar kinematic groups occupy a large area on the sky (up to thousands of square degrees), which makes the identification of members very difficult. However, by combining astrometric data with radial velocity (RV) information and by applying relevant age diagnostic methods, one can search for additional members of known groups or reveal new kinematic assemblages. Using this approach, recent studies revealed more than 300 young stars belonging to nine kinematic groups in the vicinity of our Sun (Torres et al. 2008). It is clear, however, that the census of these groups is far from complete, because of the lack of necessary kinematic information – particularly the radial velocities and the trigonometric distances – for most of the stars. For example, comparing the list of members of the β Pic moving group (BPMG) with expectations based on the typical stellar mass function, Shkolnik, Liu & Reid (2009) estimated that about 60 M-type members remain undiscovered in our neighbourhood.

The Radial Velocity Experiment (RAVE) is a large-scale spectroscopic survey with the aim of measuring radial velocities and atmospheric parameters for up to a several hundred thousand stars in the southern sky, using the UK Schmidt telescope of the Anglo-Australian Observatory equipped with the 6dF multiobject spectrograph. The project has already resulted in two data releases (Steinmetz et al. 2006; Zwitter et al. 2008)[1] and observed well over 300 000 stars away from the plane of the Milky Way ($|b| > 25°$) with apparent magnitudes $9 < I_{\rm DENIS} < 13$. Detailed comparisons with external sets revealed that the velocities are accurate to 1–2 km s^{-1}, while the errors of the stellar parameters are of the order of 400 K in temperature, 0.5 dex in gravity and 0.2 dex in metallicity, all errors changing significantly across the temperature range of the stars (Zwitter et al. 2008). Proper motion data in the catalogue have been taken from Tycho-2 for the brighter stars, and from UCAC2, USNO-B and PPMX for the non-Tycho stars.

In order to capitalize on the potential of the RAVE survey in the census of young moving groups, we used the 2008 August 30 internal release of the RAVE catalogue (with almost 250 000 entries) to search for new members of three young assemblages, the ϵ Cha association (ECA), the BPMG and the Tucana–Horologium association (THA). Each of the selected kinematic groups is younger than 40 Myr. From the location in the Hertzsprung–Russell diagram and from the lithium equivalent widths of the members, Zuckerman et al. (2001a) derived an age of 12^{+8}_{-4} Myr for the BPMG. Estimates based on dynamical back-tracing models of BPMG members, in good accordance with the previous value, yielded an age of $\sim$12 Myr (Ortega et al. 2002; Song, Zuckerman & Bessell 2003). Recently, Mentuch et al. (2008) derived a somewhat higher age, 21 $\pm$ 9 Myr, from lithium depletion in the group. For the slightly older THA, the age estimates range between 10–40 Myr (Zuckerman et al. 2001b; Makarov 2007; Mentuch et al. 2008; da Silva et al. 2009), at present the mostly approved value is 30 Myr (Torres et al. 2008). The ECA may be the youngest among the three selected assemblages. Its age estimates range between 3–15 Myr (Terranegra et al. 1999; Feigelson, Lawson & Garmire 2003; Jilinski, Ortega & de la Reza 2005; Torres et al. 2008), in most cases below 7 Myr. We used strict criteria to select potential candidates, and then the RAVE-based list was supplemented by some additional stars taken primarily from the *Hipparcos* catalogue (Section 2). In order to confirm the membership of our candidates, we performed follow-up high-resolution spectroscopy (Section 3). The final assignments of the candidate stars are summarized in Section 4, with concluding remarks in Section 5.

