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The Status of ROSAT X-ray Active Young Stars toward Taurus-Auriga

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Abstract We present an astrometric study of the candidates of T Tauri stars (TTS) and non-TTS X-ray sources around Tau-Aur, based on the Hipparcos Catalogue and the ACT Reference Catalogue. The ROSAT selected X-ray sources are found to be a mixed population. A few of them are associated with the Tau-Aur or Orion Star Forming Regions (SFR). Some, with distances similar to that of Tau-Aur but with discrepant proper motions, are probable or sure Pleiades super-cluster members or other late type young active stars with unresolved nature, more likely to originate in rapidly moving cloudlets, or else having originated from different sites other than Tau-Aur and moved to the present locations. A good many of the non-TTS X-ray sources are considered as Hyades cluster members. Some TTS candidates could be foreground pre-main sequence stars or actually young dwarfs not yet depleted of their Lithium. Under the hypothesis that the sources we studied are representative of the ROSAT selected TTS candidates discovered in the outskirts of the Tau-Aur region, we conclude that only up to one third of the weak-line TTS candidates could be expected to be physically associated with the Tau-Aur association. Along with the parallax and proper motion analysis of the non-TTS X-ray sources around the Tau-Aur SFR, our result suggests that the vast majority of the young active X-ray sources within an angular diameter of about 30° of the Tau-Aur SFR, belong to four main subgroups that are spatially separate.

Key words: stars: formation — stars: pre-main sequence — stars: late-type — Astrometry

1 INTRODUCTION

The T association Tau-Aur is one of the most widely studied Star Forming Regions (SFR) in the vicinity of the Sun. A good deal of previously known pre-main sequence (PMS) stars in this region are Classical T Tauri stars (CTTS) discovered by objective prism surveys from their conspicuous optical emission lines including Hα. The CTTS are also characterized by CaII H & K emissions, and apparent UV and IR excesses, mainly due to the presence of a circumstellar disk. The advent of the ROSAT mission made it possible to identify hundreds more weak-line T Tauri stars (WTTS), which are apparent X-ray emitters with optical properties significantly different from those of the CTTS. A total of 76 TTS (T Tauri stars), comprising 4 CTTS and 72 WTTS, have been discovered in the central part of Tau-Aur ($4^{\rm h} < \alpha < 5^{\rm h}$, $15° < \delta < 35°$, Wichmann et al. 1996, hereafter W96). In addition, about 78 TTS candidates have been identified in the outskirts of the Tau-Aur region (Li & Hu 1998, hereafter LH98; Li & Hu 2000), based on both the ROSAT All-Sky Survey Bright Source Catalog (RASS-BSC) and the ROSAT PSPC pointed observations. Some more were found (Neuhauser et al. 1995; Magazzu et al. 1997; Neuhauser et al. 1997) in an area that overlaps a little with the region surveyed by LH98, and extends further to the south of Tau-Aur, when attempting to learn more on the origin of the WTTS identified in the far-reaches of nearby SFRs.

Up to now, nearly the whole region of Tau-Aur has been surveyed for low-mass pre-main sequence stars (PMS) based on ROSAT. Further research on the nature of the widely distributed WTTS in and around the Tau-Aur SFR is needed. Here, we aim at the question whether or not all these ROSAT selected WTTS are kinematically associated with Tau-Aur, especially those found in regions far from the center (LH98; Neuhauser et al. 1995; Magazzu et al. 1997; Neuhauser et al. 1997). We are also concerned with the question whether they are bona-fide WTTS or, rather, they are ZAMS (zero-age main sequence) stars similar to the Pleiades stars. A proper motion study of the PMS in the core area of Tau-Aur was made by Frink et al. (1997) based on the STARNET catalogue. Membership investigation of the ROSAT sources, including the non-TTS X-ray active sources in the surrounding area of Tau-Aur (LH98), is checked to some extent in this paper.

2 DATA ACQUISITION AND ANALYSIS

In this study, available astrometric data of the TTS candidates discovered by LH98, previously known low-mass PMS prior to the ROSAT mission, and the ROSAT revealed TTS in the central part of Tau-Aur (W96), are extracted from the Hipparcos Catalogue, one of the primary products of the European Space Agency's astrometric mission, Hipparcos. The catalogue contains a large quantity of very high quality astrometric and photometric data for 118 218 stars. The the accuracy of parallax in the Hipparcos Catalogue is better than a few mas, and that of proper motion, a few mas yr^{-1}.

