Search for and investigation of new open clusters using the data from huge astronomical catalogues

Sergey Koposov[1,2,*], Elena Glushkova[2]
[1]Max Planck Institute for Astronomy, Königstuhl, 17, Heidelberg, D-69117, Germany
[2]Sternberg Astronomical Institute, Moscow, Universtitetskiy pr., 13, Moscow, 119992, Russia
[*] math@sai.msu.ru

Here we present the results of the recent work of search for new open clusters in the data from large surveys. This poster is devoted to the methods used to search the open clusters (and not only) and determine their parameters, while the accompanying poster by Glushkova, Koposov is focused on the results of the investigation of open clusters in the anticenter region of the Galaxy using 2MASS data.

The idea behind this work was to provide a fast, simple and effective method for search of open clusters in very large datasets coming currently from different surveys like 2MASS, SDSS, DENIS etc. Up to the moment despite the stunning amount and quality of the data coming from these surveys there was no successful attempts doing the automatic search for open clusters. The problem of doing that is in the fact that the the densities of the stars in the Milky Way are high and are varying very significantly due to intrinsic reasons, dust etc., so algorithmically it's not easy to find the clusters of stars on such complex background. And even after having found the peaks, it is important to check that the cluster is really the evolutionally connected group of stars and not a random group of stars.

