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Soft X-ray emission from intermediate-age open clusters: NGC 6940

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Abstract. We present the results of soft X-ray observations of the intermediate-age open cluster NGC 6940 performed with the ROSAT PSPC. We detected 18 sources, four of which are identified with member stars of the cluster and five with active field stars. Another source is identified with an active giant star that could belong to the cluster, although it is not classified as a cluster member. The remaining eight, most likely of extragalactic nature, need to be identified through optical follow-up. As in the case of old clusters such as M 67 and NGC 752, a high fraction of the detected members are binaries: in NGC 6940 three out of four of the identified members are among the only six binaries known in the cluster. All four sources have X-ray luminosities typical of RS CVn binaries. However, only two of the three detected binaries have system characteristics typical of active X-ray binaries. The high X-ray luminosity of the other two sources needs to be explained. All four identified members are red giants, in agreement with the presence of a saturation level. The four field stars identified as counterparts of X-ray sources are all very active, with X-ray luminosities in the range $10^{29} - 10^{30}$ erg s^{-1}, and deserve further optical investigation. We confirm the results found in other old open clusters, i.e. that binaries are still very active coronal sources at an age greater than 1 Gyr, and that good spatial resolution images in the X-ray band are a powerful tool to investigate their evolution in clusters of different ages.

Key words: stars: activity – open clusters and associations: individual: NGC 6940 – X-rays: stars

1. Introduction

The study of open clusters is extremely valuable for stellar astronomy: they provide coeval samples of stars located at the same distance, allowing to study the emission properties in a systematic way. Stellar activity is no exception: since activity depends crucially on stellar rotation (Pallavicini et al. 1981, Rosner et al. 1985), which decreases with age because of magnetic breaking (e.g. Skumanich 1972), open clusters are crucial to distinguish between truly evolutionary effects on stellar activity and effects primarily due to the rotation rate itself. From the observations of the Hyades and the Pleiades with the *Einstein* Observatory it was found that coronal emission is a common feature among the late-type stars of the clusters (Stern et al. 1981, Micela et al. 1990). With the advent of ROSAT, these two clusters were observed with a better sensitivity and larger solid angle (Stern et al. 1992, Stauffer et al. 1994); meanwhile various other nearby open cluster have been observed (Patten & Simon 1993; Randich & Schmitt 1995; Randich et al. 1995, 1996a,b; Dachs & Hummel 1996).

Since stellar activity is connected to stellar rotation and the latter decreases with age because of magnetic breaking, the attention has been concentrated mainly on young clusters (30 to 700 Myr). In contrast to younger clusters, clusters older than $\sim$ 1 Gyr are not expected to contain rapidly rotating single late-type stars, and therefore strong X-ray sources. In this respect, old and intermediate-age open clusters may appear to be of little interest to the X-ray observer. However, there are stars older than $\sim$ 1 Gyr that show rapid rotation: these are members of close binary systems, where tidal interaction prevents the stars from losing angular momentum; well-known examples are the RS CVn binaries. Another class of rapidly rotating but relatively old stars are single giants of the FK Comae type, which probably formed by coalescence. As shown by observations of field stars, these rapidly rotating objects are strong X-ray emitting sources as a consequence of the dependence of X-ray activity upon rotation in late-type stars (e.g. Fleming et al. 1989). Thus, the observation of relatively old open clusters allows to study homogeneous samples of such binaries. With the ROSAT satellite the first observations of old open clusters have been performed. A pointing to M 67 (age $\sim$5 Gyr) led to the detection of a number of sources, four of which have been identified with short-period binaries, one with a cataclysmic variable and

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one with a blue straggler (Belloni et al. 1993). Indication of chromospheric activity has been found from most of the optical candidates (Pasquini & Belloni 1994). Moreover, a DA white dwarf has been discovered during the optical follow ups (Pasquini et al. 1994). 49 X-ray sources have been detected in a ROSAT PSPC pointing to NGC 752 (∼2 Gyr). Seven of them are identified with optical cluster members, four of which are short period binaries, one is a rapid rotator and one is a blue straggler (Belloni & Verbunt 1996). The X-ray properties of these sources appear to be consistent with those of active binaries (see Dempsey et al. 1993a, 1993b).