Additional proper motions of dozens of WTTS candidates around the Tau-Aur SFR are obtained from the ACT Reference Catalogue of 988 758 stars, which was based on new reductions of the Astrographic Catalogue (AC 2000) and the Tycho Catalogue (ESA SP-1200) and which aimed at providing accurate proper motions for the majority of the Tycho stars.

Proper motions about an order of magnitude more accurate than those published in the Tycho Catalogue are provided on the Hipparcos reference frame (J2000.0).

2.1 TTS Parallaxes and Proper Motions Known Prior to ROSAT

Ten of the previously known TTS before ROSAT (Leinert, Weitzel & Zinnecker et al. 1993) are identified in the Hipparcos Catalogue. Their trigonometric parallaxes and proper motions are provided in Table 1 to further clarify their true membership of Tau-Aur, though proper motion study with similar accuracy has already been included in Frink et al. (1997). These TTS, along with the WTTS in the center of Tau-Aur (W96), are taken as a control sample. Six of the PMS candidates, with trigonometric parallaxes commensurate with that of the Tau-Aur association (7.14 mas if a distance of 140 pc is adopted) and proper motions sharing the Tau-Aur mean motion ($\mu_\alpha\cos\delta$=4.0, $\mu_\delta = -18.7\,\mathrm{mas\,yr^{-1}}$), are believed to be physical members of Tau-Aur. The T-association membership of source 42b in Frink et al. (1997) remains ambiguous, since a negative parallax is provided by the Hipparcos Catalogue indicating unreliability of the calculated parallax.

Table 1 Astrometric Data of Pre-ROSAT & ROSAT Selected TTS from Hipparcos Catalogue

No.	Hipp.	V	π	$\mu_\alpha\cos\delta$	μ_δ	$\sigma\pi$	$\sigma\mu_\alpha$	$\sigma\mu_\delta$	$B-V$	e_{B-V}	peri.	ty.	comments
TTS known before ROSAT (Leinert, Weitzel & Zinnecker et al. 1993)													
367	19762	10.71	9.88	0.65	–24.89	2.71	2.55	1.89	1.079	0.169		U	Tau-Aur CTTS
29	20097	10.78	7.31	6.04	–27.44	2.07	2.38	1.77	1.330	0.199	3.74	P	Tau-Aur WTTS
32	20160	11.96	18.98	5.28	–33.13	4.65	5.43	3.94				U	foreground CTTS
34	20387	10.20	7.49	9.08	–23.05	2.18	2.62	1.89	0.915	0.078		U	Tau-Aur CTTS
380	20388	9.02	7.81	7.52	–27.45	1.30	1.57	1.14	0.798	0.025		U	Tau-Aur WTTS
35	20390	9.81	5.66	15.45	–12.48	1.58	1.88	1.62	1.116	0.072		U	Tau-Aur CTTS
36	20777	11.96	25.72	14.48	–26.38	6.36	6.25	4.26	1.470	0.510		U	foreground CTTS
42b	20990	11.03	–6.68	8.59	–27.42	4.04	5.08	3.78				U	Tau-Aur WTTS?
79	22925	9.23	6.58	0.17	–21.69	1.92	2.24	1.28	0.833	0.056		U	Tau-Aur CTTS
81b	23873	10.20	14.18	9.69	–21.92	6.84	7.36	3.91	0.469	0.063		U	foreground CTTS
ROSAT selected WTTS in Tau-Aur (W96)													
6	19176	9.57	6.43	6.00	–15.40	1.84	1.65	1.24	0.699	0.047			Tau-Aur WTTS
30	20782	9.57	7.69	–5.93	–33.28	417.39	25.67	20.88	0.609	0.053		D	Tau-Aur WTTS
50	21852	9.55	8.68	–0.70	–20.56	1.35	1.35	1.04	0.667	0.032			Tau-Aur WTTS
ROSAT selected PMS candidates around Tau-Aur (LH98)													
044	14809	8.51	20.24	56.04	–125.11	1.42	1.68	1.72	0.710	0.126		D	foreground PMS/ZAMS
062	15844	10.38	50.54	217.18	–129.17	4.66	4.39	3.47	1.510	0.015		D	foreground PMS/ZAMS
063	15850	6.03	7.06	25.97	–21.32	0.86	0.95	0.75	1.227	0.003		C	Tau-Aur WTTS
119	18263	10.94	6.64	20.29	–48.98	2.81	3.01	2.28	0.714	0.015		C	Pleiades member
143	21697	9.62	8.90	30.66	–52.21	2.96	3.45	2.30	0.798	0.056			Pleiades member?
200	25730	6.20	11.24	28.97	–46.89	0.84	0.86	0.47	0.476	0.006		C	Pleiades member
204	25848	9.17	9.61	7.50	–38.97	1.64	1.61	0.77	0.649	0.035		U	Tau-Aur WTTS
197	25689	9.85	3.25	1.13	3.18	1.44	1.51	0.85	0.970	0.071		U	Orion CTTS