[1] See also http://www.rave-survey.org

2 SAMPLE SELECTION

2.1 Search in the RAVE catalogue

The RAVE sample was examined in the U, V, W, X, Y, Z space, defined by the heliocentric space motion (U, V, W) and the physical space coordinates centred on the Sun (X, Y, Z). The computation of these parameters for a star requires knowledge of its coordinates, proper motion, RV and distance. While coordinates (right ascension, declination), proper motion (in right ascension and in declination) and RV information could be taken from the RAVE catalogue, for most of the RAVE stars, no trigonometric distances were available. Therefore, the U, V, W, X, Y, Z values were calculated for a range of distances, between 5–120 pc with a resolution of 1 pc, to check whether any distance resulted in a coordinate, which coincided with the region of a specific association in this six-dimensional space. In those cases where a RAVE star has a trigonometric parallax, measured by *Hipparcos* (van Leeuwen 2007), we used that value in the computations. The search was limited for those stars whose proper motion measurement fulfils the following criteria:

(i) $\mu = \sqrt{\mu_\alpha{}^2 \cos\delta^2 + \mu_\delta{}^2} > 20\,{\rm mas\,yr^{-1}}$
(ii) $\mu/\sigma_\mu > 5$

The characteristic space motion (U_0, V_0, W_0) of the groups was taken from Torres et al. (2008). We selected those objects from the RAVE catalogue, where min $[((U - U_0)^2 + (V - V_0)^2 + (W - W_0)^2)^{1/2}\,] < 4$ km s^{-1}. The chosen limit corresponds to the internal dispersion of the known members of the groups, while the distance resulting the minimum value was adopted as the kinematic distance to the object. For the BPMG, Torres et al. (2006) found a correlation between the U component of the Galactic space motion and the X space coordinate that was taken into account by calculating the U_0 value as a function of X, using their equation (4). We searched for BPMG candidate members within 80 pc of the Sun. For ECA and THA candidates, the search was limited to a region defined by the known members of the groups (Torres et al. 2008). Using this method, we compiled an initial list of stars, that includes three ECA, 803 BPMG and 62 THA candidate members.

The initial lists were further evaluated and filtered: (1) by placing our candidates in the colour–magnitude diagrams (CMDs) of the specific kinematic groups; and (2) by searching for X-ray counterparts in the *ROSAT* catalogues (Voges et al. 1999, 2000). We selected only those targets whose fractional X-ray luminosities (L_X/L_{bol}) and position in the CMD were consistent with the similar properties of the known members (see Figs 1a–d). Our procedure finally resulted in two, nine and seven candidate members of the ECA, BPMG and THA, respectively. By searching the literature, we revealed that 10 of our candidates (one ECA, four BPMG and five THA stars) are already known members. Moreover, one of our THA candidate, J042110.3−243221 (HD 27679), has already assigned to the Columba moving group by Torres et al. (2008), while one of the BPMG candidate (TYC 7558-655-1) has an ambiguous assignment in the literature. Torres et al. (2008) identified TYC 7558-655-1 as a possible member of the Columba group; on the other hand, Schlieder, Lépine & Simon (2010) proposed that this star likely belongs to the BPMG. We omitted these known/ambiguous members from further observations and analyses. Thus, we finally selected six RAVE candidates (one ECA, four BPMG and one THA stars) for further investigations. These RAVE-based candidate list was supplemented by one additional star, J19560294−3207186, that is, the comoving pair of one of the new candidate object (TYC 7443-1102-1).