In view of these results, we observed two intermediate age open clusters with the ROSAT PSPC detector, NGC 6940 and IC 4651, in the framework of a project to cover the X-ray observational gap between old and young clusters. Here we present the results obtained for NGC 6940, while the results for IC 4651 will be presented in a forthcoming paper.

NGC 6940 has an estimated age of ∼1 Gyr: its low distance (∼ 900 pc) and angular size (between 27′, Trumpler (1930), and ∼ 40′, Vasilevskis & Rach (1957)) make it a good target for the PSPC detector. The reddening in the direction of the cluster is moderate, E(B-V) = 0.05–0.30 (variable across the field, Larsson-Leander 1960), low enough to allow the detection of possible soft X-ray emission from cluster members.

The paper is organized as follows: in Sect. 2 we present the PSPC observation and our data analysis, in Sect. 3 we present and discuss the results both for the cluster and non-cluster members, and in Sect. 4 we compare our results with those of other open clusters and discuss the implications.

2. Observations

NGC 6940 was observed with the Position Sensitive Proportional Counter (PSPC) on board ROSAT between 1993 Nov 30th 00:44 UT and 1993 Dec 4th 02:22 UT, for a net observation time of 7365 s. A description of the satellite and the instrument can be found in Trümper (1983) and Pfeffermann et al. (1986). The data were analyzed using the EXSAS package (Zimmermann et al. 1994). Due to the degrading of the Point Spread Function at large off-axis angles, we limited our analysis to the inner 20′ of the field of view. We followed the standard procedure within EXSAS for the detection of sources. First we produced a background map by removing all possible sources and smoothing with a spline-filter technique. Then we ran a Maximum Likelihood (ML) technique to test for deviations from a pure background distribution (Cruddace et al. 1988). The ML threshold for detection was set at 12, corresponding to a single-trial probability of a chance detection of 6.1×10^{-6}. A second run of the ML algorith with a lower threshold (ML=10, P=4.5×10^{-5}) was also run in order to increase the sensitivity. We applied the procedure described above for three PSPC channel bands: 11-240 (total band T, corresponding roughly to 0.1–2.4 keV), 11-40 (soft band S, 0.1–0.4 keV) and 41-240 (hard band H, 0.4–2.4 keV).

In the first ML run, we detected 9 sources in the T band and 15 in the H band. No sources were detected in the soft band.

Table 1. Sources detected in the NGC 6940 field. The columns give source ID number, position of the source, 90% confidence radius, countrate, and channel band to which the count rate corresponds (T=11–240, H=41–240).

no.	α(2000)	δ(2000)	Δr	cts/ksec	B
1	20h35m04.2s	28°19′10”	10.5”	3.9± 0.8	T
2	20h35m20.3s	28°33′11”	24.7”	2.1± 0.6	H
3	20h33m56.7s	28°30′58”	13.9”	3.1± 0.7	H
4	20h35m08.3s	28°24′06”	11.7”	4.0± 0.8	H
5	20h33m43.2s	28°22′53”	20.9”	2.6± 0.7	H
6	20h34m27.0s	28°22′36”	13.2”	1.1± 0.4	H
7	20h34m22.2s	28°21′40”	15.1”	1.1± 0.4	H
8	20h34m28.1s	28°20′39”	6.2”	6.2± 0.9	H
9	20h34m46.2s	28°20′31”	10.0”	1.9± 0.5	H
10	20h34m02.7s	28°18′30”	12.6”	1.3± 0.4	H
11	20h35m17.9s	28°18′31”	10.5”	2.2± 0.6	H
12	20h34m13.8s	28°14′29”	10.3”	2.0± 0.5	H
13	20h34m25.5s	28°13′52”	12.9”	1.8± 0.5	H
14	20h34m30.4s	28° 9′55”	14.8”	1.1± 0.4	H
15	20h35m07.2s	28° 9′26”	13.5”	1.7± 0.5	H
16	20h34m31.8s	28°32′17”	22.1”	1.2± 0.5	H
17	20h34m27.6s	28°28′53”	18.7”	1.2± 0.5	H
18	20h35m56.0s	27°42′43”	∼60”	591.8± 11.2	T