Sequential number as indicated in the corresponding reference, Hipparcos Catalogue number, V magnitude, Trigonometric parallax (mas), proper motions (mas yr^{-1}), standard error of parallax and proper motions, color index $B-V$, standard error of $B-V$, period for variables in day, variable type (see note) and membership classification.

*Note on variable type: P: periodic variable; C: no variability detected; D: duplicity-induced variability; U: unsolved variable.

If we assume that the Tau-Aur T-association has the same extent along the line-of-sight as the region surveyed by LH98 in the tangential direction which is about 30° ($\sim$ 70 pc) at a distance of 140 pc, then a source can be considered as a possible cloud member if a distance between 115 pc and 175 pc (corresponding to a trigonometric parallax from about 10 to 6 mas), would make it share the Tau-Aur mean proper motion. Based on this hypothesis, three of the pre-ROSAT TTS are possibly located in the foreground, though their proper motions are similar to that of the Tau-Aur association. However, these sources all have a magnitude of around 11 and could have severely suffered from the Lutz-Kelker effect in the parallax measurements (Lutz & Kelker 1973).

2.2 Membership of the ROSAT Selected TTS in the Tau-Aur Core

Trigonometric parallaxes and proper motions of 3 of the 76 ROSAT selected TTS (W96) in the central part of Tau-Aur are available in the Hipparcos Catalogue, all have parallaxes within the distance span given in the previous section and proper motions consistent with that of Tau-

Aur. These are classified as sure members of the Tau-Aur T-association and their astrometric data are presented in the middle part of Table 1. These three TTS in the central part of Tau-Aur, though too few to be statistically meaningful, give a formal mean proper motion of ($\mu_\alpha \cos\delta$=4.25, $\mu_\delta = -22.91\,\mathrm{mas\ yr^{-1}}$).

2.3 Kinematics Study of ROSAT Selected X-ray Sources around Tau-Aur

2.3.1 ROSAT Selected TTS Candidates Surrounding the Tau-Aur SFR

LH98 has uncovered about 75 WTTS and 1 CTTS candidates in the outer region of Tau-Aur. A great part of these TTS candidates have W_λ(LiI) above the Pleiades ZAMS of the same spectral types and are possibly bona-fide PMS far away from the center of the Tau-Aur molecular clouds, where most of the previously known CTTS were found to congregate. It is important to investigate the true nature of these PMS candidates around the Tau-Aur core, which will add greatly to our knowledge of star formation history in nearby SFRs such as Tau-Aur.

Eight of the ROSAT selected PMS candidates (including the only one CTTS) around Tau-Aur (LH98) are identified in the Hipparcos Catalogue. Eight TTS candidates are found to have complicated nature. The astrometric data of these are presented in the lower part of Table 1. Two of the eight (No. 063 and No. 204) are found to be kinematically associated with Tau-Aur. The slight difference of proper motion between the two and the Tau-Aur mean is supposed to be due to the large extent of the region concerned. The only CTTS candidate revealed by LH98 turns out to be consistent with the Orion T-association in trigonometric parallax (about 2.17 mas, or a distance of $\sim$ 460 pc, Alcala et al. (1998)). Three WTTS candidates (Nos. 119, 143 and 200), with trigonometric parallaxes and proper motions similar to those of the Pleiades Cluster (8 mas if a distance of 127 pc is adopted, Crawford & Perry (1976); Stauffer (1984); Gagne et al. (1995); μ_α=16, $\mu_\delta = -44\,\mathrm{mas\ yr^{-1}}$, Frink et al. (1997)), are believed to be probable Pleiades low mass members, though No. 143 and No. 200 are located far away from the center of the Pleiades super-cluster (α=3$^{\mathrm{h}}$45$^{\mathrm{m}}$, δ=24°30$^{'}$). Source No. 143 could well be a Pleiades ZAMS because it has a comparable LiI abundance to the Pleiades ZAMS with the same spectral type. No. 044 resides at a distance consistent with Hyades (45 pc) and is classified as a possible Hyades cluster member but not yet depleted of its surface Lithium. No. 062, which has a large trigonometric parallax and discordant proper motions, is considered to be a foreground PMS candidate.