2.2 Search in the *Hipparcos* catalogue

The *Hipparcos* catalogue was also searched for additional candidates members. Similarly to the RAVE sample, the *Hipparcos* stars were also examined in the U, V, W, X, Y, Z space. Here the RV data are lacking for a significant fraction of stars; therefore, the U, V, W values were calculated for a range of radial velocities (RV values were varied between $-50\,\mathrm{km\,s^{-1}}$ and $+50\,\mathrm{km\,s^{-1}}$ with a resolution of $0.5\,\mathrm{km\,s^{-1}}$). For those stars where RV data were available in the literature (Famaey et al. 2005; Gontcharov 2006; Moór et al. 2006; Torres et al. 2006; Holmberg, Nordström & Andersen 2007; Kharchenko et al. 2007), we used the measured value in the computation. The search was limited to stars with spectral type later than F8. In the selection of candidate stars, we applied almost identical criteria to that applied in the case of RAVE objects. The only change in the method was related to those stars where all six parameters were available; thus, U, V, W, X, Y, Z could be computed without any assumption, where we utilized a weaker criterion concerning to the X-ray luminosity of the object: we retained those candidates too where the upper limit of the X-ray luminosity was consistent with the similar property of the known members. Using this method in the BPMG, we could recover – with the exception of HIP 10679 – all known members that are quoted in *Hipparcos* (and has spectral type F8 or later). We note that HIP 10679 composes a binary system with HIP 10680 and the latter object has been successfully recovered by our method. Moreover, HIP 10679 could also be recovered when we applied the more accurate trigonometric parallax of HIP 10680 for this star as well. Three new candidate stars, HD 37144, HD 160305 and HD 190102, have been revealed. For HD 37144 and HD 190102, RV data and lithium equivalent widths measured in the framework of the SACY survey (Torres et al. 2006) have already been available. Although the kinematic parameters fulfilled our criteria, the low values of the lithium equivalent widths did not confirm their membership. Based on similar considerations, da Silva et al. (2009) also rejected HD 190102 as a member of the BPMG. For HD 160305, no RV or lithium data were found in the literature; thus, this object was added to the list of candidates. For the THA and ECA, we recovered all known members included in the *Hipparcos* catalogue. As a result of our search, we revealed one new THA candidate, HD 25402, for which RV was available in the catalogue of Holmberg et al. (2007). Since its computed kinematic parameters correspond well to the characteristic values of THA, we added this candidate to our list.

3 OBSERVATIONS AND DATA REDUCTION

We have obtained new high-resolution optical spectroscopy for all stars in Table 1 on six nights in 2009 July and three nights in 2009 August, using the 2.3-m telescope and the Echelle spectrograph of the Australian National University. The total integration time per object ranged from 30 to 1800 s, depending on the target brightness. The spectra covered the whole visual range in 27 echelle orders between 3900–6720 Å with only small gaps between the three reddest orders. The nominal spectral resolution is $\lambda/\Delta\lambda \approx 23\,000$ at the Hα line, with typical signal-to-noise ratios of about 100 (for the faintest red dwarf stars, the blue parts of the spectra were much noisier).

All data were reduced with standard IRAF[2] tasks, including bias and flat-field corrections, cosmic-ray removal, extraction of the 27 individual orders of the echelle spectra, wavelength calibration and continuum normalization. ThAr spectral lamp exposures were regularly taken before and after every object spectrum to monitor the wavelength shifts of the spectra on the CCD. We also obtained spectra for the telluric standard HD 177724 and IAU RV standards β Vir (spectral type F9V) and HD 223311 (K4III).

The spectroscopic data analysis consisted of two main steps. First, we measured RVs by cross-correlating the target spectra (using the IRAF task fxcor) with that of the RV standard that matched the spectral type of the target – β Vir was used for the early-type targets (A–F–mid-G) and HD 223311 for the late-type ones (late-G–K–M). Each spectral order was treated separately and the resulting velocities and the estimated uncertainties were calculated as the means and the standard deviations of the velocities from the individual orders. For most of the targets, the two IAU standards yielded RVs within 0.1–$0.5\,\mathrm{km\,s^{-1}}$, which is an independent measure of the absolute uncertainties. Using the new, more accurate RV data, we recomputed the U, V, W, X, Y, Z values for each candidate star, as described earlier. The equivalent widths of the 6708 Å Li and Hα lines were measured with the IRAF task splot.

4 RESULTS

Though stars in a specific group can be widely scattered across the sky, their common properties offer an opportunity to identify other members in the field by prescribing that a candidate must have similar space motion, as well as age, to that of the known members. The age criterion is essential, because there may be a non-negligible fraction of old field stars, which have similar space motion to that of the young group members (Zuckerman & Song 2004; López-Santiago, Micela & Montes 2009).

