在銀河系盤面搜尋疏散星團

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摘要

我們利用2MASS星源目錄搜尋未知的疏散星團，在銀經90度到270度，銀緯-3.5度到＋3.5度之間，我們指認出高星球密度、但不是已知星團的區域。利用目視檢驗DSS與2MASS影像，最後我們挑出103個可能是未知疏散星團的區域。對於這些候選星團，我們計算出它們的中心坐標、角直徑、徑向星球密度分佈，以及總星球個數等參數。這裡我們報告四個仍有雲氣相伴的星團，包括OC 0234+6147、OC 0251+6007、OC 0456+4722以及OC 0537+3159，它們應該都是年輕星團或星群。我們以OC 0536+3112爲例，說明如何利用可見光光度測量，推算其距離約爲1.82 kpc，而年齡則約爲0.2 Gyr。

Searching for Open Clusters in the Milky Way Disk

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Abstract

We present the results of star counting of the 2MASS point sources to search for uncharted open clusters (OCs). As the first attempt, we identified regions with stellar density enhancements not associated with previously known star clusters along the Galactic disk, within the band l= 90º to 270º, and b = -3.5º to +3.5º. Visual inspection of the DSS and 2MASS images led to a final list of 103 regions as star cluster candidates, for each of which the central coordinates, angular size, projected stellar density profile, and total number of possible cluster members were derived. Four newly found OCs are presented here, including OC0234+6147, OC0251+6007, OC0456+4722, and OC0537+3159, each of which is associated with nebulosity, so is likely a young stellar group. We show how CCD photometric observations of OC0536+3112 were used to derive an estimated distance of 1.82 kpc and age of 0.2 Gyr.

關鍵字（Keywords）：星團(star cluster)；紅外線觀測(infrared)；光度測量(photometry)
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1. Introduction

Galactic formation and evolution theories expect some 106 open clusters (OCs) currently in existence in the Milky Way. Yet the updated database of OCs (e.g., by Dias et al. 2002), contains only ≤ 1800 entries. The incompleteness is partly due to the dust extinction in the Galactic plane, so only OCs in the solar neighborhood are sampled, and partly because of lack of comprehensive, systematic search programs.

A star cluster is characterized by grouping of member stars in a 6-dimensional phase space in position and velocity. To recognize velocity grouping, radial velocity and/or proper motion measurements are used. Such a kinematic study, however, requires special instrumentation and is usually time-consuming. In comparison, the space grouping is relatively straightforward. One identifies stellar density enhancement on the celestial sphere and finds isochrone consistency on the color-magnitude diagram, essentially constraining the selected stars to a limited volume in space.

In this study, we applied the star-count technique to the 2MASS point source catalog to search for candidate OCs. The 2MASS provides a uniformly calibrated database of essentially the entire sky. Furthermore, infrared observations allow