All the Tau-Aur TTS, confirmed on the Hipparcos parallaxes and proper motions, are plotted in the H-R diagram (Fig. 1) for an investigation of their evolutionary status. Theoretical PMS evolutionary tracks from Forestini (1994) are taken and the H-R diagram is transformed to M_v vs. $B-V$ color to facilitate comparisons with the observational data. The V magnitude and $B-V$ color of the targets determined by the Hipparcos are used in the plot. Some TTS appear to be approximate to or below the ZAMS, which can be attributed to inhomogeneous extinction in different regions of Tau-Aur.

In addition, proper motions of 25 more WTTS candidates (LH98) were extracted from the ACT Reference Catalogue and presented in Table 2. Eleven of these have proper motions similar to the Tau-Aur mean proper motion and are classified as probable members of the T-association. The other eight, with proper motions agreeing well with the Pleiades super-cluster mean, are thought to be Pleiades low-mass cluster members and run-away stars of similar age (see Fig. 2 & Fig. 3). The remaining six are considered as foreground WTTS candidates not originating from Tau-Aur.

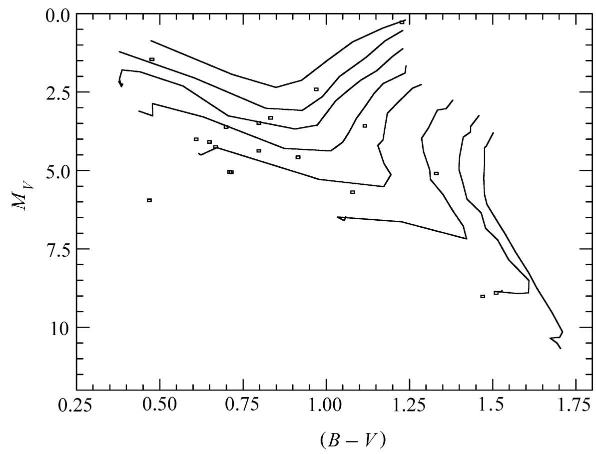

Fig. 1 Evolutionary status of the Tau-Aur TTS (Table 1) on the HR diagram M_v vs. $(B-V)$. From bottom up, the plotted PMS tracks correspond to masses of 2.5, 2.0, 1.7, 1.4, 1.1, 0.8, 0.6 and 0.5 $M_\odot$.

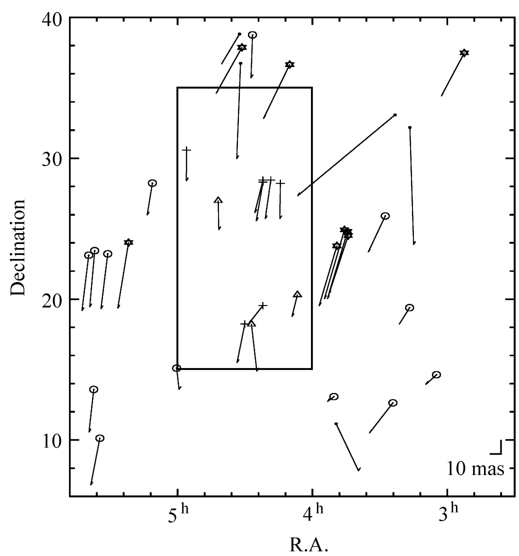

Fig. 2 Spatial dispersion of the Tau-Aur TTS and non-TTS X-ray sources classified as association members (also plotted are the positions and proper motions of probable Pleiades supercluster members and run-away stars). Solid pre-ROSAT TTS identified in Hipparcos Catalogue are marked with pluses, ROSAT selected WTTS in the core area of Tau-Aur (W96) with triangles, ROSAT selected TTS candidates (both from Hipparcos Catalog and ACT Reference Catalog) around the Tau-Aur SFR (LH98) with circles and other non-TTS X-ray sources are marked as dots (probable Pleiades members as stars).

