New galactic open cluster candidates from DSS and 2MASS imagery *

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Abstract. An inspection of the DSS and 2MASS images of selected Milky Way regions has led to the discovery of 66 stellar groupings whose morphologies, color-magnitude diagrams, and stellar density distributions suggest that these objects are possible open clusters that do not yet appear to be listed in any catalogue. For 24 of these groupings, which we consider to be the most likely to be candidates, we provide extensive descriptions on the basis of 2MASS photometry and their visual impression on DSS and 2MASS. Of these cluster candidates, 9 have fundamental parameters determined by fitting the color-magnitude diagrams with solar metallicity Padova isochrones. An additional 10 cluster candidates have distance moduli and reddening derived from $K$ magnitudes and $(J - K)$ color indices of helium-burning red clump stars. As an addendum, we also provide a list of a number of apparently unknown galactic and extragalactic objects that were also discovered during the survey.

Key words. Galaxy: open clusters and associations: general, HII regions, reflection nebulae, planetary nebulae: general, Galaxies: general

1. Introduction

In the most up-to-date catalogues of galactic star clusters, Dias et al. (2002) (hereafter DAML02) and Bica et al. (2003a) (hereafter BDB03), a total of 1875 open clusters, open cluster candidates, and stellar groups visible in the visual or infrared spectral bands are listed. Despite the large number of objects included in these catalogues, they are apparently still far from complete, illustrated by the fact that several hundred new clusters and cluster candidates have been added to the list of known stellar groupings since these catalogues were published.

This large number of new discoveries is mostly the result of the release of the Two Micron All Sky Survey (Skrutskie et al. 1997, hereafter 2MASS). The images and photometric data obtained from this survey in the $J$, $H$, and $K_S$ spectral bands have proved to be fertile ground in the search for new open clusters and have offered new possibilities for the analysis of newly detected and already known cluster candidates. Important to mention in this respect are the following publications: Bica et al. (2003), who reported 3 new open cluster candidates in the Cygnus X region, detected by visually inspecting 2MASS and Digitized Sky Survey (hereafter DSS) images; Bica et al. (2003b) and Dutra et al. (2003), who carried out a survey of infrared star clusters and stellar groups around the central positions of optical and radio nebulae and found 167 and 179 previously unknown objects, respectively; and Ivanov et al. (2002) and Borissova et al. (2003), who used a search algorithm based on finding peaks in the apparent stellar surface density, leading to the detection of an additional 14 clusters via 2MASS.

Other important publications include: Alessi et al. (2003), who discovered 11 previously unknown cluster candidates in the solar neighborhood using astrometric and photometric data provided by the Tycho-2 catalogue (Høg et al. 2000); Bica et al. (2004), who reported 3 new open clusters found on maps obtained from the Guide Star Catalogue and images from the DSS; and Drake (2005), who discovered 8 clusters by searching for density fluctuations within the USNO A2.0 catalogue.

The recent discovery of new galactic open clusters in optical wavelengths by Bica et al. (2003b) and Drake (2005) is remarkable in that it illustrates that it is still possible to detect unknown clusters on the DSS, even though the systematic searches for faint clusters on the Palomar and ESO/SERC Schmidt plates – which led to the Berkeley open

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* Tables 2e, 4a and 4b are only available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.125.5) or via cdsweb.u-strasbg.fr/Abstract.html
cluster list (Setteducati & Weaver [1962] and to the individual lists which generated the ESO catalogue (Lauberts [1982]) were carried out very carefully. This is also underlined by Pfleiderer et al. (1977) and Saurer et al. (1994), who reported the discovery of a number of faint clusters apparently not detected during these surveys.

As a first result of a systematic survey of selected Milky Way fields based on the visual inspection of DSS and 2MASS images, we announce in this paper the discovery of 66 previously unknown (or, at least, unlisted) clusters and cluster candidates.

A discussion of the search technique and a description of the methods used to analyze the objects is given in the following section. Section 3 is dedicated to the presentation and discussion of the most interesting cluster candidates, and it provides a list of basic and fundamental parameters derived for these objects. Finally, in Section 4, concluding remarks are given.

2. Search strategy and analysis

A stellar field in which an open cluster is present is characterized by a number of specific features which reveal its existence:

1. The presence of an open cluster in a star field leads to increased stellar density when compared with the neighboring fields.
2. The cluster members show similar radial velocities and proper motions.
3. Due to their common origin, the member stars of an open cluster have similar ages and chemical compositions.

Starting with these considerations, we carried out a systematic survey of several Milky Way fields near the galactic plane using red, blue, and infrared First and Second Generation DSS images extracted from the ESO Online Digitized Sky Survey facility. As target fields for this survey, we favored Milky Way regions close to the galactic equator and characterized by a distinct lack of catalogued open clusters, as well as fields with evidence of active star formation. The DSS images of these regions were then examined in order to search for fields containing aggregates with a morphology similar to open clusters, i.e. fields with a stellar density significantly higher than the surrounding ones. A number of reflection and emission nebulae visible on the DSS images were also investigated, and to examine whether they contained any embedded clusters or stellar groups, we extracted additional J, H, and K_s images of these objects from the 2MASS facility. Finally, the exact position and apparent angular diameter of each cluster candidate were measured using the Aladin Interactive Sky Atlas provided by the CDS, Strasbourg.