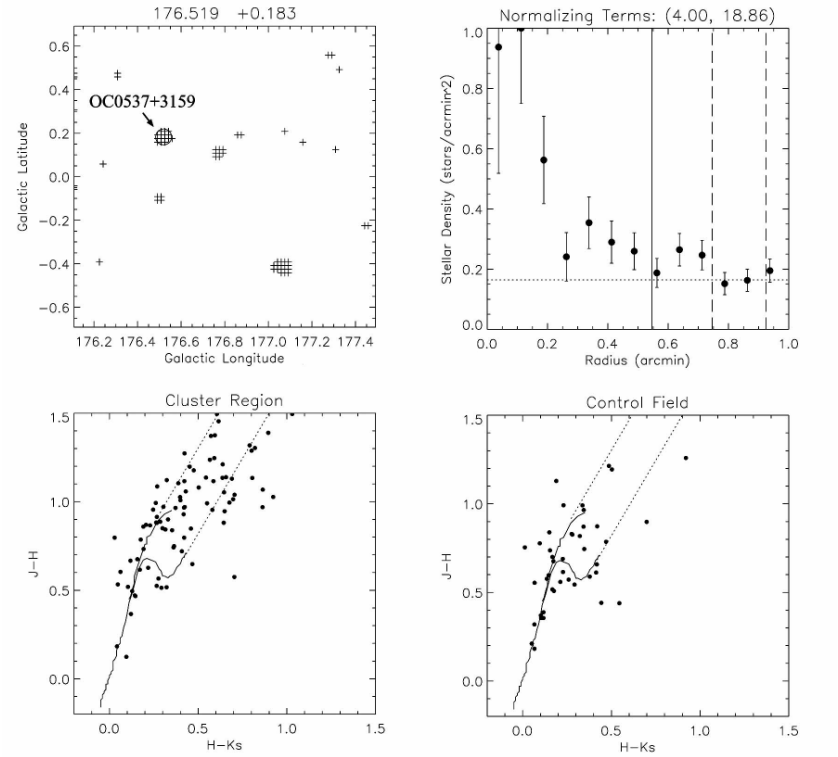

Fig. 1: (Top, Left) The stellar density enhancement near OC0537+3159, (Top, Right) The radial density profile. The 2MASS J-H versus H-Ks diagram for (Bottom, Left) the cluster region and (Bottom, Right) the control field. In the color-color diagrams, the curved lines represent the unreddened main sequence and giant loci (Bessell & Brett 1988), and the dotted lines indicate the interstellar reddening vectors (Rieke & Lebofsky 1985). The cluster region has significantly more stars than the control field of the same sky area, with some stars showing infrared excesses.

us to recognize OCs even with moderate dust extinction, i.e., partially embedded, young star clusters. As a pilot study, we analyzed the zone along the Galactic disk, 90º < l < 270º and −3.5º < b < +3.5º, and selected regions with stellar density enhancements. Some of the OC candidates have been observed with optical imaging to confirm their cluster nature and, if applicable, to derive their cluster parameters. A couple of examples are presented here.

2. Regions of Stellar Density Enhancements

We analyzed a 1.4º × 1.4º patch of sky at a time. This is then divided into 1' square grids to compute the stellar density. To increase the contrast, hence bringing out stellar grouping, the grid of density is smoothed with a boxcar average of 3' width. Any grid of the smoothed array with a stellar density