The selected threshold is so high that none of these sources is considered spurious. In the second run at a lower threshold, three additional sources were detected in the hard band. These sources have carefully been checked visually: one of them resulted an obvious spurious detection, while the other two were included in our list of detections (sources 16 and 17 in Table 1). After cross-correlating the hard and total lists, we produced a final list of 17 sources detected in the inner 20′ of the PSPC detector. A summary of the sources with their positions, positional errors and detection band is given in Table 1. The reported positions have been corrected for the offset (∼ 8″) between the X-ray detector and the optical star sensor by means of a cross-correlation with stars in the Space Telescope Guide Star Catalog (GSC: Lasker et al. 1990). Since six sources could be identified with GSC entries, the boresight correction obtained with this procedure is robust. The 90% error radius includes a systematic error of 3″ to keep into account residual uncertainties.

Although we restricted our analysis to the central region of the PSPC, we also considered a strong source (0.59±0.01 cts/s) detected at a large off-axis angle (source # 18 in Table 1). Given the uncertainties on the point spread function in this region of the detector, we estimate the positional error to be of the order of 1-2′.

3. Results

3.1. Identifications

As reported in the previous section, six X-ray sources could be identified with GSC stars. In order to examine the error boxes more carefully, we inspected the Palomar red plates from the Digitized Sky Survey and cross-correlated the results with the catalogs of stars in the field of NGC 6940 by Vasilevskis & Rach (1957: VR stars) and by Larsson-Leander (1960: LL stars), who performed deep photometric studies of the region of sky around the cluster. We consider an identification if there is a star brighter than $m_v \sim 14$ (the limit of current optical studies) within the 90% error box. The proposed identifications are summarized in Table 2. In some cases (#3, 6, 7, 12 and 17) a fainter object ($m_v \sim 15-17$) is also present in the error box, in some others (#2, 5, 16) there are few weak objects ($m_v >$16–17), while for sources #1, 8, 10, 11, 14 and 15 no objects brighter than ~ 20 are in the error box (although star VR 165 for source #1 and two stars of $m_v \sim$15–16 for source #15 lie just outside the error boxes). Table 2 includes an additional object, HD 340540 (=SAO 88882), a bright K0 star of V=8.9 that appears neither in the catalog of Vasilevskis & Rach nor in that of Larsson-Leander. It is not a member of the cluster and its optical coordinates, as given in the SIMBAD database, differ by less than 10" from the X-ray coordinates of the strong X-ray source detected at a larger off-axis angle (source #18 in Table 1). Its X-ray to optical flux ratio is consistent with coronal emission (see Stocke et al. 1991), as it is the case for all proposed identifications. We regard this star as the most likely optical counterpart of the X-ray source, although there are other objects with magnitude in the range 17–20 within $1'$ from the X-ray position.

Four of the proposed counterparts are with high probability members of the cluster (Vasilevskis & Rach 1957, Sanders 1972, see also Table 2). A search for binaries among the red giants of NGC 6940 has been performed by Mermilliod & Mayor (1989), who studied 24 giants in this region of the sky, 20 of which should be members of the cluster. They found that six of these 20 giants are binaries with periods ranging between ~ 54 and ~ 3600 days. Three out of four cluster members identified with our X-ray sources are among this list of binaries (see Table 2 and Fig. 1). The fourth X-ray source identified as a member of the cluster is also a giant studied by Mermilliod & Mayor, who quote a probability of 87% against binarity. The six binaries detected by Mermilliod & Mayor and the four X-ray sources identified with cluster members (three are coincident) are all red giants, with the position of the three more luminous binaries shifted toward bluer colors, within the Hertzsprung gap (see Fig. 1). This is probably due to a composite type: a red giant primary and an A- or F-type main sequence secondary, with mass ratio larger than 0.8 (Mermilliod & Mayor 1989).