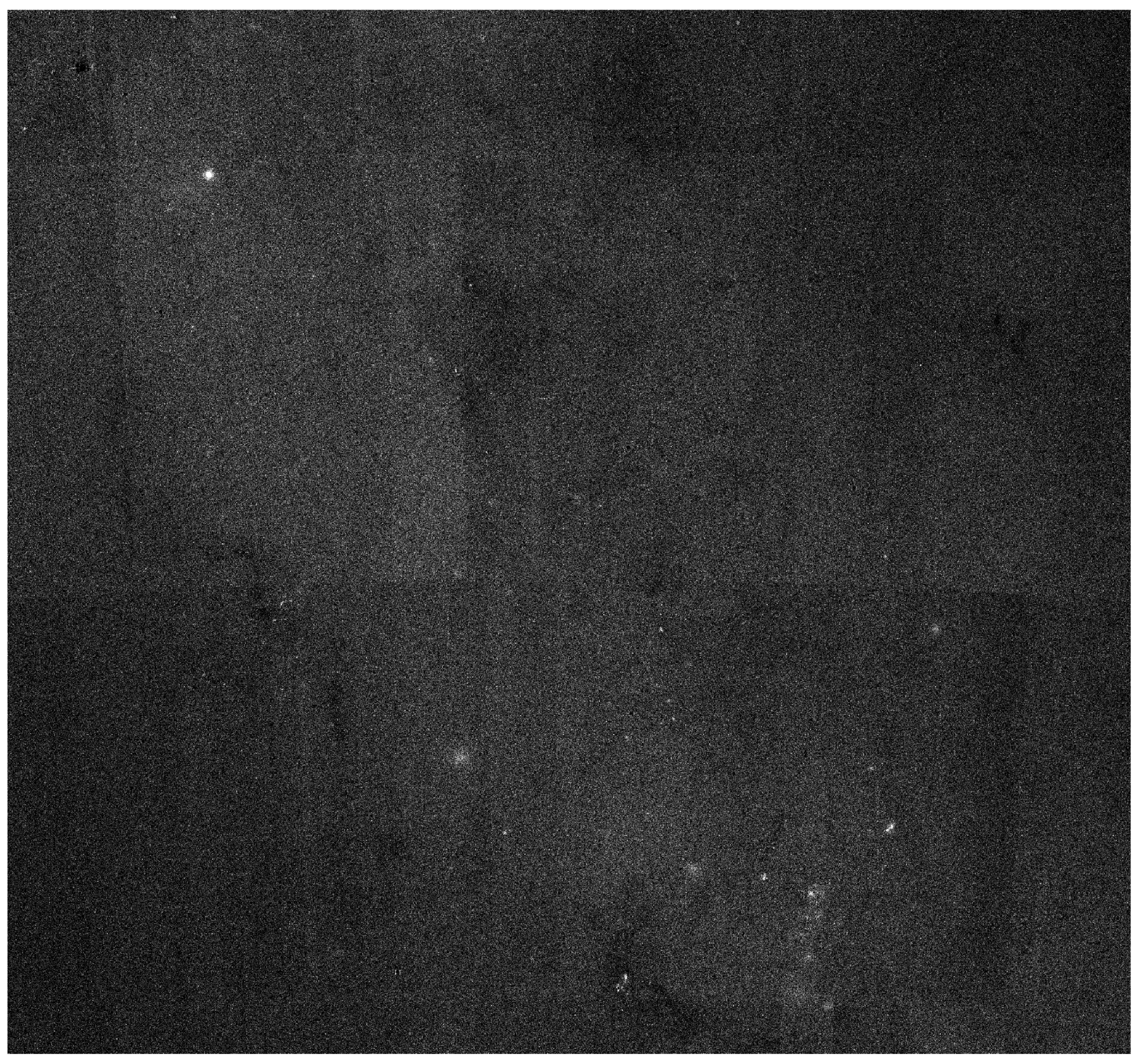

Figure 1: The 16°x16° area around the Galactic Anticenter using the data from 2MASS data.

So first idea was how we can detect the density peaks on the very changing background, and how we can be sure that the detected peaks are statistically significant. Also it is quite important to have a scheme which should not depend on any pixelization, and which should allow to detect the structures of any size (from large to small). So our idea was first to create the density map like Fig 1 (which is generally the number counts map in ra, dec) and after that the image should be convolved with the special filter like this (Fig 3).

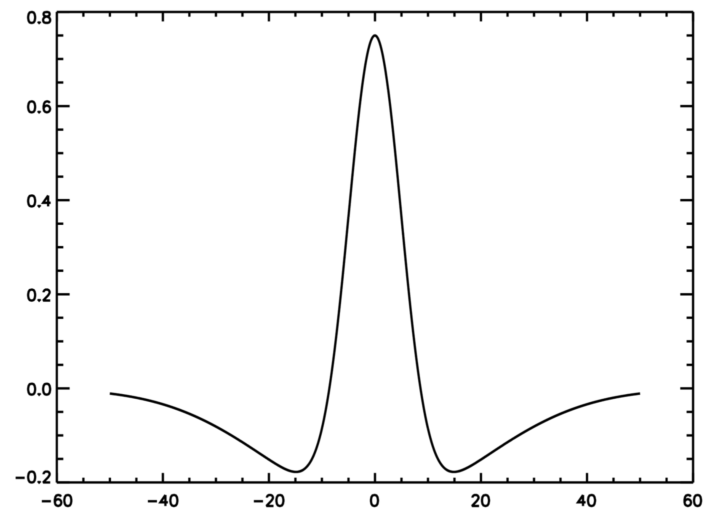

Figure 3: The kernel for the density map convolution

The idea of that filter is that it is the difference between two 2D gaussians and has the zero integral. And when we convolve the image with that filter it is evident that the flat background density and even slowly changing background density will produce the zero flux, whereas the clusters will produce the high signal. We must notice that for the clusters having the size close to the size of the inner gaussian the filter will be very close to optimal. Also it is worth notice, that it is rather easy to see that one can normalize the convolved image to have the pixels on output image showing the over-densities in Sigmas (the convolution of the random uniform density field produce the gaussian distribution). So after that the search for the clusters is quite easy, one just loop through every pixel of the image and collect only those pixels having flux greater than 5 (i.e. 5σ detection). The example of the convolved image for the Anticenter region of our Galaxy is shown on the Figure. 2. A huge population of peaks is clearly seen. All these peaks are mainly open clusters (among them 1/3 is new). the same image for the region in the Perseus arm is shown on Figure 3.