2.1. Color-magnitude diagrams (CMDs)

As an increased stellar density alone is not definite proof that the observed stellar field contains an open cluster (as it can also be caused by chance agglomerations of stars and absorption holes), we obtained a photometric analysis of the candidate fields using data from the 2MASS Point Source Catalogue (Cutri et al. 2003) to get further clarity on their nature and their properties.

As a first step, we generated preliminary \([J,(J-H)]\) and \([K_s,(J-K_s)]\) CMDs for every candidate. To minimize possible contamination, we selected only those sources with accurate photometric measurements. This selection was done by checking the read flag \((rd_flg)\) of the sources provided in every band, which indicates how the magnitude of the source was determined and therefore contains information on the quality of the photometric measurement. Based on this criteria, we restricted the data base to: sources with \(rd_flg = 2\) (point spread function fitting) or \(rd_flg = 1\) (aperture photometry); sources with a read flag of 0, 4, 6, or 9 in any of the specific bands, indicating either that the source could not be detected in this band or that there was a bad photometric measurement, were omitted from the CMDs. In addition, we examined all other flags of the selected sources given in the 2MASS Point Source Catalogue, such as the quality flag \((qual)\) and the extended source contamination flag \((gal_contam)\), to minimize the influence of further sources of error.

The CMDs of the cluster fields were then compared with the CMDs of 4 control fields with the same size as the cluster fields and situated N, S, E, and W of the cluster candidate; the center-to-center distance between comparison field and cluster field was, in each case, taken as 3 times the radius of the cluster candidate.

2.2. Fundamental parameters

The majority of the clusters and cluster candidates presented in this publication exhibited certain features in their CMDs which enabled us to determine fundamental parameters of these objects.

For those cluster candidates whose CMDs revealed a well-defined cluster sequence, we determined the distances, reddening, and ages by fitting the cluster sequence with solar metallicity Padova isochrones from Girardi et al. (2002) calculated for the \(J, H,\) and \(K_s\) spectral bands. To correct for the influence of interstellar reddening, we assumed a value of \(R_V = 3.09\) for the total-to-selective absorption and used the relations \(A_J = 0.282 \cdot A_V\) and \(E(J - H) = 0.33 \cdot E(B - V)\) (Rieke & Lebowski 1985).

In a number of cases, the CMD exhibited a structure resembling a helium-burning red clump (hereafter RC). This RC – a typical feature of intermediate-aged and old open clusters – is a valuable standard candle and allows a determination of the clusters’ distance and reddening. In case the CMD of such a cluster did not allow obtaining an isochrone fit, we applied the approach of Grocholski & Sarajedini (2002) (hereafter GS02), who used the mean values \(m_{Ks,RC}\) and \((J-K_s)_{RC}\) of the stars composing the RC to derive the distance and reddening parameters. These values were computed by determining the corresponding values \(m_{Ks,RC}\) and \((J-K_s)_{RC}\) of the RC stars and subse-

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1. http://archive.eso.org/dss/dss
2. http://irsa.ipac.caltech.edu
3. http://aladin.u-strasbg.fr/aladin.gml
4. http://pleiadi.pd.astro.it/isoc_photosys.01/isoc_photosys.01.html
Table 1. mean values of $m_{K,Rc}$, $(J - K)_{Rc}$ and $(J - K)_{Rc}/(J - H)_{Rc}$ for the clusters with RCs.

| DSH ID   | $m_{K,Rc}$ | $(J - K)_{Rc}$ | $(J - K)_{Rc}/(J - H)_{Rc}$ |
|----------|------------|----------------|-----------------------------|
| DSH J0347.3-5354 | 11.75 ± 0.06 | 1.50 ± 0.03 | 1.44 ± 0.03 |
| DSH J0920.5-5251 | 12.95 ± 0.12 | 1.12 ± 0.01 | 1.44 ± 0.02 |
| DSH J1054.2-6144 | 13.92 ± 0.08 | 1.09 ± 0.03 | 1.36 ± 0.04 |
| DSH J1323.6-6340 | 12.85 ± 0.10 | 1.11 ± 0.01 | 1.36 ± 0.02 |
| DSH J1106.8+0935 | 12.02 ± 0.05 | 1.66 ± 0.02 | 1.45 ± 0.02 |
| DSH J1120.8+1540 | 12.09 ± 0.05 | 1.72 ± 0.01 | 1.49 ± 0.01 |
| DSH J1940.1+2615 | 14.06 ± 0.17 | 1.06 ± 0.03 | 1.37 ± 0.03 |
| DSH J1942.7+2951 | 13.13 ± 0.03 | 0.90 ± 0.03 | 1.37 ± 0.04 |
| DSH J1945.1+2809 | 13.07 ± 0.09 | 0.91 ± 0.01 | 1.32 ± 0.03 |
| DSH J2126.1+5351 | 12.77 ± 0.06 | 1.40 ± 0.02 | 1.39 ± 0.02 |

quent transformation of the 2MASS $K_s$ to the standard Johnson $K$ band magnitudes using the equations quoted in GS02 (see Table 1).