We identify source #17 with star VR114, classified as G8 III by Larsson-Leander (1960, LL407). This source is not considered member of the cluster on the basis of proper-motion measurements (Vasilevskis & Rach 1957, Sanders 1972). Assuming an absolute magnitude of M_v=0.7 (Gray 1992), zero interstellar absorption and the visual magnitude given in Table 2, we derive a distance of ~ 1280 pc, i.e. behind NGC 6940. However, given the distance obtained, the interstellar absorption cannot be ignored. In his study of NGC 6940, Larsson-Leander (1960) obtains values of E(B–V) between 0.2–0.3 for the stars of this sky region around these distances (see his Fig. 14). In particular, he obtains E(B–V)=0.23 for star LL459, that is very near star VR114 (LL407). Using this value for the interstellar absorption,

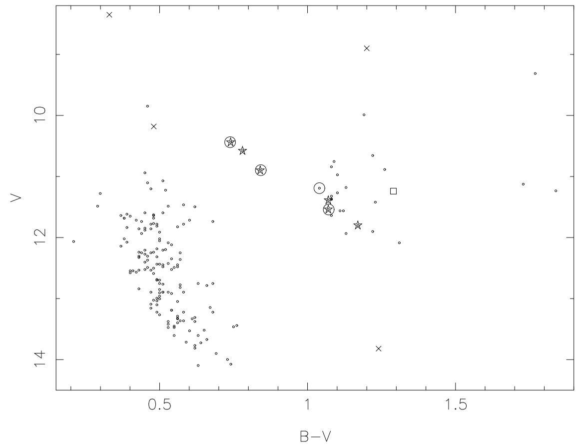

Fig. 1. Color-magnitude diagram for NGC 6940 (data from Larsson-Leander 1960, membership from Sanders 1972). Stars indicate binary systems (from Mermilliod & Mayor 1989), circles are X-ray detections with a member counterpart, crosses are X-ray detections with a non-member counterpart. The square is star VR114, that we suspect to be associated with the cluster (see text).

we derive a distance of ~ 900 pc (d$\simeq$ 830 pc for E(B–V)=0.3 and d$\simeq$ 950 pc for E(B–V)=0.2). This value are very similar to the distance of the cluster, d$\simeq$ 870 pc. Thus, although this star is not classified as member of the cluster, it could be somehow associated with it (e.g. it could be a run-a-way member). This is shown also in Fig. 1, where VR114 (square symbol) lies in the region of the giant stars belonging to the cluster. In the following, we will consider this source as a field star, possibly associated with the cluster.

NGC 6940 is located at low galactic latitude ($l_{II} \sim -7°$), with a total galactic interstellar absorption, estimated from radio data, of $N_H \sim 2.6 \times 10^{21}$cm^{-2} (Dickey & Lockman 1990). To estimate the number of extragalactic sources expected in the field we assumed a typical power-law spectrum with photon index 2.0 and the quoted value of N_H. With these parameters our limiting countrate of $\sim$1 ct/ksec corresponds to a flux limit of 2.5×10^{-14} erg cm^{-2}s^{-1} (in the 0.4–2.5 keV band). From the log N–log S distribution derived from the ROSAT deep survey (Hasinger 1992), we estimate that roughly 10 extragalactic sources should be detected in our observation. This means that all our unidentified sources might be extragalactic.

3.2. X-ray properties

3.2.1. The cluster members

The photon distribution of all sources is rather hard, reflecting the relatively high absorption towards the cluster. The number of counts detected is however too low to produce meaningful hardness ratios. In order to estimate the X-ray luminosity in the ROSAT band for the detected members, we adopted a spectral model typical of RS CVn binaries. Following Dempsey et al. (1993a), who studied the full sample of RS CVn binaries detected in the RASS, we used a two temperature thin emission plasma model (according to Raymond &

Table 2. Optical identifications for sources in the NGC 6940 field. The columns contain ID of the X-ray source, ID of the optical object in Vasilevskis & Rach (1957), V and $B-V$ of the optical object from Larsson-Leander (1960) (for source #18 from SIMBAD), membership probability from Sanders (1972), distance, X-ray luminosity in the 0.1–2.4 keV band, orbital period, eccentricity, and remarks.