Table 2 Proper Motions of WTTS Candidates (LH98) from ACT Reference Catalogue

No.	R.A.(J2000)	Dec.(J2000)	$\mu_\alpha\cos\delta$	μ_δ	$\sigma\mu_\alpha$	$\sigma\mu_\delta$	V	$B-V$	H.D.
WTTS candidates with proper motions consistent with the Tau-Aur mean									
067	3 27 32.46	25 54 0.320	18.90	–25.50	0.91	1.77	9.341	0.651	0
107	3 50 24.95	13 4 13.977	6.90	–3.40	1.15	1.08	10.869	0.656	0
219	5 39 30.94	23 6 32.733	7.50	–39.30	1.34	1.03	9.808	0.880	245924
040	3 4 44.50	14 37 28.239	12.00	–6.90	1.22	1.00	10.656	0.804	0
053	3 16 43.87	19 23 4.187	11.55	–11.70	0.98	1.50	11.074	0.309	0
136	4 26 37.38	38 45 2.302	1.65	–30.40	5.21	2.47	10.878	0.734	0
155	5 0 24.31	15 5 25.269	–2.70	–15.10	0.97	0.95	9.917	0.559	31950
175	5 11 10.54	28 13 50.422	5.85	–22.60	4.83	3.70	10.658	0.951	0
213	5 36 51.67	23 26 5.378	5.55	–39.90	0.83	1.12	8.877	0.713	245358
214	5 37 18.43	13 34 52.526	5.25	–30.20	1.08	2.12	9.606	0.755	245567
208	5 34 34.90	10 7 6.364	10.05	–33.10	2.39	3.07	10.162	0.709	245059
WTTS candidates with proper motions consistent with Pleiades									
137	4 31 18.90	37 51 52.634	28.65	–32.50	1.84	1.85	11.500	0.628	279935
088	3 44 3.53	24 30 15.252	23.10	–44.70	2.45	3.14	11.047	0.817	0
091	3 44 20.09	24 47 46.218	20.85	–44.40	2.71	4.62	10.509	0.776	0
097	3 45 42.11	24 54 21.659	22.35	–48.80	2.32	0.85	9.707	0.693	0
103	3 49 6.12	23 46 52.630	19.65	–42.50	1.24	1.42	10.874	0.000	0
131	4 10 4.69	36 39 12.237	29.10	–38.30	1.37	1.36	9.528	0.559	26182
018	2 52 24.72	37 28 51.727	25.35	–30.50	2.17	3.62	10.719	0.574	0
184	5 21 46.83	24 0 44.432	12.00	–46.60	0.90	0.86	10.658	1.042	0
WTTS candidates with proper motions significantly different from the Tau-Aur mean									
017	2 52 17.59	36 16 48.151	63.75	–40.60	6.93	2.98	10.703	0.985	0
042	3 7 59.21	30 20 26.076	37.35	–70.80	0.92	2.61	9.272	0.677	0
073	3 35 29.90	31 13 37.458	48.45	–45.00	3.55	3.45	8.990	0.618	22179
092	3 44 24.24	28 12 23.220	48.60	–51.90	3.46	0.85	8.893	0.621	0
145	4 41 1.33	39 29 0.893	–34.50	–30.10	4.90	12.18	10.886	0.000	0
212	5 36 50.05	13 37 56.097	3.00	–107.70	1.17	1.05	10.768	0.760	0

2.3.2 Non-TTS X-ray Sources around Tau-Aur

For nine possible cloud members and 18 optical counterparts of corresponding X-ray sources around Tau-Aur (LH98), identified simply on the basis of their Li abundance, the astrometric data are also extracted from the Hipparcos Catalogue and presented in Table 3.

Two of the 27 non-TTS X-ray sources (Nos. 138 and 139), with proper motions and parallaxes comparable to those of the Tau-Aur Association, are considered to be association members. Another 3 (Nos. 104, 051 and 060), having proper motions significantly greater than the Tau-Aur mean but similar parallaxes, are more likely to be formed in rapidly moving cloudlets (Feigelson 1996), or else originated differently from the Tau-Aur SFR and migrated to the present locations. No. 130, 159 and 167 are considered as possible Orion association members for having consistent trigonometric parallaxes; they could otherwise be associated with the Gould Belt (Guillout et al. 1998). All the others are suggested to be foreground sources, mostly Hyades cluster members with similar distances and proper motions.