For the absolute magnitude $M_{K,Rc}$ of the RC, we adopted the value of $M_{K,Rc} = -1.61 ± 0.03$ (Alves 2000) used in GS02. As color index $(J - K)_{Rc}$, we assumed $(J - K)_{Rc} = 0.62 ± 0.05$, which was derived from solar metallicity Padova isochrones with $8.5 ≤ log t ≤ 10.0$; this value is close to the mean value of 0.61 ± 0.06 for the clusters quoted in GS02.

To ensure that the observed feature is indeed an RC and not the brightest part of a highly reddened MS, we also computed the ratio $(J - K)_{Rc}/(J - H)_{Rc}$ (Table 1). Assuming moderate reddening $(0 < E(B - V) < 2)$, this ratio has a value of 1.2 to 1.4 for RC stars and a value close to 1.6 for stars of early spectral type; therefore, it provides information concerning the stellar composition of the feature.

It should be noted, however, that the parameters that were derived from $m_{K,Rc}$ and $(J - K)_{Rc}$ should only be taken as estimates, as both $M_{K,Rc}$ and $(J - K)_{Rc}$ should show a dependence on age and metallicity (GS02; Girardi & Salaris 2001); differences from the actual values of up to 30% can be expected. To determine more precise fundamental parameters, deeper studies of the cluster candidates are therefore required.

2.3. Radial density profiles (RDPs)

In addition to the CMDs, we created RDPs from 2MASS data by counting stars in concentric rings and dividing the counts by the area of each ring. To avoid misleading results due to spatial variations in the number of faint stars, we applied a cut-off at $H = 15.5$ for optical clusters and at $K_s = 14.5$ for infrared clusters. These RDPs were used to determine the diameter of each candidate with good precision. They also provided a check on whether the fields of the potential clusters indeed exhibited a significant excess in the number of stars compared to the stellar background density.

3. Results and discussion

3.1. Open clusters and promising open cluster candidates

In Tables 3a to 3c, we provide positions, angular diameters, reddenings, distances, and ages of 24 stellar aggregates visible in optical or infrared wavelengths that we consider as being open clusters or, at least, promising open cluster candidates according to the results of the analytical procedures described in Sect. 2. Cluster candidates whose CMDs allowed a fit to solar metallicity Padova isochrones are listed in Table 3a, while candidates with RCs in their CMDs are given in Table 3b. Finally, Table 3c contains those candidates for which the determination of fundamental parameters was found to be impossible. Every cluster candidate has a designation in the IAU-recognized format DSH Jhhmm.m+ddmm and its discoverer-ID assigned. Unless otherwise noted, all candidates were discovered between June 2003 and December 2004; the discovery was in each case announced to the DSH newsgroup. One of the described cluster candidates (DSH J0718.1-1734 = Teutsch 49) turned out to be independently discovered by Drake (2003); it is listed therein as DC 2.

Figures 1 to 3 show the DSS images of all optical cluster candidates extracted from the CADC facility. The RDPs of the clusters are given in Figures 4 to 6. Finally, in Figures 7 to 9, the results of the photometric analysis of the clusters are presented. In each case, the radius of the extraction area equals the visually determined cluster radius $R_{vis}$. To increase the contrast between cluster features and background scatter in the CMDs, we used different grey-tones, with lighter tones indicating a larger distance from the cluster center.

3.2. Extended notes

3.2.1. Isochrone-fitted cluster candidates

DSH J0355.3+5823 = Juchert 9 is a small and slightly irregularly shaped cluster with 15 brighter stars and an unknown number of fainter members. It is well separated from the Milky Way background (Fig. 1). The center of the cluster is dominated by a pair of equally bright stars, which is listed in the Washington Catalogue of Double Stars (Worley & Douglass 1997, hereafter WDS) as Stein 2015. As can be seen from the CMD shown in Fig. 2, the cluster stars align along a well-defined MS. A giant branch is not evident, implying that the cluster is a rather young object. As an upper limit, we found $t = 7.6$.

DSH J0528.3+3446 = Kronberger 1 is an irregularly shaped, N-S elongated cluster situated 22° N of the HII region IC 417 and 4.7° N of the bright K0 star HD 35 742. The brightest cluster member, LS +34 33 (Reed 1998), is a luminous star of spectral type B, which is also listed as a double star with the designation Scheiner 272 in the WDS. The CMD of Kronberger 1 (Fig. 2) exhibits a sparsely populated, but fairly well-defined cluster sequence that lacks any evolutionary features and shows a gap between $J = 11.5$ and $J = 13$. The solar metallicity isochrone fit of this feature gives a distance of $d = 1.9 ± 0.2$ kpc and a reddening of $E(B - V) = 0.52 ± 0.06$. As in the case of Juchert 9, an exact age cannot be determined; the upper limit appears to be $t = 7.5$.  

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5 http://groups.yahoo.com/group/deepskyhunters
Table 3a. Positions, angular diameters, reddenings, distances, and ages of the open cluster candidates with CMDs fitted with Padova solar metallicity isochrones.

Note: * see Sect. 3.2.1.