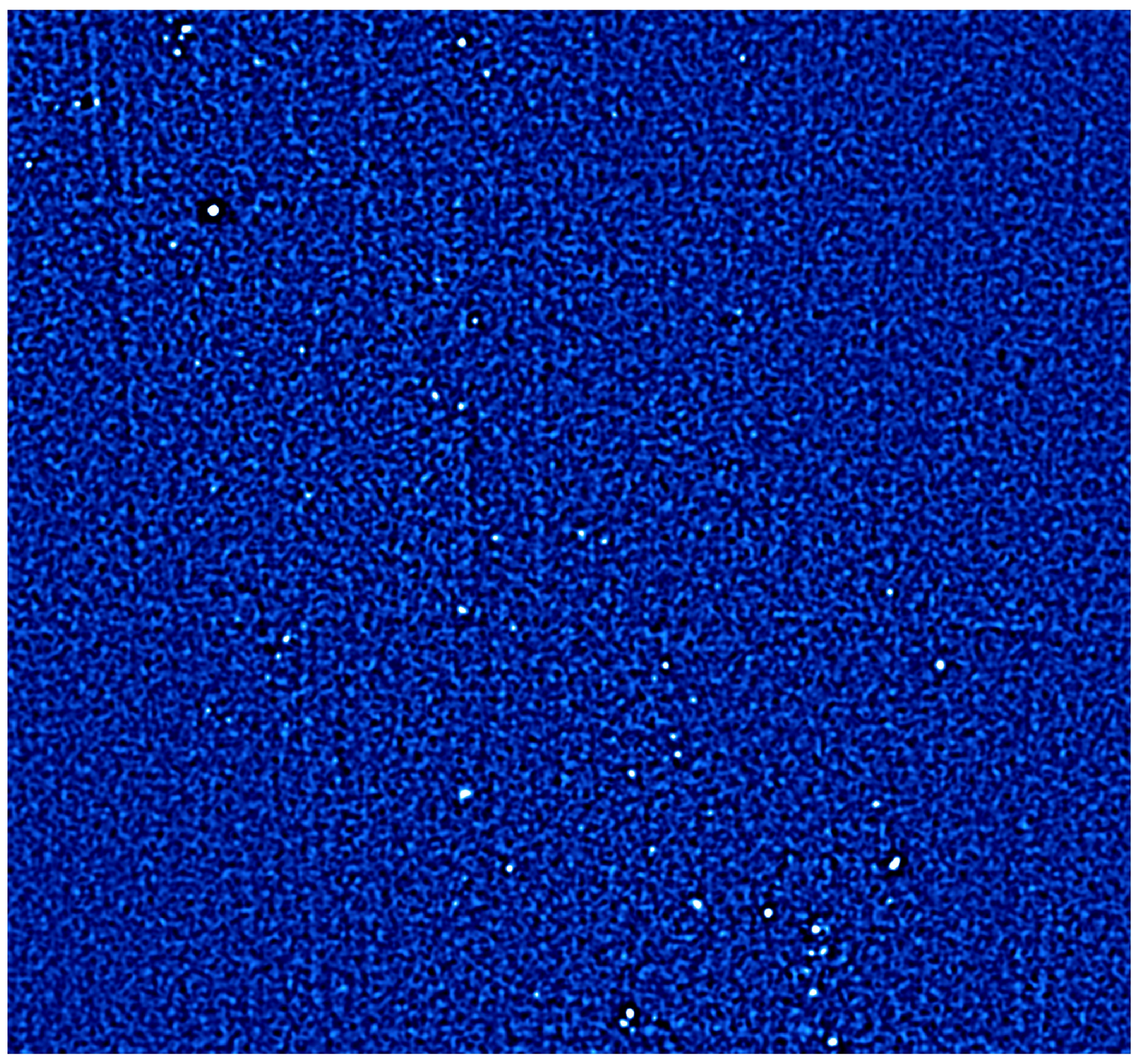

Figure 2: The same field after the convolution with density functions, now the values of each pixel contains the statistical significance of the density fluctuation in the point. Each bright point on this image is usual an open cluster, and ~1/3 of them are new.

But after having detected the individual density peaks it is still a question how would you distinguish whether the peak is density peak related to the real cluster or just a random fluctuation. So we need a method to determine that the density peak is coming from the stars lying on one isochrone. This is really the problem and the current samples of open clusters are polluted by significant fraction of not-clusters.

So the main idea allowing us to confirm the reality of the clusters is the fact that when we see the density peak of the stars in some point on the sky, then if it is really an open cluster then there should be an isochrone (shifted in some way), such as all the stars lying near that isochrone on the CMD should show a peak, whereas the stars lying far from the isochrone on the CMD should NOT show any peak of density. By using this method we succeed in several points: we higher the significance of the detection, comfirm or refute the reality of the cluster, and we able to determine the parameters of the cluster. The figures 4 are illustrating the idea for one of new open clusters found by us in the region of the Perseus arm.