Using the new RV data, we recomputed the U, V, W values for each candidate star and compared the values with the characteristic space motion (U_0, V_0, W_0) of the corresponding kinematic groups. Apart from HD 25402 and HD 160305, we used kinematic distances, and the proper motion data were taken from the UCAC3 catalogue (Zacharias et al. 2010) for all of our targets. For HD 25402 and HD 160305, distances and proper motions were taken from the *Hipparcos* catalogue. For J19560294−3207186, we adopted the kinematic distance and U, V, W values of its companion (TYC

[2] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

Table 1. Properties of the candidate stars. References for spectral types: 1 – Riaz, Gizis & Harvin (2006); 2 – *Hipparcos* catalogue; 3 – Lépine & Simon (2009); and 4 – this paper, based on $V - K_s$. For HD 25402 and HD 160305, distances were taken from the *Hipparcos* catalogue; otherwise, we used kinematic distances (in parentheses). The typical uncertainty of the kinematic distances is estimated to be ∼10 per cent, based on a comparison between the kinematic and trigonometric distances of known members of the BPMG and THA. The estimated uncertainty of the U, V, W components is about 1–2 $km\,s^{-1}$.

Source ID	RA (2000)	Dec. (2000)	Spectral type	V (mag)	K_s (mag)	D (pc)	v_{rad} ($km\,s^{-1}$)	U, V, W ($km\,s^{-1}$)	EW_{Li} (Å)	EW_{H_α} (Å)	$\log \frac{L_X}{L_{bol}}$ (dex)
Candidate ϵ Cha group members											
J12210499−7116493	12 21 05.00	−71 16 49.3	K7[1]	12.16	8.24	(98)	+8.1 ± 0.6	[−11.8,−18.7,−9.8]	0.550 ± 0.020	−0.80 ± 0.02	−2.99
Candidate BPMG members											
J01071194−1935359	01 07 11.94	−19 35 36.0	M1[1]	11.41	7.25	(54)	+11.5 ± 1.4	[−8.6,−16.9,−8.3]	0.302 ± 0.005	−2.00 ± 0.05	−3.13
J16430128−1754274	16 43 01.33	−17 54 26.9	M0.5[1]	12.63	8.55	(57)	−13.0 ± 4.0	[−11.3,−16.0,−6.6]	0.300 ± 0.020	−2.50 ± 0.10	−3.13
HD 160305	17 41 49.04	−50 43 28.1	F9V[2]	8.35	6.99	72.5	+2.4 ± 1.1	[−6.1,−19.2,−10.5]	0.130 ± 0.040	2.60 ± 0.40	−3.67
J19560294−3207186	19 56 02.94	−32 07 18.7	M4[1]	13.30	8.11	(56)	−11.0 ± 5.0	[−9.8,−16.3,−8.1]	<0.100	−4.50 ± 1.00	−2.91
TYC 7443-1102-1	19 56 04.37	−32 07 37.7	M0[3]	11.80	7.85	(56)	−7.2 ± 0.4	[−9.8,−16.3,−8.1]	0.110 ± 0.020	−0.68 ± 0.04	<-3.47
J20013718−3313139	20 01 37.18	−33 13 14.0	M1[1]	12.25	8.24	(62)	−5.6 ± 1.8	[−8.7,−16.5,−8.3]	<0.100	−1.03 ± 0.07	−3.39
Candidate THA members											
J01521830−5950168	01 52 18.29	−59 50 16.8	M2-3[4]	12.94	8.14	(39)	+7.9 ± 1.6	[−10.2,−19.5,0.7]	<0.020	−2.30 ± 0.10	−3.16
HD 25402	04 00 31.99	−41 44 54.4	G3V[2]	8.40	6.88	48.5	+16.3 ± 0.7	[−9.1,−20.9,−1.7]	0.145 ± 0.005	+2.20 ± 0.30	<−4.02

7443-1102-1). We required $\{[(U - U_0)^2 + (V - V_0)^2 + (W - W_0)^2]^{1/2}\} < 4\,km\,s^{-1}$ for the group membership. This criterion was fulfilled for all candidate stars, that is, none of the refined RV data resulted in a deprived candidacy.