The three cluster candidates DSH J0553.8+2649 = Teutsch 51, DSH J1453.4-6028 = Teutsch 80 and DSH J1704.3-4204 = Teutsch 84 are cluster candidates that are situated in Milky Way parts that appear to be heavily obscured by interstellar dust; it is therefore possible that these objects are actually regions of lower extinction and not physical groups of stars. Nonetheless, in all cases the CMD (Fig. 7) supports the idea of a real clustering, as they all reveal well-defined structures that resemble cluster sequences and are not visible in the CMDs of the comparison fields.

DSH J1930.2+1832 = Teutsch 42 is a compact cluster candidate that is located 17° N of the HII region S 82 (Sharpless 1959) in Sagitta. It appears as a tight group dominated by a triangle of brighter stars (Fig. 1). As its color excess of $E(B - V) = 2.55 \pm 0.09$ implies, it is a highly reddened object. One of the remarkable things about this cluster is the presence of the X-ray source 2E 1928.0+1825 = 2RXP J193013.8+183216 (Harris et al. 1994; ROSAT 2000) in its field. Whether there is indeed a physical connection between this object and the cluster requires deeper study and will not be discussed in this publication; we note, however, the short distance from the cluster center of 12 ± 10 arcseconds (ROSAT 2000).

DSH J1933.9+1831 = Kronberger 79 is a compact object of irregular morphology that contrasts very well with the Milky Way background (Fig. 1). This is also indicated by its RDP (Fig. 2). With a sharp central peak and a steady decline with increasing distance from the center, it has a shape that is typical of open clusters with a strong central condensation. Photometric analysis of the cluster field reveals a well defined cluster sequence with a MS, a possible turn-off at about $J = 12$ and $(J - H) = 0.4$, and a few possible giant stars positioned around $J = 11.2$ and $(J - H) = 0.9$ (Fig. 7). Assuming that these stars are indeed members of Kronberger 79, distance, age, and color excess are found to be $d = 2.7 \pm 0.4$ kpc, $E(B - V) = 1.30 \pm 0.06$, and log $t = 8.35 \pm 0.1$. Another solution, excluding the giant stars, yields $d = 3.6 \pm 0.4$ kpc, $E(B - V) = 1.52 \pm 0.06$, and log $t = 7.4 \pm 0.3$.

DSH J2002.3+3518 = ADS 13292 CI is a very compact group with a morphology similar to the Trapezium Cluster in the Orion Nebula (Fig. 1). Although it was noted as a multiple star as early as 1894 by Thomas Espin, who catalogued it as Espin 202 (WDS), and listed as potential trapezium system #67 by Ambartsumian (1954), it was not recognized as a possible cluster until recently when it was independently discovered by B. Skiff and P. Teutsch (Archinal & Hynes 2003). A recent study of trapezium systems by Abt & Corbally (2000) (hereafter AC00) revealed the group indeed to be a physical system and identified 6 probable cluster members, all of them within 0.55 arcmin from the cluster center. However, as AC00 considered just the brightest stars of the system and ignored the fainter group members the actual number of cluster members may therefore be much higher. From a solar metallicity isochrone fit of the CMD (Fig. 7), we found a distance modulus $(m - M)_0$ of 11.0 ± 0.2 and a color excess $E(B - V) = 0.58 \pm 0.06$. This is in good agreement with the values quoted in AC00, which are $(m - M)_0 = 10.9$ and $E(B - V) = 0.61$, respectively. The cluster appears to be a very young object, with an age of probably less than 10 Myr.

DSH J2027.7+3604 = Teutsch 30 is a fairly poor and loose group of stars associated with the faint HII region LBN 198 (Lynds 1965) and located immediately E of a long, thin streak of interstellar matter that runs in N-S direction (Fig. 1). The stellar aggregate is positioned around the B star BD+35 4126, which is also listed in the WDS as a quadruple star with the designation Espin 2193. As its position within a HII region suggests, this cluster appears to be a very young object, with log $t \leq 6.9$. 