Spatial dispersion of the Tau-Aur TTS identified in this study is presented in Fig. 2. Young active X-ray sources considered as association members rather than TTS are also shown. The proper motions of the sources in Fig. 2 are plotted in Fig. 3. As indicated, young X-ray sources associated with Tau-Aur and those of the Pleiades super-cluster could be easily distinguished from their congregating in different parts of the diagram.

Table 3 Non-TTS Astrometric Data from Hipparcos Catalogue

No.	Hipp.	V	π	$\mu_\alpha\cos\delta$	μ_δ	$\sigma\pi$	$\sigma\mu_\alpha$	$\sigma\mu_\delta$	$B-V$	e_{B-V}	peri.	ty.	comments
Possible Tau-Aur cloud members as classified in LH98													
014	13246	8.46	14.15	–10.33	–108.18	1.35	1.71	1.21	0.813	0.022		U	foreground ZAMS
066	16042	6.47	19.91	41.35	–104.29	1.25	1.41	1.35	0.882	0.007	6.39	P	foreground variable
104	17873	7.64	8.73	–24.87	–33.31	1.03	1.12	0.98	0.729	0.015		U	Tau-Aur?
125	18986	7.13	27.42	144.21	–97.59	1.46	1.57	1.36	0.680	0.015		D	foreground
130	19359	8.76	3.45	–10.34	–22.81	1.78	3.20	3.64	0.668	0.042			Orion ZAMS
133	19796	7.11	21.08	119.81	–5.22	0.97	1.12	1.03	0.514	0.008		C	Hyades*
139	21178	8.81	9.66	19.91	–21.08	3.15	2.80	2.13	0.560	0.025		D	Tau-Aur ZAMS
191	25278	5.00	68.19	250.40	–7.42	0.94	0.88	0.61	0.544	0.004	3.65	P	foreground variable
054	15300	11.11	29.49	182.90	–47.44	4.70	5.12	4.55	1.408	0.007		D	Hyades*
Optical counterparts of corresponding X-ray sources (LH98)													
010	13118	6.94	22.73	212.44	–174.20	0.89	0.88	0.74	0.956	0.005	16.58	P	foreground variable
026	13801	9.87	16.51	–25.05	–92.03	1.51	1.45	1.24	0.774	0.056		U	foreground
036	14152	7.92	13.81	101.08	–31.70	1.16	1.31	0.97	0.506	0.015		C	foreground
044s	14807	10.55	19.36	59.21	–129.85	3.04	3.69	3.67				D	foreground
051	15241	5.98	5.92	–4.10	–83.07	1.01	0.80	0.81	0.988	0.005		U	Tau-Aur?
060	15767	7.96	8.09	108.28	–57.43	1.06	1.01	1.10	0.598	0.015			Tau-Aur?
071	16713	6.66	14.75	54.98	–41.96	1.87	1.93	1.87	0.429	0.008			foreground
075	16879	7.28	26.78	237.51	–271.85	0.95	0.96	0.84	0.704	0.015	24.53	P	foreground variable
077	17076	8.24	27.18	188.20	–193.16	1.40	1.57	1.28	0.810	0.020		U	foreground
078s	17102	9.03	20.03	–39.81	–5.41	2.14	2.29	2.19	1.090	0.015			foreground
106	17928	7.29	26.91	155.06	–63.56	1.13	1.12	0.88	0.538	0.015			foreground
127	19255	7.13	48.59	172.94	–226.60	1.17	1.01	0.89	0.865	0.008		D	foreground
129	19335	5.52	46.87	163.93	–203.52	0.77	0.65	0.55	0.520	0.005	3.05	P	foreground variable
138	21144	6.35	8.47	4.23	–67.69	0.87	0.77	0.71	1.089	0.020	12.56	P	Tau-Aur variable
140	21179	11.00	17.55	102.37	–18.77	2.97	3.58	2.75	1.194	0.006	1.48	P	Hyades variable*
151	22607	6.30	23.91	106.84	–16.00	1.04	1.18	0.74	0.502	0.007		D	Hyades*
159	23371	8.64	2.44	–9.00	–8.49	1.32	1.41	1.01	1.270	0.020		D	Orion
167	23898	7.88	3.53	–0.34	–6.46	1.08	0.97	0.63	1.001	0.016			Orion?

*Perryman et al. 1998

3 SUMMARY AND DISCUSSION

We have identified 13 previously known TTS from Leinert et al. (1993) and W96 in the Hipparcos Catalogue. Except three with discrepant parallaxes, all are believed to be sure Tau-Aur members and with a mean proper motion ($\mu_\alpha\cos\delta$=4.25, $\mu_\delta = -22.91\,\mathrm{mas\ yr}^{-1}$).

