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$ROSAT$ HRI observations of the intermediate-age open cluster IC 4756

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Abstract. We have obtained an 88 kilosecond $ROSAT$ HRI exposure of the intermediate-age open cluster IC 4756 with the purpose of detecting stars in the high luminosity tail ($\log L_X \geq 10^{29}$ erg s^{-1}) of its X-ray luminosity distribution. However, only 1 cluster member (HSS 201) out of the 60 members inside the central high-sensitivity region of the HRI field of view (FOV) was detected. This star has spectral type A8, suggesting a close binary system with a low mass X-ray emitting companion. We compare the distribution of upper limits for F and G-type dwarfs in IC 4756 with the X-ray distribution functions of the similarly aged Hyades and Praesepe clusters. The results of this statistical analysis are inconclusive for G-type stars, but suggest that at least F-type stars in IC 4756 are not as X-ray luminous as their Hyades counterparts, thus indicating intrinsic differences between the two clusters. Finally, our data indicate a deficit of very active binaries with respect to both Hyades and Praesepe, and older open clusters.

Key words: stars: activity – X-rays: stars – open clusters and associations: individual: IC 4756

1. Introduction

Open clusters are one of the basic stellar components of our Galaxy and form the primary tools for astronomers studying star formation and stellar evolution. The comparison of stars in the same cluster allows the study of different stellar properties, such as chromospheric and coronal emission, mass, rotation rate, binarity, etc., for a coeval ensemble of stars, whereas the comparison of clusters of different ages tells us about the evolution of these properties with time. Finally, the study of two or more clusters with similar ages makes it possible to address the question whether and to what extent, in an ensemble of stars, properties such as rotation and coronal activity are a function of age alone (i.e., with no dependence on such other cluster properties as, for example, the angular momentum of the original star-forming molecular cloud).

The launch of the $ROSAT$ satellite has provided an opportunity to carry out sensitive X-ray surveys of a variety of open clusters covering the whole age range from the very youngest recognizable clusters such as the Orion Trapezium Cluster, with ages $\sim 1-3$ million years, up to the oldest open clusters like NGC 188 with ages of ≥ 6 billion years (e.g., Caillault 1996 and references therein; Randich 1998 and references therein; Belloni 1998 and references therein). The issue of the time evolution of X-ray emission has been addressed in some detail and a number of papers present $ROSAT$ observations and derive results focusing on the age - rotation - X-ray activity paradigm (e.g., Patten and Simon 1996; Randich et al. 1995, 1996; Prosser et al. 1996; Micela et al. 1996; Stauffer et al. 1994). The general (anti-)correlation of X-ray activity with age, previously deduced from *Einstein Observatory* data (e.g., Stern et al. 1981; Caillault & Helfand 1985; Micela et al. 1988, 1990) has been confirmed, although the functional dependence of X-ray emission on age has been shown to be different for different masses and to not be as simple as a Skumanich-type ($t^{-1/2}$) law (e.g., Patten & Simon 1996). In addition, a surprising exception to the general scheme of activity declining with age has been found: two clusters of essentially identical ages, the Hyades and Praesepe, nevertheless do show significant differences in their X-ray luminosity distributions. Almost all of the F and G-type Hyades (age ~ 600 Myr, distance=46 pc) dwarfs were detected in the $ROSAT$ All-Sky Survey (RASS) above a limiting sensitivity of the order of $\log \mathrm{L_X} \simeq 28.3$ ergs s^{-1} (e.g., Stern et al. 1995), and a median X-ray luminosity of $\log \mathrm{L_X} \sim 28.9$ was deduced. On the contrary, barely 30% of the F and G dwarfs were detected in Praesepe (age ~ 600 Myr, distance=179 pc) by Randich & Schmitt (1995) above a sensitivity threshold (with respect to X-ray luminosity) which, in the deepest part of the image, was comparable to that of RASS for the Hyades. A small fraction of Praesepe members, mostly binaries, exhibited very high X-ray luminosities, similar or even higher than their Hyades counterparts; however, the bulk of Praesepe population appeared considerably less X-ray luminous than the Hyades.