We used three different age diagnostic methods to evaluate whether the candidates are approximately coeval with the corresponding kinematic groups. In all age indicators, we compared the specific properties of the candidate stars to the corresponding properties of the known members with similar colour indices.

Figs 1(a)–(c) show the CMDs (M_{K_s} versus $V - K_s$) of the ECA, BPMG and THA groups. The lists of known group members are from Torres et al. (2008), which have then been queried in the *Hipparcos* and 2MASS data bases to produce Figs 1(a), (b) and (c). Candidate members are plotted with different symbols in the corresponding panels, showing that they indeed occupy a distinct region in the CMD. Since in these young groups a significant fraction of the stars are in pre-main-sequence evolutionary stage, the characteristic loci of the members in the CMD deviate from the position of the main-sequence stars, which helps filter out spurious (old) candidates. The younger the association is, the higher the deviation will be, because more and more massive stars are still in pre-main-sequence stage.

Young stars are also known to have enhanced coronal activity with strong X-ray emission making the latter property a good indicator of youth. We have cross-correlated the list of the candidates and known members of the three groups with the *ROSAT* All-Sky Survey catalogues (Voges et al. 1999, 2000). We selected only those objects where the match between the optical and X-ray positions was within 40 arcsec. In all of the positive matches, we checked the DSS images to evaluate whether there are any other nearby sources of X-ray emission within the *ROSAT* positional uncertainties. The X-ray fluxes of the sources were computed using the count rate-to-energy flux conversion formula by Schmitt, Fleming & Giampapa (1995). For those two objects where no X-ray counterparts were found, we utilized the *ROSAT* All-Sky survey images to derive an upper limit in the X-ray flux. Fig. 1(d) displays the fractional X-ray luminosities versus $V - K_s$ for the group members and the candidate stars. The *ROSAT* X-ray hardness ratios (HR1 and HR2) of the X-ray counterparts were also plotted in an inset of Fig. 1(d). Analysing the *ROSAT* hardness ratio values (HR1 and HR2) for T Tauri stars, young moving group members and old field stars, Kastner et al. (2003) demonstrated that the X-ray spectra of F–M stars soften with age. They argued that the distributions of hardness ratios for BPMG, THA and TW Hya association members are tightly clustered and very similar to one another. Thus, these ratios can also be used to discriminate between young and old stars.

Lithium is burned at low temperatures (2.5×10^6 K) in stellar interiors. Since lithium is destroyed and never created in nuclear reactions, primordial lithium depletes monotonically with time in stars with a convective layer. It makes lithium one of the best age indicators for young stars (Zuckerman & Song 2004). The measured lithium equivalent widths of the candidates (from Table 1), as well as the known group members, are plotted in Fig. 1(e) as a function of $V - K_s$. For known group members, the lithium data were taken from different surveys (Torres et al. 2006; da Silva et al. 2009).

In tight binaries, the tidal interactions can induce strong activity, indicating a spurious young age even if the system is old otherwise. Thus, in these cases, the usage of X-ray luminosity as a diagnostic of youth could be erroneous. The confusion between single and binary stars can also lead to the estimates of spurious stellar parameters. Our high-resolution spectra allowed us to search for double- and multilined binaries by cross-correlating with the IAU RV standards.