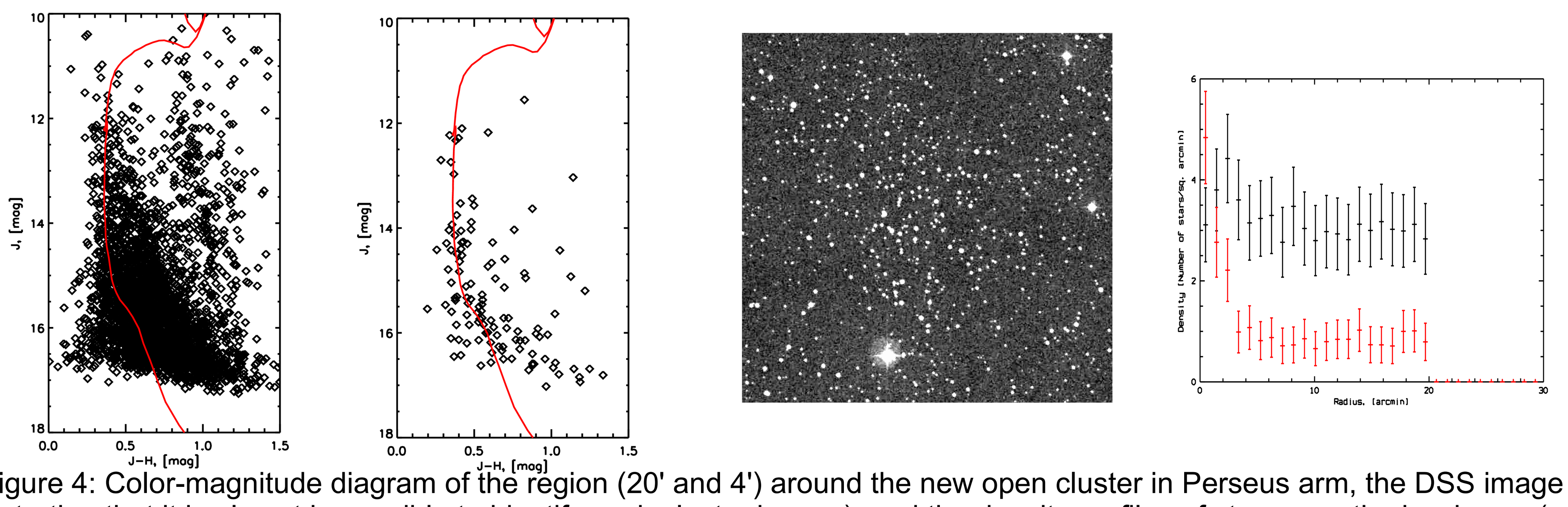

Figure 4: Color-magnitude diagram of the region (20' and 4') around the new open cluster in Perseus arm, the DSS image (illustrating that it is almost impossible to identify such cluster by eye), and the density profiles of stars near the isochrone (red points) and far from isochrone (black points).