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Randich & Schmitt (1995) suggested possible causes for this dichotomy, but could not offer any definitive explanation. More recently, Mermilliod (1998) has shown that the distribution of rotation rates of Praesepe solar-type stars does not differ significantly from that of the Hyades, and thus a difference in the average rotational properties cannot be invoked as the cause for the discrepancy in the X-ray properties. In addition, Barrado Y Navascués et al. (1998) demonstrated that such a discrepancy cannot be explained by contamination of the Praesepe sample with spurious members; they also showed that the level of chromospheric emission, at least as far as M dwarfs are concerned, is comparable in the two clusters.

Existing $ROSAT$ observations are not sensitive enough to detect main sequence solar-type stars in clusters older than Hyades. This is basically due to the large distances of such clusters from the Sun; X-ray emission at solar levels can be detected only in the immediate environment of the Sun (d $<$ 10 pc; Schmitt 1997). However, in all the intermediate age/old open clusters surveyed to date (M67, 4.5 Gyr, Belloni et al. 1993; NGC 752, 2 Gyr, Belloni & Verbunt 1996; NGC 6940, 1 Gyr, Belloni & Tagliaferri 1997; IC 4651, 2 Gyr, Belloni & Tagliaferri 1998), a significant number of short-period, active RS CVn - type giant binary stars has been detected.

As a consequence, it is unclear at present whether one should consider the Hyades stars as X-ray overluminous or the Praesepe stars as X-ray underluminous and studies of further clusters with the same age are required to settle this issue. Here we present $ROSAT$ observations of intermediate-age open cluster IC 4756. An age of $\sim$ 800 Myr is generally quoted for this cluster (e.g. Gilroy 1989; Phelps et al. 1994), but a larger age of 1-2 Gyr is also reported by some authors (e.g., Strobel 1991; Mermilliod & Mayor 1990). A comparison is, therefore, due with both the Hyades and Praesepe, and the older clusters. The original goal of the $ROSAT$ proposal was to reach a sensitivity comparable to the median luminosity of the Hyades. Unfortunately, only ~ 50 % of the time was actually acquired, and therefore, given the distance to the cluster (d = 390 pc; Herzog et al. 1975) and its average reddening, E_{B-V} = 0.19, our 88 ksec pointing was not sufficiently sensitive to attain the originally proposed sensitivity. In consequence we are not able to survey the X-ray properties of the bulk of IC 4756 population, unless the stellar population of this cluster was considerably more X-ray luminous than that of the Hyades. Nevertheless, our data are sensitive enough to allow us to *i)* sample those stars in IC 4756 with X-ray luminosities similar to those in the high luminosity tails of the X-ray luminosity distribution function (XLDF) of the Hyades and Praesepe clusters, and therefore to detect active binary dwarf stars, if present, in the cluster; *ii)* to detect very active giant stars (presumably due to their being in binary systems), such as have been detected in other intermediate-age and old open clusters.

The plan of our paper is as follows: In Sect. 2, we discuss the optical catalog used for this study of the cluster IC 4756, in Sect. 3 we give the details of the $ROSAT$ data and the adopted analysis techniques, in Sect. 4 we present our X-ray results for this cluster and compare them with previous studies of other clusters, and in Sect. 5 we summarize our conclusions.