Proper motions of 33 TTS candidates from LH98 are extracted from both the Hipparcos Catalog and the ACT Reference Catalogue, 13 are possibly associated with Tau-Aur though their proper motions are somewhat different from the Tau-Aur mean;— this is believed to be due to the large sky area involved. If the TTS studied in this paper are representative of the TTS candidates discovered by LH98, then only up to one third of the 76 TTS candidates around

Tau-Aur could be associated with the Tau-Aur SFR and they might have originated differently from the TTS identified in the inner part of Tau-Aur. We believe that the majority of the physical TTS members of Tau-Aur would still be limited to the intensely obscured regions or the core area.

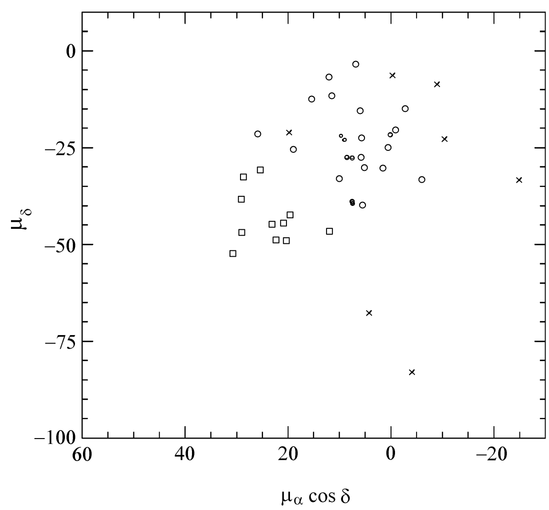

Fig. 3 Proper motions of Tau-Aur association members and probable Pleiades super-cluster members. The Tau-Aur TTS are marked as circles, the non-TTS X-ray sources, as crosses and the Pleiades super-cluster members, as boxes.

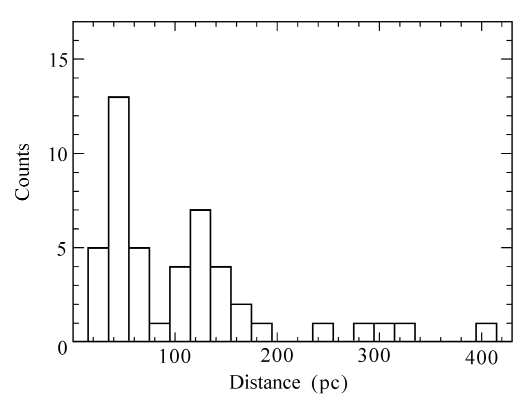

Fig. 4 Spatial distribution of the young active X-ray sources within an angular diameter of 30° in the direction of the Tau-Aur SFR.

As we have indicated, the TTS candidates identified in the outskirts of Tau-Aur are actually a mixture of young X-ray active sources from different origins. Eleven of the TTS are probable Pleiades members, and of which seven could be projected right onto the Pleiades super-cluster. The other four, located far away from the Pleiades center, are possible run-away stars during the early evolution of the cluster. The probable CTTS (No. 197) in LH98 and a few non-TTS X-ray sources are found to have parallaxes and proper motions close to those of the Orion SFR, which is located at a distance several times further than Tau-Aur. For the non-TTS X-ray sources we have been involved with, only a few could be associated with Tau-Aur or Orion, the majority are probably foreground young active stars (Perryman et al. 1998).

Both the parallaxes and proper motions of 48 young active X-ray sources located within an angular diameter of 30° toward the Tau-Aur SFR have been presented in this paper, which allows us to statistically investigate their spatial distribution along the line of sight. Based on the analysis in previous sections, the sample of ROSAT X-ray sources can definitely be divided into several major subgroups in the direction of Tau-Aur, namely, active X-ray sources dominated by the Hyades and Pleiades cluster members in the front, physical members of the Tau-Aur T association in the middle and those associated with Orion at the back (Fig. 4). Furthermore, there is a noticeable congregation of young active X-ray sources located between about 100 pc and 180 pc (Fig. 4), that may indicate our assumption in Sect. 2.1 on the size of the Tau-Aur T association along the line of sight is reasonable. However, the distance of the center of the Tau-Aur T association is still hard to define from Fig. 4, because of the spatial proximity of Tau-Aur and Pleiades.

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