X-ray no.	V.–R. no.	V	$B-V$	M	Dis. (pc)	L_X (erg/s)	Period (days)	Eccentr.	remarks
3	57	10.18	0.48	0	216	$> 1.4 \times 10^{29}$			HD 334742
4	171	8.35	0.33	0	257	$> 2.6 \times 10^{29}$			HD 196244
6	111	11.54	1.07	93	870	4.2×10^{30}	3595	0.30 ± 0.03	
7	100	10.44	0.74	95	870	4.3×10^{30}	82.5	< 0.01	
9	LL137	13.82	1.24	?					No VR nr.
12	84	10.90	0.84	78	870	1.3×10^{31}	54.2	<0.01	
13	108	11.19	1.04	90	870	9.0×10^{30}			
17	114	11.24	1.29	0?	900	6.9×10^{30}			member?
18	—	8.9	1.2	0	38	1.2×10^{30}			HD 340540

Smith 1977). The parameters used are the average of the values in Dempsey et al. (1993a): kT_{low}= 0.175 keV, kT_{high}=1.4 keV, EM_{low}/EM_{high}=6. For each star we used a value for the interstellar absorption N_H between 9.2×10^{20} and $1.8\times10^{21}\,cm^{-2}$, as derived from the E(B–V) reported by Larsson-Leander (1960). The derived X-ray luminosities, assuming a distance of 870 pc (Larsson-Leander 1964), are reported in Table 2. Although the detections correspond to the hard PSPC band (0.4–2.4 keV), the values are given for the full PSPC range 0.1–2.4 keV to allow comparison with other systems. We estimate that the uncertainties on the derived luminosities, due to a different value of the temperatures and/or EM ratio but still within the typical range observed for coronal sources, are up to 50%.

3.2.2. The non-member stars

Source #3 is identified with HD 334742, classified in the SIMBAD database as an F5V, source #4 is identified with HD 196244, classified in SIMBAD as A2V, while source #18 is identified with HD 340540, classified in SIMBAD as K0V. Assuming an absolute magnitude of M_v=3.5, 1.3 and 6.0 for the three stars (Gray 1992) and the visual magnitudes given in Table 2, we derived a distance of 216, 257, and 38 pc respectively. These values are obtained assuming a negligible interstellar absorption. While this is probably the case for the nearby star HD 340540, the derived distances for HD 334742 and HD 196244 should be considered as lower limits.

For source #18 we have enough counts to derive a hardness ratio (defined as HR=(H–S)/(H+S), see Sect. 2). The obtained value of HR=0.28 $\pm$ 0.02 is high for a normal coronal source (e.g. Schmitt et al. 1995), but is commonly found in very active X-ray selected stars (Fleming et al. 1995). A two-temperature thermal fit yields $N_H = 8^{-4}_{+7} \times 10^{19}$ cm^{-2}, $kT_{low} = 0.20^{-0.05}_{+0.15}$ keV, $kT_{high} = 1.25^{-0.20}_{+0.50}$ keV, and EM_{low}/EM_{high} = 0.2 (90% confidence errors). These temperatures are in line with those derived by Dempsey et al. (1993a) for the ROSAT RASS sample of RS CVn binaries, although the dominating component in our case is the harder one, as already implied by the hardness ratio value. The resulting 0.1–2.4 keV luminosity is 1.2×10^{30} erg s^{-1}. This is also the only source that shows significant variability, whit a steady increase in countrate from 0.3 to 1.0 cts s^{-1} throughout the observation.

For the other two sources (# 3,4) we can neither perform a spectral analysis nor derive a meaningful hardness ratio. We derived their X-ray flux by adopting the conversion formula by Fleming et al. (1995), assuming HR=0. We estimate a maximum error of $\sim$ 40% from this procedure. The derived X-ray luminosities, reported in Table 2, should be regarded as lower limits, since by ignoring the interstellar absorption we are underestimating both the spectral distances and the X-ray fluxes.