2. Optical catalog

Proper motion and photometric studies of IC 4756 have been carried out by Kopff (1943), Alcaino (1965), Seggewiss (1968), and Herzog et al. (1975). In particular, Herzog et al. (1975) present proper motions for 464 stars in the cluster field down to a limiting magnitude of B $\simeq$ 14, together with UBV photometry for 471 objects down to a limiting magnitude B $\simeq$ 15, which corresponds to a spectral-type $\sim$ G6 – G8 for dwarfs. About 110 out of the 293 objects common to both the proper motion and photometric surveys were found to be probable cluster members. Radial velocity measurements have been carried out only for a restricted number of giant stars (Mermilliod & Mayor 1990) and no complete, more recent membership studies exist. Therefore, our input cluster catalog is based on Herzog et al. (1975). The full field of view (radius= 18 arc minutes) of the High Resolution Imager (HRI) on $ROSAT$ (see Zombeck et al. 1990 and Trümper et al. 1991 for a description of this instrument) used for this observation includes 214 stars for which proper motion data are available. Of these stars, 86 have membership probability larger than 85%, and, according to Herzog et al. (1975), are also photometric members of the cluster. 60 of these most likely members are included in the inner region of the HRI field (radius = 15 arc mins).

Equatorial coordinates (B1950.0) were kindly provided by Dr. J.-C. Mermilliod (private communication) for a subset of cluster members within the HRI field of view. For additional cluster stars in the HRI field, having rectangular plate coordinates tabulated by Herzog et al. (1975), celestial coordinates were derived in the usual manner, as described in standard references, such as König (1962).

3. The $ROSAT$ observations

IC 4756 was observed with the High Resolution Imager on board $ROSAT$ between Sep. 16, 1996, 20:28 UT and Sep. 27, 1996, 20:07 UT. The net exposure time was 87.8 kiloseconds. The nominal pointing position was RA = $18^h31^m31.2^s$ and DEC = $+05^\circ\ 29^{'}24.0^{''}$ (J2000.). The field was centered on the G-type star HSS 194 (henceforth we will use HSS to denote the stars in Herzog et al. (1975) catalog) and was chosen so to include as many F and G-type stars as possible.

The analysis was carried out using EXSAS routines (Zimmerman et al. 1994) running under MIDAS. The following standard steps were carried out for data reduction: i) a photon image was generated from the the Photon Events Table (PET); ii) a background map was then created by removing from the photon image all possible sources and then smoothing with a spline filter technique; iii) source detection was performed using the Maximum Likelihood (ML) algorithm (Cruddace et al. 1988). We chose ML = 10 as a threshold, which corresponds to a significance of 4σ. In this way, 10 sources were detected in the whole HRI field. No additional sources were detected by using

Table 1. Detected sources

source #	RA	DEC	ML	rate	optical	Δr	Notes
	(J2000.)			(cts/s)	counterpart	(arcsec)	
1	18 38 20.04	+05 24 57.9	19	0.0004 ± 0.00009	–	–	A
2	18 38 31.20	+05 23 09.0	13	0.0003 ± 0.00009	–	–	B
3	18 38 31.87	+05 31 52.0	25	0.0004 ± 0.00009	–	–	C
4	18 38 35.66	+05 34 51.5	52	0.0008 ± 0.00012	HSS 201/ BD +05 3863	2.7	D
5	18 38 36.90	+05 35 45.5	11	0.0003 ± 0.00008	–	–	E
6	18 38 37.80	+05 33 59.0	28	0.0004 ± 0.00009	–	–	F
7	18 38 50.93	+05 31 54.4	98	0.001 ± 0.0001	HSS 247	1.7	G
8	18 39 04.68	+05 19 34.4	20	0.001 ± 0.0002	–	–	H
9	18 39 05.57	+05 35 00.9	29	0.0009 ± 0.0001	–	–	I
10	18 39 05.67	+05 34 23.4	90	0.0016 ± 0.0002	GSC 0455 00727	0.5	J

A: 2-3 faint unclassified stars in the error circle.
B: A couple of faint unclassified objects in the error circle.
C: 1 very faint object in the error circle.
D: See Table 2 for the properties of this star belonging to IC 4756.
E: 1 very faint object in the error circle.
F: 1 very faint object in the error circle.
G: V_{mag}=10.9, spectral Type is F.
H: A faint star with $V_{mag} \simeq 15.0$ is within the error circle.
I: A clump of 4-5 unclassified objects in the error circle.
J: V_{mag}=12.8, spectral type unknown.