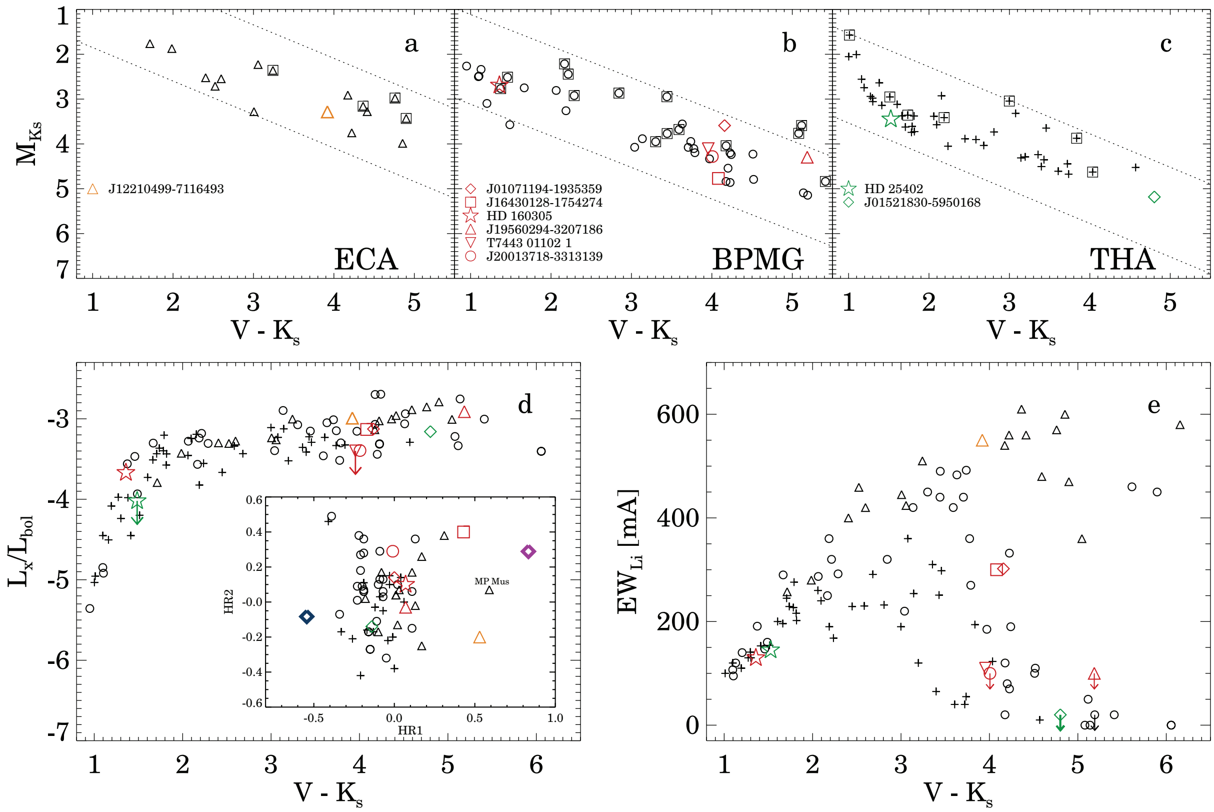

Figure 1. Upper panels: Absolute K_s magnitude versus $V - K_s$ colour diagrams for the known and candidate members of the ECA (panel a), BPMG (panel b) and THA (panel c) kinematic groups. Following Lépine & Simon (2009), the loci of the known members of the specific groups were fitted by a line and the ±1 magnitude range of the fitted loci is denoted by the dotted lines in panels (a)–(c). Nearly all known members are located within these lines in the diagrams. Candidate objects out of these area were omitted from our survey (see Section 2). Panel (d): fractional X-ray luminosities as a function of $V - K_s$ for the known and candidate members of the three kinematic groups. The inset shows the X-ray hardness ratio HR1 versus hardness ratio HR2 for the same objects. The large purple and blue diamonds show the characteristic hardness values for T Tauri stars and old K- and M-type main-sequence field stars, respectively. The characteristic values were taken from Kastner et al. (2003). The inset does not cover any symbol of the large panel. Panel (e): equivalent width of Li λ6707.76 as a function of $V - K_s$. In all panels, known members of the BPMG, THA and ECA are plotted as the black circles, black plus signs and black triangles, respectively. Squares denote those known close binaries where no photometric data are available separately for the individual components. Upper limits are displayed with down arrows.