Finally, source #9 is identified with a star listed in the catalog of Larsson-Leander (1960) that does not seem to be a member of the cluster (see Fig. 1). Not knowing its spectral type, we can neither infer the spectral parallax nor its X-ray luminosity. From its B–V (see Table 2), we suspect it to be an active K-M field star.

4. Discussion

Stellar activity is connected to stellar rotation, which decreases with age because of magnetic breaking, so no detectable coronal X-ray emission would be expected from old stars. However, there are stars older than $\sim$ 1 Gyr that are still fast rotators; those that are members of close binary systems where tidal interaction prevents the stars from losing angular momentum. It is now clear that stars in short period binaries show significant chromospheric and coronal X-ray emission even at very old age (Pasquini et al. 1991; Belloni et al. 1993; Fleming & Tagliaferri 1996; Cutispoto et al. 1997). This situation is shown by the study of the intermediate and old open clusters with ROSAT. As in the case of M 67 (Belloni et al. 1993) and NGC 752 (Belloni & Verbunt 1996), in NGC 6940 we find that the majority of detected members are binary systems. Three out of four, possibly five, are among the only six binaries known in NGC 6940. All five sources are extremely bright in X-ray, with values typically found in the RS CVn type of binaries (e.g. Dempsey et al. 1993b), confirming that 1 Gyr old binary stars can still be extremely active coronal sources.

In binary star systems, tidal interaction acts to synchronize the stars' rotation to the orbital revolution and to circularize the orbit. In order to achieve this the binary period must be short, of the order of P$\lesssim$ 8 d for binaries with main-sequence stars, whereas binaries containing a giant are circularized at P$\lesssim$ 150 d (Mayor & Mermilliod 1984; Mermilliod & Mayor 1992; but see also Verbunt & Phinney 1995). Note that, although the RS CVn systems were originally defined as a class of close binaries with orbital periods between 1 and 15 days (Hall 1976), nowadays this class includes binaries with periods up to $\sim$ 100 days, in particular those containing a giant component, that are still very active in X-rays (e.g. Dempsey et al. 1993b). Two of the X-ray detected binaries in NGC 6940 conform to these expectations, but one does not (see Table 2). Star VR 111 has a remarkably long period ($\sim$3600 days) and a relatively high eccentricity (0.3). Being the system not circularized, it is not expected to be in corotation. In any case, even if it was in corotation, its period is so long that the star rotation rate would not be high enough to sustain such a level of stellar activity as the one detected in our data. Its detection as an X-ray source is puzzling. An alternative possibility is that star VR 111 is not the counterpart of the X-ray source. Indeed there is another fainter object within the error box, although the chance probability of having a 11.5 magnitude star within the error box is rather small. Another possibility is that the system is a triple, with one of the two stars being itself a spectroscopic binary. A more detailed optical investigation of this star and of the field is needed in order to establish the nature of the X-ray emission. The same is true for the other X-ray source of the cluster that is not a known binary (#13). Since the search for binarity by Mermilliod & Mayor (1989) is complete for amplitudes $>$ 4 km s^{-1} and periods $<$ 4000 days, if the star is a binary outside these values it is a rather extreme case that should not be relevant for the stellar activity. If this source is a single giant star, it is not at all clear why it shows such a strong X-ray emission (at an age of $\sim$ 1 Gyr). The possibility that this star is a binary system missed in the analysis by Mermilliod & Mayor seems to be excluded for amplitudes $>$1.5 km/s (Mermilliod, private communication), in which case the period is probably not very short. Additional optical investigation is required.

We identify source #17 with star VR114, a G8 III star that we estimate to be more or less at the cluster distance, but that is not identified as a cluster member from the astrometric studies. As for source #13, if this star is a single giant it is not at all clear why it shows such a strong X-ray emission. However, since VR114 is not classified as a cluster member, it was not included in the sample studied by Mermilliod & Mayor, leaving the binary possibility open.

The remaining three binaries of the six discovered by Mermilliod & Mayor are not detected in the PSPC X-ray observation, but this is in line with the above picture. They have quite long periods (210.7, 281.7 and 549.2 days respectively) and eccentric orbits (0.3, 0.16, 0.45), so that they are not expected to be fast-rotator active stars. Moreover, the 3–σ upper limits that we can derive in the 0.1–2.4 keV X-ray energy band are not extremely stringent (7.6, 4.7 and 8.7 $\times$ 10^{30} erg s^{-1} respectively).