a lower threshold of ML = 8. Visual inspection of the X-ray image confirmed the reality of all 10 sources. The sources, their positions, ML values, count rates and 2 σ errors are listed in Table 1. Possible optical counterparts to the X-ray sources and offsets between the X-ray and optical positions are given in the last columns of the table. Finally, for all 214 catalogued stars in the HRI FOV, 3σ upper limits in X-ray count rate were inferred at the optical input catalog positions. Only HSS 201, detected in the previous step, was retrieved as an X-ray source. The 60 stars with membership probability larger than 85% and no more than 15 arcmin off-axis are listed in Table 2. Herzog numbers, V magnitudes, B−V colors, and membership probabilities are given in Columns 1–4.

We converted the count rates to fluxes adopting a conversion factor of 5.2×10^{-11} ergs cm^{-2} s^{-1} per HRI count s^{-1} assuming N(H)= 10^{21} cm^{-2} and $\log T = 6.6$. A Raymond-Smith spectral model has been used. For $\log T = 6.8$ and 7.0, the conversion factors would be 3.9 and 4.2×10^{-11} ergs cm^{-2} s^{-1} per HRI count s^{-1}, respectively. X-ray luminosities or upper limits to X-ray luminosities were computed using a distance of 390 pc; these values are listed in the last column of Table 2. Note that the upper limits in L_X are in the range from $1-6 \times 10^{29}$ erg s^{-1}. Schmidt (1978) and Smith (1983) report variable reddening across the cluster; our tabulated upper limits could therefore be over/under-estimated in individual cases.

4. Results and discussion

4.1. Cluster members

Tables 1 and 2 indicate that only two out of the 214 stars in our input catalog were detected as X-ray sources, i.e., HSS 201 and HSS 247. HSS 201 is a cluster member; on the contrary, HSS 247 has a membership probability equal 0 according to Herzog et al. (1975) and it is also classified as a photometric non-member by the same authors. HSS 201 has a spectral type of A8, according to the information listed in the SIMBAD database, and, as such, is of rather early spectral type compared to the active, 'coronal-type' stars which typically comprise F0 and later type stars. It has a measured $B-V = 0.42$ (Herzog et al. 1975), a reddening of $E_{b-y} = 0.158$ (Schmidt 1978), or $E_{B-V} = 0.22$ and, thus, an unreddened $B-V$ colour of 0.20; this value is in fact somewhat bluer than the blue edge of the coronal star domain in the H-R diagram of $B-V = 0.25$ (Schmitt et al. 1985; Simon & Drake 1993). Given the uncertainty in the spectral type and reddening, we cannot completely rule out that this star with $\log L_X = 29.9$ is yet another, rather more X-ray luminous, example of an active F0 V star like the Hyades star 71 Tau (log $L_X = 30.1$; Stern et al. 1995). It is quite plausible that both HSS 201 and 71 Tau are close binary systems with later-type secondary companions that are the actual X-ray emitters, but the hypothesis that they are active single stars, while less likely, cannot be completely discounted .

The other eight detected X-ray sources cannot be associated with any known cluster members and therefore none of the known F- or G-type stars in IC 4756 stars were detected nor any of the cluster K-type giant stars. If IC 4756 is indeed similar in age to the Hyades and Praesepe and if the sensitivity of the present survey had been comparable to that of the Hyades and Praesepe surveys, the straightforward conclusion would have been that the X-ray properties of IC 4756 are different from those of the Hyades. However, the sensitivity was, in fact, an order of magnitude poorer than the levels achieved for the latter