| DSH ID       | Discoverer ID | RA J2000 | Dec J2000 | $D_{vis}$ arcmin | $E(B - V)$ | $(m - M)_0$ | Distance kpc | Age log $t$ |
|--------------|---------------|----------|-----------|------------------|------------|-------------|--------------|------------|
| DSH J0355.3+5823 | Juchter 9     | 03 55 21.0 | +58 23 30 | 3.0 | 0.79 ± 0.06 | 13.20 ± 0.30 | 4.4 ± 0.6 | < 7.6       |
| DSH J0528.3+3446  | Kronberger 1  | 05 28 21.0 | +34 46 30 | 1.6 | 0.52 ± 0.06 | 11.40 ± 0.20 | 1.9 ± 0.2 | < 7.5       |
| DSH J0553.8+2649  | Teutsch 51    | 05 53 51.9 | +26 49 47 | 3.6 | 1.06 ± 0.09 | 12.60 ± 0.20 | 3.3 ± 0.3 | 8.90 ± 0.10 |
| DSH J1453.4-6028  | Teutsch 80    | 14 53 25.6 | −60 28 57 | 3.4 | 1.61 ± 0.06 | 11.95 ± 0.60 | 2.5 ± 0.6 | 8.10 ± 0.15 |
| DSH J1704.3-4204  | Teutsch 84    | 17 04 20.1 | −42 04 24 | 4.0 | 1.12 ± 0.15 | 11.75 ± 0.25 | 2.2 ± 0.3 | 9.00 ± 0.10 |
| DSH J1930.2+1832  | Teutsch 42    | 19 30 13.1 | +18 32 09 | 1.2 | 2.55 ± 0.09 | 11.00 ± 0.20 | 1.6 ± 0.2 | 7.50 ± 0.25 |
| DSH J1933.9+1831  | Kronberger 79 | 19 33 55.0 | +18 31 12 | 2.1 | 1.52 ± 0.06 | 12.80 ± 0.30 | 3.6 ± 0.4 *  | 7.40 ± 0.30 * |
| DSH J2002.3+3518  | ADS 13292 CI  | 20 02 23.3 | +35 18 41 | 1.1 | 0.58 ± 0.03 | 11.00 ± 0.20 | 1.6 ± 0.2 | < 7.0       |
| DSH J2027.7+3604  | Teutsch 30    | 20 27 43.0 | +36 04 32 | 3.2 | 1.24 ± 0.03 | 11.05 ± 0.15 | 1.6 ± 0.1 | < 6.9       |
3.2.2. cluster candidates with RCs

DSH J1323.6-6340 = Teutsch 79 is a faint cloud of stars not well separated from the background Milky Way and with an obvious dark spot in the immediate center (Fig. 2). Its CMD (Fig. 3) reveals a distinct RC with similarities to the structure that is observed in the CMD of the cluster C 1426-607 = Pismis 19 (DAML02) (Fig. 11). From the position of the RC in the CMD, distance and reddening of this cluster candidate are found to be $d = 6.7 \pm 0.4$ kpc and $E(B-V) = 0.95 \pm 0.12$.

DSH J1226.1+5331 = Kronberger 81 is a rich cloud of stars, appearing as a dense cloud of extremely faint stars on red and infrared DSS images (Fig. 2), on blue DSS images, the cluster is invisible, indicating strong interstellar absorption in the cluster field. As in the case of Teutsch 42, an X-ray source is located in the immediate vicinity of the cluster, about 2.0' distant from the cluster center and less than 10' from the star TYC 3966-892-1; its designation in the ROSAT all-sky Bright Source Catalogue (Voges et al. 1999) is IRRXS J122622.1+533224. The CMD of the cluster (Fig. 3) differs significantly from the CMDs of the comparison fields, as it completely lacks a distinct population of blue stars but instead reveals a conspicuous feature on the red side of the diagram at $(J - H) \approx 1$, which is, in all probability, the well-populated giant branch of the cluster, with the RC positioned at $J \approx 14$. This is especially distinct in the innermost 0.55' of the cluster, where almost all stars detected by 2MASS align along this feature. All this is a strong argument in favor of the reality of this object, as the presence of a dust hole, which might have a similar optical appearance, would result in a shift of the stellar distribution to the blue side of the CMD. Moreover, the $(J - k)_{RC}/(J - H)_{RC}$ value of 1.39 $\pm$ 0.02 that is determined for this feature (see Table 1) indicates that it is indeed composed of giant stars and not a population of reddened main-sequence stars. As a comparison with the cluster NGC 2158 (whose giant branch is of comparable appearance) shows, the lack of an MS in the CMD of Kronberger 81 is probably due to the fact that the MS stars are too faint to be detected (Fig. 11).

3.2.3. Cluster candidates without fundamental parameters

DSH J0718.1-1734 = Teutsch 49 is a fairly rich cluster of faint stars that is separated very well from the Milky Way background (Fig. 3). It is identical with the object DC 2 in Drake (2005). The visually estimated diameter of this cluster is 2.4', but the RDP (Fig. 5) suggests that outliers extend as far as 2.2' from the cluster center. A similar cluster radius (2.4') is found by Drake (2005), who furthermore notes a King model core radius of 0.55' for this cluster. The cluster CMD