All the identified members are red giants. As pointed out by Belloni & Verbunt (1996), this is in agreement with the presence of a saturation level in the X-ray flux per unit area (see Vilhu 1987), the brightness per unit area being approximately constant and the total X-ray luminosity increasing with the bolometric luminosity (i.e. the radius). This has been found for different samples of active stars, e.g. for a sample of X-ray selected stars (Fleming et al. 1989), for a sample of flaring stars (Pallavicini et al. 1990) and for various young open clusters (Stauffer et al. 1994, Randich et al. 1995, 1996a). This means that the maximum X-ray luminosity possible for each star scales with the star's surface. In this scenario, the presence of a detection threshold could make all main–sequence stars unobservable, while bright giants are still detectable (see also Fig. 2 in Belloni & Verbunt 1996). To check this we assumed a saturation level of $L_x/L_{bol} \sim 10^{-3}$ (e.g. Stauffer et al. 1994), which implies a maximum X-ray luminosity for G–K main sequence stars of the order of $2 - 6 \times 10^{30}$ erg s^{-1}. These values are similar to those we determined for two of the four cluster members detected, so that in principle we should have been able to also detect main–sequence stars near their saturation level, but we found none. Of course to exist these stars must be in binary systems. This could mean either that the cluster distance is larger than the assumed value of 870 pc (which would imply that the luminosities reported in Table 2 are underestimate) or that in NGC 6940 the saturation level is below the canonical value of $\sim$ 10^{-3}. Indeed, the four detected cluster members have $\log(L_x/L_{bol})$ in the range -4.6 to -4.0 (-4.2 for source #17)

Eight sources lack optical counterparts. Although they can be all extragalactic in nature, some of them could still be a cluster member. The remaining three sources identified with field stars also deserve attention. Source #9 its probably an active K–M spectral type field star. Source #3, HD 334742 (F5V), and source #18, HD 340540 (K0V), have an X-ray luminosity that, although very high, is not unusual for X-ray selected active stars (Fleming et al. 1995). However, these values imply that these sources, HD 340540 in particular, are either very young objects or spectroscopic binaries (e.g. Favata et al. 1993, Tagliaferri et al. 1994). Source #4 (HD 196244), being of spectral type A2, is more peculiar. Stars of spectral type B8-A5 are known to be very weak X-ray emitters, if at all, with upper limits of the order of 10^{26} erg s^{-1} (e.g. Schmitt 1997). An exception seem to be the Ap-Am stars, for which X-ray emission has been observed with the *Einstein* observatory at a level of 10^{28}–10^{30} erg s^{-1} for four out of nine stars studied (Cash & Snow 1982). However, a more complete study based on a sample of $\sim$ 100 magnetic Bp–Ap stars observed with ROSAT finds only 3–5 cases where the X-ray emission could be attributed to the chemically peculiar star and not to a late type star companion (Drake et al. 1994). And even in these few cases it cannot be completely excluded that the chemically peculiar star has a late type companion responsible for the X-ray emission. Recently Simon et al. (1995) used PSPC data to search for X-ray emission in a sample of 58 early-A type stars, with 10 positive detections. Of these, 5 are known to be in binary systems, while the other 5 could be either single or binary and would require more optical follow-up observations to determine their nature. All in all, it seems unlikely that the

A2 star is the real counterpart of the X-ray source. It is rather more probable that the X-ray emission arises from a low–mass binary companion (e.g. Stauffer et al. 1994; Stern et al. 1995).

In summary, we can say that the ROSAT data on NGC 6940 confirm the results found in other old open clusters, i.e. that binary stars are still very active coronal sources at an age ≥ 1 Gyr, and that good spatial resolution images in the X-ray band are a powerful instrument to investigate their evolution in clusters of different age. However, it is clear that an optical follow-up is necessary in order to better establish the physical nature both of the detected members of the cluster and also of the objects still to be identified.

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