Table 2. X-ray measurements for cluster members

HSS	V	B−V	membership probability (%)	L_X (10^{29} erg/s)	HSS	V	B−V	membership probability (%)	L_X (10^{29} erg/s)
87	9.36	1.25	96	$\leq$ 2.9	202	11.54	0.45	97	$\leq$ 1.2
106	9.96	0.60	91	$\leq$ 3.9	207	10.48	0.57	91	$\leq$ 2.5
107	12.20	0.70	96	$\leq$ 2.3	209	12.71	0.65	93	$\leq$ 2.6
113	11.54	0.65	92	$\leq$ 1.9	212	12.65	0.63	92	$\leq$ 2.3
116	....	....	89	$\leq$ 2.3	214	11.28	0.45	96	$\leq$ 1.0
118	9.91	0.49	96	$\leq$ 2.4	215	10.58	0.44	97	$\leq$ 2.3
125	10.98	0.53	94	$\leq$ 2.6	221	11.12	0.41	96	$\leq$ 1.0
131	10.14	0.55	96	$\leq$ 3.8	225	11.30	0.42	96	$\leq$ 1.0
138	9.84	0.68	97	$\leq$ 1.9	226	12.17	0.54	96	$\leq$ 1.4
144	9.12	1.10	96	$\leq$ 2.8	227	9.58	0.31	96	$\leq$ 3.6
145	10.64	0.40	96	$\leq$ 3.6	228	9.34	1.05	94	$\leq$ 3.3
151	10.48	0.45	97	$\leq$ 1.1	235	12.75	0.64	96	$\leq$ 2.2
152	9.59	0.67	93	$\leq$ 2.9	236	10.26	0.33	96	$\leq$ 3.1
154	10.57	0.47	87	$\leq$ 3.8	240	13.48	0.76	96	$\leq$ 4.5
156	....	....	92	$\leq$ 1.5	241	11.71	0.56	96	$\leq$ 2.5
160	12.09	0.59	97	$\leq$ 5.7	245	10.57	0.41	95	$\leq$ 1.5
161	....	....	97	$\leq$ 1.5	248	....	....	90	$\leq$ 4.0
165	13.50	0.81	90	$\leq$ 1.7	249	8.96	1.16	96	$\leq$ 1.9
166	9.91	0.64	94	$\leq$ 3.9	258	11.62	0.57	96	$\leq$ 1.1
174	12.43	0.74	96	$\leq$ 2.6	265	10.66	0.41	95	$\leq$ 1.1
176	9.29	1.03	91	$\leq$ 0.9	267	....	....	97	$\leq$ 1.9
183	12.23	0.76	92	$\leq$ 1.3	269	....	....	95	$\leq$ 2.4
188	13.36	0.83	96	$\leq$ 6.2	275	9.62	0.36	97	$\leq$ 1.2
189	13.00	0.78	93	$\leq$ 1.0	301	10.25	0.38	96	$\leq$ 3.6
191	12.59	0.50	92	$\leq$ 6.2	302	12.55	0.57	92	$\leq$ 3.3
192	12.21	0.61	96	$\leq$ 1.5	304	9.97	0.33	97	$\leq$ 3.7
194	12.71	0.68	94	$\leq$ 0.7	305	10.11	0.33	96	$\leq$ 5.1
199	10.78	0.59	96	$\leq$ 0.9	308	10.41	0.41	96	$\leq$ 3.4
201	9.88	0.42	96	7.3	318	....	....	96	$\leq$ 4.4
202	11.54	0.45	97	$\leq$ 1.2	322	9.58	0.42	97	$\leq$ 2.7
324	10.37	0.41	97	$\leq$ 3.1					