| DSH ID                  | discoverer ID | RA J2000  | Dec J2000 | $D_{68}$ arcmin | $E(B-V)$   | $(m-M)_0$    | distance kpc |
|------------------------|---------------|-----------|-----------|-----------------|------------|--------------|--------------|
| DSH J0347.3+5354       | Juchert 11    | 03 47 18.0 | +53 54 35 | 5.0             | 1.68 $\pm$ 0.15 | 12.75 $\pm$ 0.15 | 3.6 $\pm$ 0.2 |
| DSH J0920.5-5251       | Teutsch 48    | 09 20 31.8 | +52 51 06 | 2.2             | 0.96 $\pm$ 0.11 | 14.25 $\pm$ 0.20 | 7.0 $\pm$ 0.6 |
| DSH J1054.2-6144       | Kronberger 39 | 10 54 13.6 | +61 44 16 | 0.8             | 0.90 $\pm$ 0.15 | 15.20 $\pm$ 0.15 | 11.1 $\pm$ 0.8 |
| DSH J1323.6-6340       | Teutsch 79    | 13 23 38.8 | +63 40 10 | 2.0             | 0.95 $\pm$ 0.12 | 14.15 $\pm$ 0.10 | 6.7 $\pm$ 0.4 |
| DSH J1906.8+0935       | Alessi 56     | 19 06 52.1 | +09 35 00 | 2.2             | 2.00 $\pm$ 0.13 | 12.95 $\pm$ 0.10 | 3.9 $\pm$ 0.2 |
| DSH J1920.8+1540       | Alessi 57     | 19 20 53.8 | +15 40 36 | 2.5             | 2.11 $\pm$ 0.11 | 12.95 $\pm$ 0.10 | 3.9 $\pm$ 0.2 |
| DSH J1940.1+2615       | Kronberger 31 | 19 40 11.0 | +26 15 48 | 1.3             | 0.84 $\pm$ 0.15 | 15.40 $\pm$ 0.15 | 11.9 $\pm$ 0.8 |
| DSH J1942.7+2951       | Teutsch 43    | 19 42 46.9 | +29 51 20 | 1.3             | 0.54 $\pm$ 0.15 | 14.55 $\pm$ 0.10 | 8.1 $\pm$ 0.4 |
| DSH J1945.1+2809       | Kronberger 4  | 19 45 11.4 | +28 09 40 | 1.3             | 0.56 $\pm$ 0.12 | 14.50 $\pm$ 0.15 | 7.9 $\pm$ 0.6 |
| DSH J2126.1+5331       | Kronberger 81 | 21 26 08.9 | +53 31 58 | 3.5             | 1.50 $\pm$ 0.13 | 13.85 $\pm$ 0.15 | 5.9 $\pm$ 0.4 |

Table 3b. Positions, angular diameters, redenning and distances of the open cluster candidates with RCs.
implies strong reddening \( E(B - V) \) in the range of 1.5 – 2.0. A giant branch is not evident in the CMD, indicating that the stellar aggregate is rather young.

DSH J1052.8-5927 = Teutsch 31 is a very compressed star-cluster candidate with a diameter of 1.2 arcminutes in the vicinity of the \( \eta \) Carinae Nebula NGC 3372. The CMD of this candidate (Fig. 2) contrasts well with the comparison fields and reveals traces of the MS at about \( J - H = 0.4 \), but it is not defined well enough to determine any fundamental parameters.

DSH J2003.1+3158 = Kronberger 54 is a small cluster of stars that is well separated from the Milky Way background. It is situated 4.1′ E of the bright star HD 190227 and 3.6′ N of the possible planetary nebula CoMaC 3 (Acker et al. 1992).

The CMD of Kronberger 54 (Fig. 2) shows practically all cluster stars aligned along a well-defined, although fairly broad MS; a giant branch is not present, indicating that this group is of rather young age. Unfortunately, the scatter of the MS, together with the obvious lack of stars with \( J > 15 \) in the cluster field, prevents a reliable determination of the fundamental parameters of this cluster.

DSH J2111.8+5222 = Kronberger 80 is also a likely galactic cluster. It is situated in a part of the Milky Way with fairly strong interstellar obscuration. Very small \( D_{\text{vis}} = 0.9′ \) and dense, it appears as a conspicuous object on the DSS image shown in Fig. 5.

### 3.3. Other candidates

Table 3c lists further stellar agglomeration reported to the DSH newsgroup between June 2003 and December 2004, which we consider to be possible open clusters from the analytical procedures described in Sect. 2. As in Tables 3a to 3c, positions and angular diameters of the cluster candidates are given, and a DSH designation and the discoverer ID are assigned. It should be noted that 2 of the objects presented in this section (DSH J0629.4+0910 = Alessi 53 and DSH J1959.5+4918 = Patchick 89) turned out to be described by Drake (2005) as objects DC 6 and DC 7, respectively; nevertheless, as in the case of Teutsch 49 (see Sect. 3.2.3), we decided to include these objects as they have been discovered independently.

Although the evidence that the objects listed in Table 3c are indeed genuine open clusters is weaker than for the candidates presented in Tables 3a to 3b, their morphologies, CMDs and RDPs are good arguments in favor of their being clusters. However, as with the cluster candidates described in the previous section, deeper studies are necessary to further clarify their nature.

An additional list of 174 stellar fields with evidence that an open cluster might be involved (= Table 2e) is available via the CDS. As in Table 3b, the following information is given: DSH ID, discoverer ID, RA J2000, DE J2000, and the visual diameter \( D_{\text{vis}} \).