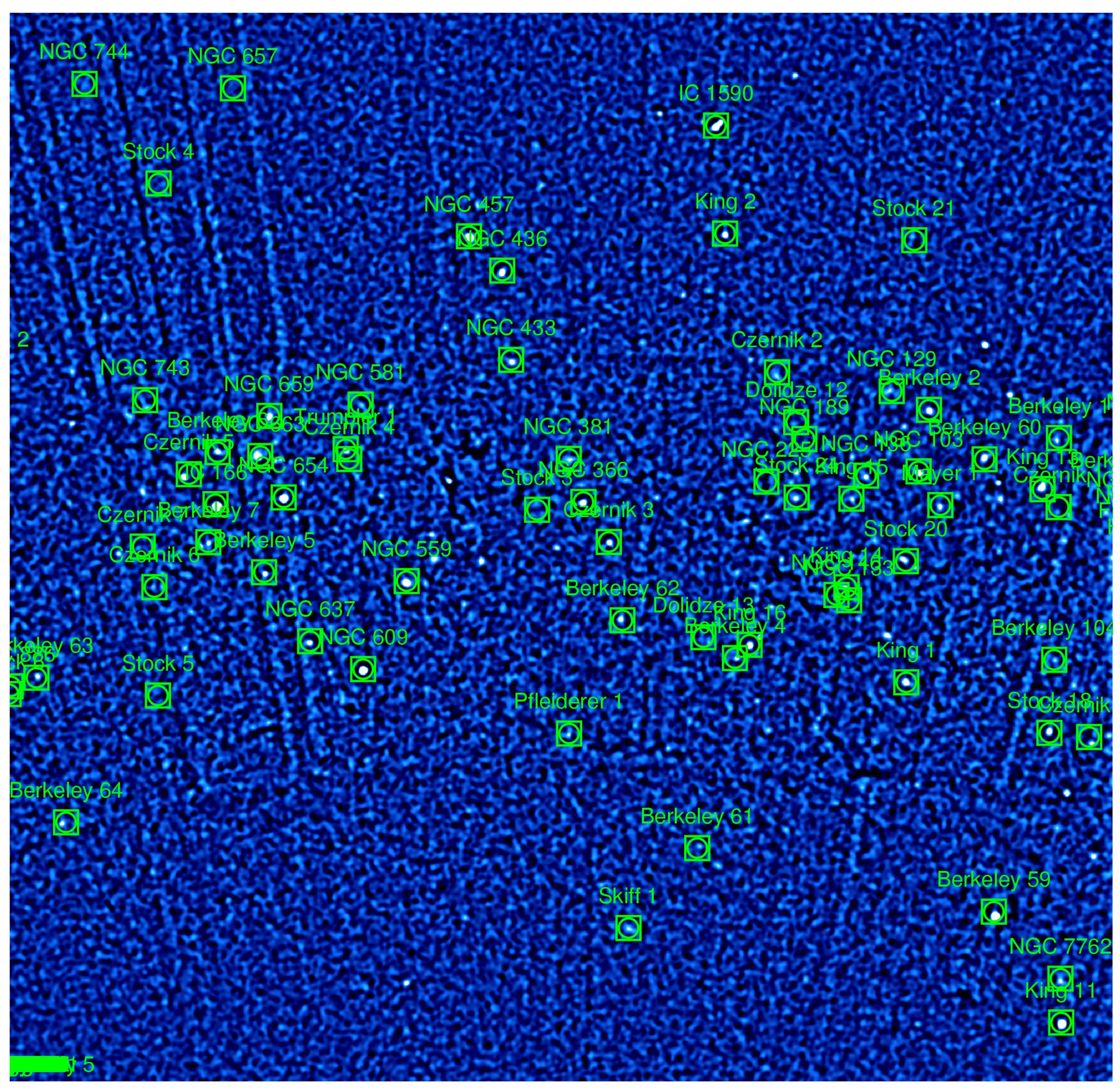

Figure 3: The region of the Perseus arm with known open clusters marked. Significant population of not yet discovered clusters is seen.

So that method was applied to each point detected in the first stage of search for density peaks. For every peak one basically loop through different isochrones, distances and reddenings to reach the higher significance of the peak of stars lying near the corresponding isochrone. The cases where the peak seen in th e near-isochrone and far-from-isochrone stars usually indicates that the peak is not due to real cluster.

This method have been fully applied to the Anticenter region of the Galaxy using 2MASS data and allowed us to find around 20 new open clusters and investigate the large population of already known but not yet studied clusters. These results are presented in the poster by Glushkova, Koposov.

As a conclusion we also want to show that the method can be easily applied for the different datasets. The figure 6 show the 180°x20° stripe from DR5 SDSS, the green regions are marking easily detected known globulars and !!New!! dwarf satellites discovered by recent works (Belokurov et al. 2006).