clusters; in the following discussion we explore the question of the possible significance of the non-detection of stars in IC 4756 and compare our results with the earlier analyses of the Hyades and Praesepe clusters. In Fig. 1 we plot the X-ray luminosity distribution functions (XLDFs) for the F and G-type stars in the Hyades (bottom and top panels, respectively) with the upper limits for IC 4756 stars in the same spectral ranges indicated as vertical bars. Fig. 2 is similar, except that the XLDFs shown are for Praesepe. The non-detection of stars in IC 4756 and the values of the upper limits indicate that IC 4756 members are not systematically more active than their Hyades (and, obviously) Praesepe counterparts. The more important conclusion to draw from these figures, however, is that our exposure was not deep enough to reach the median value of the XLDF for G dwarfs in the Hyades. In order to perform a more formal analysis to assess whether there are any significant differences of IC4756 with respect to the Hyades and Praesepe population, we proceeded as follows: As Fig. 1 shows, there are seven non-detected G-type stars in our IC 4756 sample. The values of the observed Hyades XLDF corresponding to the X-ray upper limits for those stars are 0.35, 0.2, 0.05, 0., 0., 0., 0.. If we assume that the IC 4756 XLDF is the same as that of the Hyades, the probability of getting the observed upper limits, given the Hyades XLDF, can be calculated as follows: $P_{res} = (1-0.35)\times(1-0.2)\times(1-0.005)\times 1^4 = 0.5096$. Applying similar arguments to F-type stars, we obtain $P_{res} \sim 0.0130$. Considering Praesepe (Fig. 2), we find probabilities P_{res} = 0.55 and 0.62 for G and F-type stars, respectively. Therefore, we cannot make any definitive statement about G-type stars (i.e., we cannot exclude that the XLDF of IC 4756 is similar to that of the Hyades, nor to that of Praesepe). As to F stars, nothing can be said about how IC 4756 compares with Praesepe, but the probability that F-type stars in the Hyades and IC 4756 have the same XLDF can be rejected at high significance. To conclude: The G-type stars in IC 4756 can have an XLDF similar to either the Hyades or Praesepe, or even below. The IC 4756

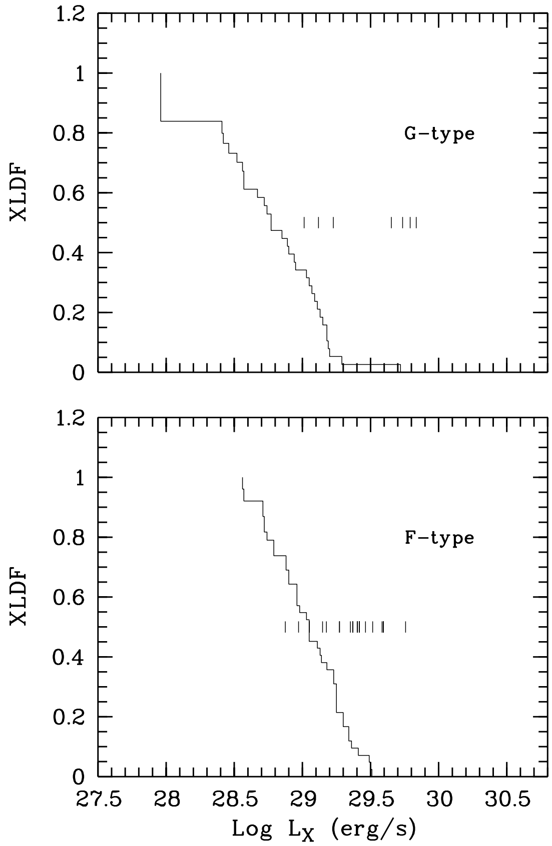

Fig. 1. Top Panel: XLDF for G-type dwarfs in the Hyades. Vertical bars indicate the upper limits which we derived for G-type dwarfs in IC 4756; Bottom Panel: same as Top panel, but F-type stars are considered. The XLDFs for the Hyades have been constructed using the X-ray data from Stern et al. (1995)