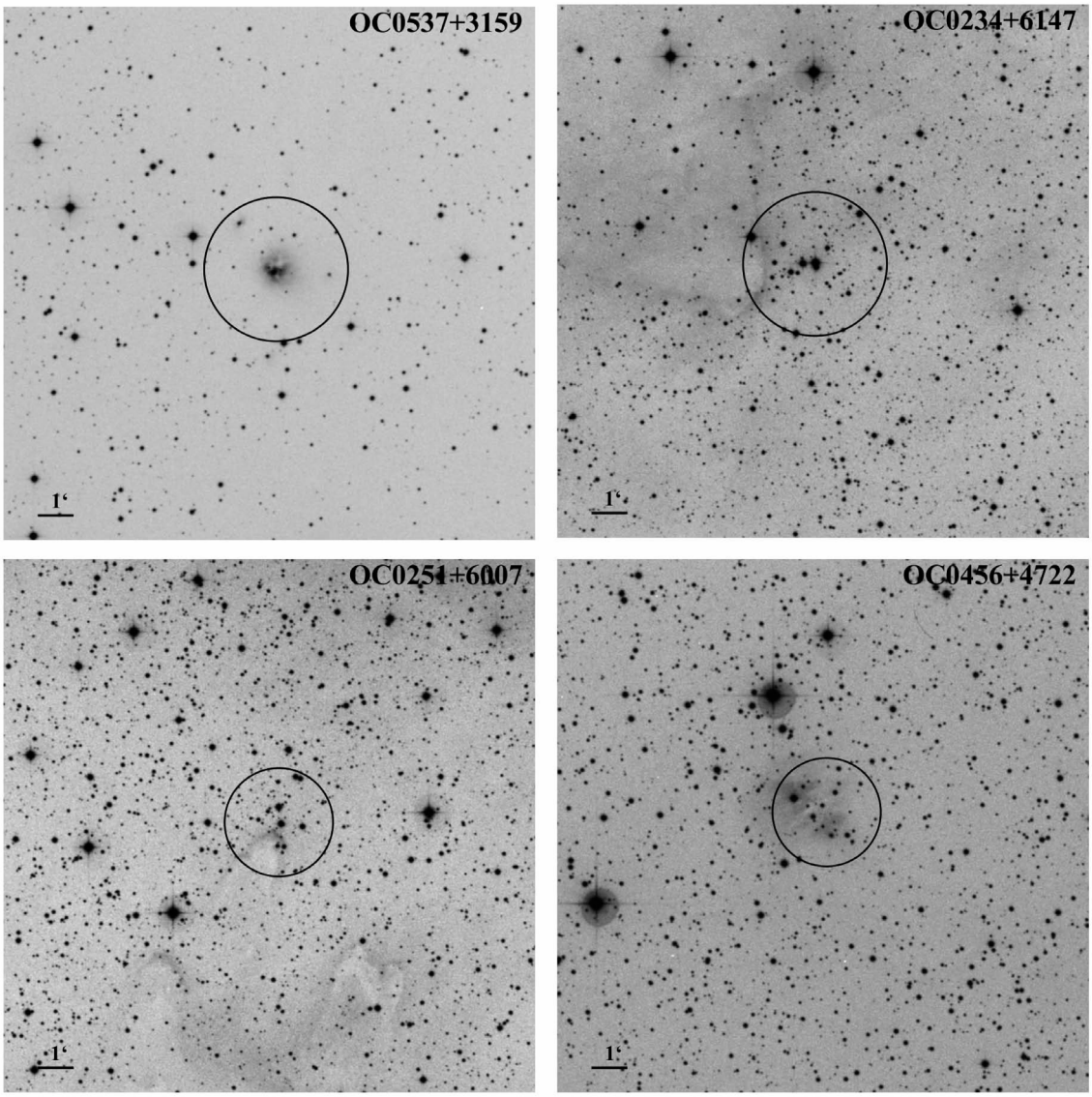

Fig. 2: DSS blue images of 4 open clusters associated with reflection nebulosity.

above three times of background, determined by an iterative 3-sigma clipping of the smoothed array, is considered overly dense. An algorithm is devised to identify connected over-density grids as a possible grouping, for which the central coordinates, angular size and number of member stars are derived. Fig. 1 shows an example of an open cluster candidate found by our analysis pipeline. It has been reported by Bica et al. (2003).

Visual inspection of the DSS and 2MASS images led to a final list of 103 candidate OCs within the zone l = 90º to 270º and b = −3.5º to +3.5º that we searched. In comparison, there are about 500 open clusters presently known in the same area, with about half of which having age/distance determinations. The results of our search will be reported elsewhere.

Using the example in Fig. 1, we see that OC0537+3159 is associated with reflection nebulosity (Fig. 2), which, together with the presence of infrared-excess stars, suggests OC0537+3159 to be a young star cluster. Three additional open clusters have been found that are associated with reflection nebulosity (Fig. 2). Their center coordinates, angular sizes, and numbers of member stars suggested by our analysis are listed in Table 1. Naturally further studies are needed to learn more about these young cluster candidates.

Table 1. Newly Found Candidates of Young Open Clusters.

Name	RA	DEC	Diam	Num
OC0234+6147	02:34:31	+61:47:01	4'	52
OC0251+6007	02:51:55	+60:07:27	3'	22
OC0456+4722	04:56:06	+47:22:50	3'	22

3. Follow-up Observations

Some of the OC candidates have been observed by UBV or BVI CCD imaging with the Lulin One-meter Telescope in January 2008 or with the CTIO 0.9 meter in February 2008. The images were processed with standard IRAF routines including bias and dark subtraction, and flat-field correction.