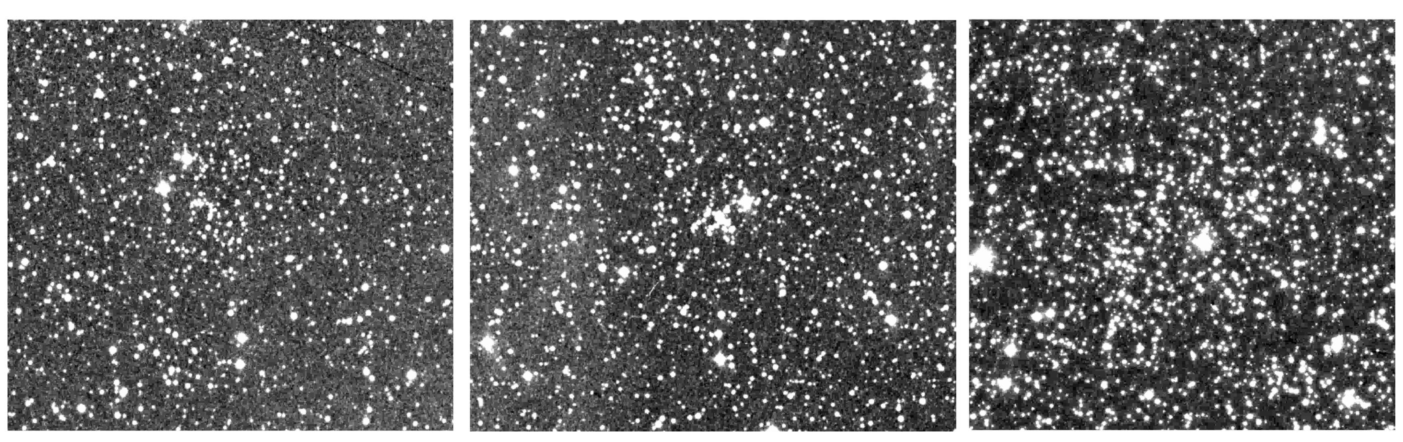

Figure 5: The DSS images of several new open clusters discovered using our method in the anticenter region of 2MASS

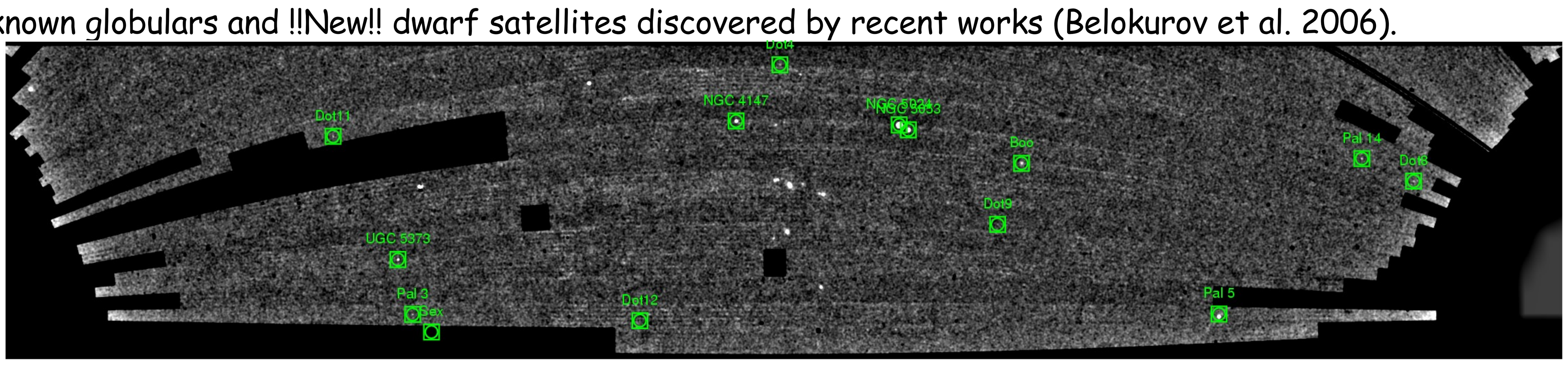

Figure 6: 180°x20° stripe from DR5 SDSS showing the detected by our method recently discovered dwarf galaxies and known globulars

References:

•Koposov S., Gluskova E. & Zolotukhin I. , Astron. Nachr. 325, 597-597, (2005)
•Zolotukhin I., Koposov S., Glushkova E.,2006, astro-ph/0601691
•Belokurov V., et al. 2006, astro-ph/0608448