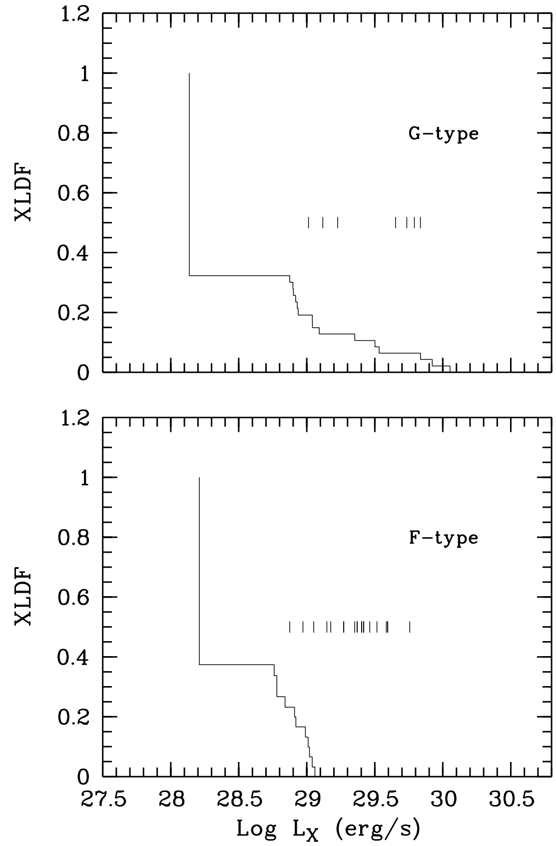

Fig. 2. Same as Fig. 1, but Praesepe XLDFs are shown. The XLDFs for Praesepe have been constructed using the X-ray data from Randich & Schmitt (1995)

F-type stars parent population may turn out to be different from that of Hyades and appears to be more similar to Praesepe. A much deeper detection level (by at least a factor of 3) is clearly needed in order to obtain definitive conclusions concerning the XLDF for IC 4756.

An interesting feature evident in both Figs. 1 and 2 is that our sensitivity should have permitted the detection of objects belonging to the high luminosity tails of both Hyades and Praesepe XLDFs, i.e., active binary stars with X-ray luminosities in excess of $\sim 2-3\times10^{29}$ ergs s^{-1}. As mentioned in the introduction, giant binary stars have also been detected in clusters older than the Hyades. Such binary stars have X-ray luminosities of the order of a few $\times10^{30}$ ergs s^{-1}, and if they were present in IC 4756, they would have been detected. An estimate of the significance of the non-detection of active binaries in our HRI field can be obtained as follows: About 10% of the Hyades dwarfs in the RASS survey of Stern et al. (1995) are spectroscopic binaries with X-ray luminosities larger than 2×10^{29} ergs s^{-1}. There are $\sim$ 50 IC 4756 dwarfs in our FOV. If all of them had upper limits below 2×10^{29} erg s^{-1}, the probability of detecting no binaries in our FOV would just be the probability of having no such binaries in IC 4756, and can be estimated using the binomial distribution, under the assumption that the same percentage of binaries as in the Hyades is present in IC 4756:

$$P(N,50,0.1) = \frac{50!}{N!(50-N)!}0.1^N 0.9^{50-N},$$

which gives $P(0,50,0.1) = 5\times10^{-3}$. The obvious assumption that an IC 4756 star is either a binary or a single star has been made. However, only 25 dwarf stars in IC 4756 have upper limits lower than 2×10^{29} erg s^{-1}, with the remaining 25 in the range $2\times10^{29} < \mathrm{UL_X} < 6\times10^{29}$ erg s^{-1}. The probability of detecting no binary in our FOV is therefore larger than 5×10^{-3}, but smaller than $P(0,25,0.1) = 7.2\times10^{-2}$. This probability is in any case quite small, although not infinitesimal, and we believe that our data should have allowed us to detect more than one active binary with nearly 100% probability. The fact that we detected only one early-type cluster member suggests that the fraction of rapidly rotating active late-type dwarf binaries in IC 4756 is likely to be considerably lower than in the Hyades and similar arguments hold for the comparison with Praesepe.