### 4. Conclusions

An inspection of several Milky Way fields using DSS and 2MASS \( JHK_\text{S} \) imagery has led to the discovery of 66 stellar aggregates that are thought to be open clusters or, at least, promising open cluster candidates due to their appearance, their stellar density distributions, and their CMDs. For 9 of these objects,
chances are high that a number of unknown galactic clusters as presented in this paper, can be seen as a sign of the low be the object of a deeper investigation. cannot be answered from the available data and therefore shall these are indeed physically connected with the clusters or not involved in nebulosity DSH J0542.7+3057B (see Appendix A) situated within the NE part of Sh2-240 (Sharpless 1959) Teutsch 42 and Kronberger 81; however, the question whether sources in the immediate vicinity of 2 clusters presented here, isochrones and found distances E(J2000) = D(Vis) = d + 0.7 ln(1 + B/V) for these objects is still awaiting discovery. It should be noted, however, that further studies are required to confirm that the objects presented here are true clusters and to determine their precise fundamental parameters. 5. Addendum During our survey for new open cluster candidates on DSS and 2MASS, we noted a number of galactic nebulae and galaxies that were found not to be listed in any current database. The most impressive of these objects are listed in Table 4 with a more extensive list (Tables 4a and 4b) available via the CDS. All objects are tentatively classified on the basis of their bright- ness and morphology on DSS-2 blue, red, and infrared images. However, further detailed investigations are needed to establish their true nature. Acknowledgements. This publication made use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science

Table 3d. Positions and angular diameters of additional open cluster candidates.
## Table 3. Positions and angular diameters of apparently uncatalogued galactic and extragalactic objects.

| DSH ID            | discoverer id | RA_{J2000}   | Dec_{J2000} | \(D_{\text{maj}}\) \(\text{arcmin}\) | \(D_{\text{min}}\) \(\text{arcmin}\) | notes                                                                 |
|-------------------|---------------|--------------|-------------|-----------------------------------|-----------------------------------|-----------------------------------------------------------------------|
| DSH J0540.7+3144  | Teutsch PN J0540.7+3144 | 05 40 44.6  | +31 44 32   | 1.8                               | 1.8                               | PN; independent IPHAS discovery (Frew 2005a)                          |
| DSH J0542.7+3057B | Teutsch GN J0542.7+3057B | 05 42 44.3  | +30 57 57   | 2.1                               | 2.1                               | HII region; associated with DSH J0542.7+3057A = Teutsch 45 compact HII region or PN |
| DSH J0600.5+2141  | Teutsch GN J0600.5+2141  | 06 00 34.8  | +21 41 11   | 1.2                               | 1.1                               | confirmed spectroscopically as PN (Frew 2005a)                       |
| DSH J0646.4+0828  | Riddle PN J0646.4+0828   | 06 46 24.7  | +08 29 02   | 1.1                               | 1.0                               | reflection nebula?                                                    |
| DSH J1140.9-6640  | Riddle GN J1140.9-6640   | 11 40 58.5  | -66 40 14   | 1.7                               | 1.1                               | small disk 0.6' N of SAO 160 398; planetary nebula?                   |
| DSH J1174.8-1415  | Patchick 2             | 17 14 48.9  | -14 15 54   | 0.17                              | 0.17                              | reddish circular nebosity; planetary nebula?                         |
| DSH J1190.9+1204  | Teutsch GN J1190.9+1204 | 11 59 54.9  | +12 04 52   | 0.2                               | 0.2                               | probable bipolar PN (Block 2005)                                    |
| DSH J1191.5+4445  | Patchick 5             | 11 19 30.6  | +44 45 44   | 2.6                               | 1.6                               | probable bipolar PN (Block 2005)                                    |
| DSH J1190.6+2930  | Kronberger PN J1190.6+2930 | 11 90 40.4  | +29 30 09   | 0.4                               | 0.4                               | as galaxy by Roman et al. 2008a, PN (Frew 2005a)                    |
| DSH J1191.4+1908  | Kronberger GN J1191.4+1908 | 11 91 07.7  | +19 08 26   | 0.6                               | 0.3                               | irregular nebosity surrounding 2 stars; classification uncertain     |
| DSH J1742.4+2145  | Teutsch J1742.4+2145    | 17 42 26.1  | +21 45 23   | 0.35                              | 0.35                              | small bipolar nebula?                                                |
| DSH J1744.9+2245  | Kronberger PN J1744.9+2245 | 17 44 59.1  | +22 45 49   | 4.0                               | 4.0                               | PN (Frew 2005a); Lan 21 (Lanning & Meade 2000) assoc.               |
| DSH J1947.0+2930  | Patchick 1             | 19 47 02.7  | +29 30 26   | 0.21                              | 0.18                              | confirmed spectroscopically as PN (Frew 2005a)                      |
| DSH J1957.3+2639  | Teutsch PN J1957.3+2639 | 19 57 22.3  | +26 39 06   | 2.3                               | 1.5                               | nebuloity with very blue central star? (Frew 2005a)                 |
| DSH J2002.4+5334  | Patchick 4             | 20 02 28.4  | +53 33 18   | 3.5                               | 3.5                               | probable bipolar PN (Frew 2005a)                                    |
| DSH J2009.6+4116  | Patchick 6             | 20 09 40.9  | +41 14 43   | 0.7                               | 0.7                               | probable bipolar PN (Frew 2005a)                                    |
| DSH J2046.1+5257  | Patchick 3             | 20 46 10.5  | +52 57 06   | 0.5                               | 0.5                               | nebuloity with very blue central star; planetary nebula?             |
| DSH J2051.0+7222  | Schoenball GN J2051.0+7222 | 20 51 05.0  | +72 22 27   | 2.5                               | 2.0                               | even illuminated elliptical nebula; reflection nebula?               |
| DSH J2055.4+3903  | Teutsch PN J2055.4+3903 | 20 55 27.3  | +39 03 57   | 0.35                              | 0.25                              | small bipolar nebula?                                                |
| DSH J2120.0+5141  | Patchick 7             | 21 20 00.1  | +51 41 05   | 0.08                              | 0.08                              | very small emission-line object; planetary nebula?                   |
| DSH J2122.0+5504  | Kronberger PN J2122.0+5504 | 21 22 00.0  | +55 04 30   | 0.33                              | 0.33                              | nebuloity consisting of 2 opposing arcs; planetary nebula?           |
| DSH J2308.8+1712  | Riddle GX J2308.8+1712  | 23 08 51.4  | +17 12 36   | 1.8                               | 1.5                               | bright galaxy; variable star DY Pegasi superimposed                 |
| DSH J2327.2+6509  | Teutsch PN J2327.2+6509 | 23 27 13.8  | +65 09 15   | 0.3                               | 0.3                               | probable planetary nebula (Frew 2005a)                               |