It is in general difficult to distinguish member stars of a sparse OC against field stars with imaging photometry. We analyzed the color-color and color-magnitude diagrams in an iterative way to select probable cluster members. We started out with selecting stars near an initially guessed reddened main sequence and giant branch (Johnson 1966) in the color-color diagram. Those that do not show up consistently also as members in the color-magnitude diagram then were excluded. The revised list of possible members in turn would be used in the color-color diagram again, now with an improved estimate of reddening and a narrower main sequence. This process continued until no further significant improvement was evidenced. The distance and age of the cluster were then derived by comparing with stellar evolution isochrones (e.g., Yi, et al. 2001).

Fig. 3 illustrates an example for OC0536+3112 (RA=05:36, DEC=+31:12, J2000) found in our search. After 3 iterations, the cluster is estimated to have a distance of 1.82 kpc, and age of 0.20 Gyr. We note that this cluster has recently been discovered by Koposov et al. (2008) who estimated a distance of 1.7 kpc and age < 0.22 Gyr. Our

results are consistent with those reported lately by Koposov et al. (2008).

4. Conclusion

We have developed an efficient star-count pipeline to identify possible star clusters in 2MASS point-source catalog. Four newly found OCs are presented here (OC0234+6147, OC0251+6007, OC0456+4722, OC0537+3159), each of which is associated with nebulosity, hence is likely a young stellar group. CCD photometric observations of OC0536+3112 yield an estimated distance of 1.82 kpc and age of 0.2 Gyr, thereby ascertain its cluster nature. Applications of our pipeline to star catalog of sky surveys, such as the Pan-STARRS, will allow us to explore a larger volume in the solar neighborhood, hence a more complete sample of OCs in the Galaxy.

Acknowledgments

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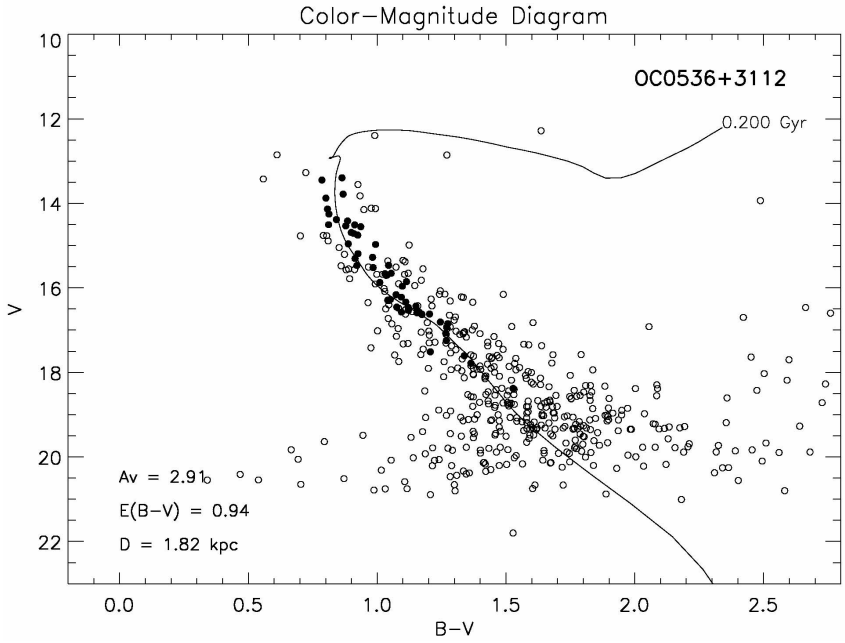

Fig. 3: The color-magnitude diagram of OC0536+3112. Solid circles represent probable main-sequence members, which are consistent with a distance of 1.82 kpc, whereas other stars are shown as open circles. An age of 0.20 Gyr (Yi et al. 2001) seems to fit well the data, including a few giants.