More information is available about giant binaries in IC 4756, for which a binarity survey was carried out by Mermilliod & Mayor (1990). They analyzed Coravel radial velocities for 19 red giants in the cluster; seven of them are included in our FOV. Besides rejecting or confirming membership for the stars in their sample[1], they discovered three spectroscopic binaries (HSS 170, HSS 314, and HSS 144). For one of them (HSS 144) an orbit with a period of 2000 d and a very small eccentricity (e=0.04) was determined. For the other two stars only lower limits to the period (7 years) are available. Two out of the three binaries were covered by our observations, but none were detected, although their non-detection is not surprising given their long orbital periods (note however that Belloni & Tagliaferri (1997) did detect a very long period and high-eccentricity binary in the intermediate-age cluster NGC 6940 as an X-ray source). Thus, optical and X-ray data for the giants in this cluster are consistent with this cluster having a smaller fraction of short-period active binaries compared with other, both younger and older, open clusters.

4.2. Non-members

Apart from the detection of HSS 201, only two additional X-ray sources (out of a total of 10) detected in our observations could be securely identified from positional coincidence with optical counterparts. The known characteristics of these two stars as taken from the SIMBAD database and from the HST Guide Star Catalog are given in Table 1. Little information is available on these stars: HSS 247 has a crude spectral type estimate of F, while GSC 0455 00727 has no estimated spectral type. Assuming reasonable values for its absolute visual magnitude and reddening E_{B-V} of $3.5 - 3.9$ and 0.13, respectively, HSS 247 is likely to be a foreground object at a distance of $200 - 250$ pc and an implied X-ray luminosity of ~ 29.5 close to the maximum L_X observed in solar neighborhood, single, F-type dwarf stars (cf. Schmitt et al. 1985, Schmitt 1997).

In addition to the catalog searches, for all of the detected X-ray sources we examined the digitised sky survey plates available online at http://skyview.gsfc.nasa.gov/. The information gained from this examination for the seven X-ray sources with no catalogued optical counterparts is listed in Table 1 in the notes. The possible optical counterparts of these sources are very faint ($V_{mag} \geq 15.0$), and no detailed information is available for any of them. Given the low galactic latitude of IC 4756 ($b \sim +5°$), it is unlikely that a large fraction of these sources is of extragalactic nature.

5. Conclusions

A 88 ksec deep *ROSAT* HRI exposure of the open cluster IC 4756 resulted in the detection of 10 X-ray sources. Three of the sources have a known optical counterpart, but only one of these is a known cluster member. It is a A8 star and, therefore, its X-ray emission is quite likely coming from a late-type companion. Upper limits for the undetected 59 cluster members in the inner 15 arcmin of the FOV (37 of them are later than F0) range in the interval $\sim 10^{29} - 6 \times 10^{29}$ erg s^{-1}. Because of insufficient exposure, the sensitivity was not enough to reach the median X-ray luminosity observed in the Hyades and Praesepe clusters and therefore a conclusive comparison of the X-ray properties of IC4756 with the Hyades and Praesepe cannot be made. It is extremely unlikely that IC4756 is more X-ray luminous than the Hyades or Praesepe, and in fact, there is indication that F-type stars tend to be less X-ray luminous than their Hyades counterparts. Furthermore, there is an apparent lack of very active binary stars, both dwarfs and giants, which are observed to be present in slightly younger or coeval clusters, such as Hyades and Praesepe, and also in considerably older ones like M67. It is unclear whether this lack of active binaries reflects a general deficit of binaries, or just a lack of short period binaries, i.e., a different distribution of orbital periods with respect to other clusters. It is highly desirable to carry our more extended optical binarity surveys of IC 4756 in addition to that carried out by Mermilliod & Mayor (1990), in order to better determine the binarity properties of this cluster. Furthermore, a new X-ray survey of IC 4756 should be carried out which goes about three times deeper than the present HRI survey in order to actually reach the median X-ray luminosity level seen in the Hyades cluster. For the time being we advise caution in extrapolating the X-ray properties of one open cluster specimen, i.e., the Hyades, to other coeval clusters.

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[1] Note that all the stars which turned out to be non-members are outside our field of view or already identified as non-members through photometry.

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