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Fig. 1. Second generation DSS red images of the cluster candidates presented in Table 3a. The field of view is in each case $8' \times 8'$. North is up and East is left.
Fig. 1. (cont.)
Fig. 1. (cont.)

Teutsch 30
Fig. 2. Second generation DSS red images of the cluster candidates presented in Table 3b. The field of view is in each case 8′ × 8′. North is up and East is left.

Teutsch 79

Kronberger 81

Juchert 11

Teutsch 48
Fig. 2. (cont.)
Fig. 2. (cont.)

Teutsch 43

Kronberger 4
Fig. 3. Second generation DSS red images of the cluster candidates presented in Table 3c. The field of view is in each case 8′ × 8′. North is up and East is left.
Fig. 3. (cont.)
**Fig. 4.** RDPs of the cluster candidates presented in Table 3a, with the vertical scale normalized to the maximum stellar density in the cluster field. In each diagram, the maximum stellar density (in stars/arcmin$^2$) and, in brackets, the actual number of stars observed in this area are given. The mean density of the background is shown in each diagram as a horizontal line, with the 2σ error ranges of the background indicated as shaded areas. Only 2MASS sources with $H < 15.5$ were taken into account.
Fig. 4. (cont.)
Fig. 5. RDPs of the cluster candidates presented in Table 3b, with the vertical scale normalized to the maximum stellar density in the cluster field. In each diagram, the maximum stellar density (in stars/arcmin$^2$) and, in brackets, the actual number of stars observed in this area are given. The mean density of the background is shown in each diagram as a horizontal line, with the 2$\sigma$ error ranges of the background indicated as shaded areas. Only 2MASS sources with $H < 15.5$ were taken into account.
Fig. 5. (cont.)
Fig. 6. RDPs of the cluster candidates presented in Table 3c, with the vertical scale normalized to the maximum stellar density in the cluster field. In each diagram, the maximum stellar density (in stars/arcmin$^2$) and, in brackets, the actual number of stars observed in this area are given. The mean density of the background is shown in each diagram as a horizontal line, with the 2$\sigma$ error ranges of the background indicated as shaded areas. Only 2MASS sources with $H < 15.5$ were taken into account.
Fig. 7. CMDs of the cluster candidates presented in Table 3. Each diagram contains only those stars with a distance from the cluster center that is less than the visual cluster radius $R$ and with $J$ and $H$ magnitudes derived either via aperture photometry ($rd_{flg} = 1$) or via point-spread function fitting ($rd_{flg} = 2$). Also included are the best-fit solar metallicity isochrones of the CMD.
Fig. 7. (cont.)
Fig. 7. (cont.)
Fig. 8. CMDs of the cluster candidates presented in Table 3b. Each diagram contains only those stars with a distance from the cluster center that is less than the visual cluster radius $R$ and with $J$ and $H$ magnitudes derived either via aperture photometry ($rd_{flg} = 1$) or via point-spread function fitting ($rd_{flg} = 2$).
Fig. 8. (cont.)
Fig. 8. (cont.)
Fig. 8. (cont.)
Fig. 9. CMDs of the cluster candidates presented in Table 3c. Each diagram contains only those stars with a distance from the cluster center that is less than the visual cluster radius $R$ and with $J$ and $H$ magnitudes derived either via aperture photometry ($rd\_flg = 1$) or via point-spread function fitting ($rd\_flg = 2$).
Fig. 9. (cont.)
Fig. 10. Comparison of the CMDs of Pismis 19 (left) and Teutsch 79 (right). Both diagrams contain only those stars with $J$ and $H$ magnitudes derived either via aperture photometry ($rd_{lg} = 1$) or via point-spread function fitting ($rd_{lg} = 2$). Extraction radii of 1.5′ (Pismis 19) and 1′ (Teutsch 79) were taken.

Fig. 11. Comparison of the CMDs of NGC 2158 (left) and Kronberger 81 (right). Both diagrams contain only those stars with $J$ and $H$ magnitudes derived either via aperture photometry ($rd_{lg} = 1$) or via point-spread function fitting ($rd_{lg} = 2$). In each case, an extraction radius of 1.75′ was taken.