We found no double-lined binaries among our sample stars. Apart from HD 160305 – where no previous RV data were available – velocities measured by us all agree well with those in the RAVE data or published by Holmberg et al. (2007). Thus, presently, there is no evidence to suggest that any of our candidates reside in a tight multiple system.

4.1 Final assignment of candidate stars

Unfortunately, we have parallax information only for two of our candidates (HD 25402 and HD 160305). The lack of reliable trigonometric distances for RAVE stars makes the identification of new members ambiguous, even in those cases where the age diagnostic methods confirm the youth of the objects, because we cannot completely exclude the possibility that we observe a young star whose kinematic properties deviate from those of the moving group, because its real distance deviate from the one we predicted using our method. Thus, the RAVE-based candidates – in accordance with the nomenclature proposed by Schlieder et al. (2010) – are classified as likely new members even in those cases when all of the prescribed membership criteria are fulfilled.

J12210499−7116493: Its position coincides well with the known members of ECA in all age diagnostic figures (Figs 1a, d and e). The star has a somewhat larger HR1 ratio than most of the young group members, similar to the classical T Tauri star MP Mus recently assigned to the ECA by Torres et al. (2008). Kastner et al. (2003) proposed that for T Tauri stars the presence of a star–disc interaction and especially accretion can explain the stronger X-ray hardness ratios. Using the empirical criterion proposed by Barrado y Navascués & Martín (2003) to distinguish between stars with chromospheric activity and objects with accretion, we conclude that the weak Hα emission of J12210499−7116493 (Table 1) may be of chromospheric origin. Based on photometric data from ASAS3, Bernhard, Bernhard & Bernhard (2009) found J12210499−7116493 to be a probable BY Dra type variable star with a period of 6.855 d. Since the properties of J12210499−7116493 fulfilled all of our criteria, we propose it is a likely new member of the ECA.

J01071194−1935359 and J16430128−1754274: All three age determination methods confirm that these stars are likely to be coeval with the BPMG. Although their spatial location somewhat deviates from the location of the known members, we classify both stars as likely new members of the BPMG.

HD 160305: This star is located quite close to three other BPMG stars (GSC 8350−1924, CD-54 7336 and HD 161460), all within a sphere of 14 pc across. The position of the star in the age diagnostic diagrams is in good accordance with the known members of the

BPMG; hence, we identify HD 160305 as a new member of the BPMG.

J19560294−3207186, TYC 7443-1102-1 and J20013718−3313139: Lépine & Simon (2009) proposed that TYC 7443-1102-1 and J19560294−3207186, forming a common proper motion pair, belong to the BPMG. Our observations showed that the radial velocities of the two stars are also in good agreement within the uncertainty of the measurements. J20013718−3313139, one of our candidates, is located at an angular distance of 1°.6 from TYC 7443-1102-1/J19560294−3207186. Both the proper motions ($\mu_\alpha \cos\delta = 27.1 \pm 2.6$ mas, $\mu_\delta = -60.9 \pm 1.8$ mas) and the radial velocities ($v_{\rm rad} = -5.6 \pm 1.8\,{\rm km\,s^{-1}}$) of J20013718−3313139 are in good agreement with the corresponding astrometric properties of TYC 7443-1102-1 ($\mu_\alpha \cos\delta = 30.3 \pm 1.5$ mas, $\mu_\delta = -66.6 \pm 1.0$ mas, $v_{\rm rad} = -7.2 \pm 0.4\,{\rm km\,s^{-1}}$). The derived kinematic distance of J19560294−3207186 is also close to that of TYC 7443-1102-1. We note that all three stars overlap well with the space distribution of previously known BPMG members. Even if J20013718−3313139 and TYC 7443-1102-1/J19560294−3207186 do not form a bound system, the stars are likely to be coeval; therefore, we can combine the results of different age diagnostic methods for the three objects. The absolute magnitudes and the X-ray fractional luminosities (only an upper limit for TYC 7443-1102-1) overlap well with the locus of known BPMG members in the CMD (Fig. 1b) and in X-ray-related diagrams (Fig. 1d). On the other hand, the Li equivalent widths of TYC 7443-1102-1 and J20013718−3313139 (the latter is only an upper limit) are somewhat lower than that of the known members with similar $V - K_{\rm s}$ colour. We classified these three stars as likely new BPMG members.

J01521830−5950168: For stars with $V - K_{\rm s} > 4.5$ in the THA, lithium is burning on a time-scale shorter than the age of the group (∼30 Myr). Thus, this age diagnostic method cannot be used to support or reject the youth of J01521830−5950168. Since both the X-ray properties and the position of the star in the CMD coincide well with the known THA members, we list this object as a likely new member of the THA.

HD 25402: Both the $K_{\rm s}$ absolute magnitude and the measured lithium equivalent width of HD 25402 are consistent with the similar properties of early G-type stars of the THA. The star was not detected in the *ROSAT* survey. HD 25402 is identified as a wide binary system in the CCDM catalogue (Dommanget & Nys 2002). However, according to the UCAC3 catalogue (Zacharias et al. 2010), the proper motion of the proposed companion (CCDM J04005−4145B, $\mu_\alpha \cos\delta = 60.2 \pm 1.7$ mas, $\mu_\delta = -32.4 \pm 1.8$ mas) deviates from the proper motion of HD 25402 ($\mu_\alpha \cos\delta = 70.2 \pm 0.9$ mas, $\mu_\delta = +2.0 \pm 2.1$ mas), implying that a physical connection between these stars is unlikely. Based on the current data, we assign this star to the THA.

5 CONCLUSION

We searched for new members of three young kinematic assemblages (BPMG, ECA and THA) by combining RV data from the RAVE survey with other astrometric information. We used strict selection criteria to filter out false candidates by requiring consistency with the colour–magnitude relationship and X-ray properties of the known members. In addition to recovering 10 known members of the three groups, we identified seven late-type (K, M) new candidates. This list was supplemented by two additional member candidates, HD 25402 and HD 160305, that were selected from the *Hipparcos* catalogue.

Utilizing our new high-resolution spectroscopic observations, we found further pieces of evidence for the membership of our targets. As a result, we identified two new members (one BPMG, one THA) and seven likely members (one ECA, five BPMG, one THA) of the groups. All stars, except TYC 7443-1102-1 and J19560294−3207186, two likely BPMG members identified by Lépine & Simon (2009), are new discoveries. These results demonstrate the potential of the RAVE survey in improving the census of young moving groups. Using the same methods, the searches can be extended to other moving groups as well. Moreover, the final version of the RAVE catalogue will contain data for approximately three times more stars, offering a great opportunity for further steps towards a full census of young kinematic groups in the Galactic neighbourhood.

ACKNOWLEDGMENTS

This project has been supported by the Australian Research Council, the University of Sydney, the 'Lendület' Young Researchers Program of the Hungarian Academy of Sciences, and the Hungarian OTKA Grants K76816, MB0C 81013 and K81966. Funding for RAVE has been provided by the Anglo-Australian Observatory, by the Astrophysical Institute Potsdam, by the Australian Research Council, by the German Research foundation, by the National Institute for Astrophysics at Padova, by The Johns Hopkins University, by the Netherlands Research School for Astronomy, by the Natural Sciences and Engineering Research Council of Canada, by the Slovenian Research Agency, by the Swiss National Science Foundation, by the National Science Foundation of the USA (AST-0508996), by the Netherlands Organisation for Scientific Research, by the Particle Physics and Astronomy Research Council of the UK, by Opticon, by Strasbourg Observatory, and by the Universities of Basel, Cambridge and Groningen. The RAVE website is at www.rave-survey.org.

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