# VVV Galactic Star Clusters: VVV CL059

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## ABSTRACT

The VISTA variables in the Vía Láctea (VVV) maps the inner disk and bulge area of our galaxy, and one of the principal objectives is to search for new star clusters in 5 different infrared bands with the aim to build a statistically significant sample. The new open clusters allows us not only estimate their distance and age, but also provided important information about formation, evolution and dinamical theories of this systems in the Galactic environment.
We present some resent results of photometric and spectroscopic investigation of VVV young cluster CL059, we derived fundamental parameters such as reddening, distance and age by fitting isochrones to the color-magnitude diagram. In addition we obtained a preliminary view of the proper motion on stars cluster.

## Introduction

The Vista Variables in the Vía Láctea (VVV) is one of the six ESO Public Surveys using the 4 m VISTA telescope (Arnaboldi et al. 2007). VVV is scanning the Milky Way (MW) bulge and an adjacent section of the mid-plane, where star formation activity is high (Minniti et al 2010). One of the main goals of the VVV Survey is to study star clusters of different ages in order to build a homogeneous, statistically significant sample.

To study VVV CL059 cluster (Fig. 1), we use VVV images in J, H, and Ks bands and spectra taken with ISAAC, VLT, ESO.



**Fig. 1. A VVV true color image from J, H, Ks bands. The field of view is approx. 2.2× 2.2 arcmin and North is to the left, East is up.**

## Observation and Data Reduction

**Images:** The images (Fig. 2) in J, H, and Ks bands of 10x10 arcmin fields, was retrieved from VISTA Science Archive (VSA) database (Cross et al., 2012).
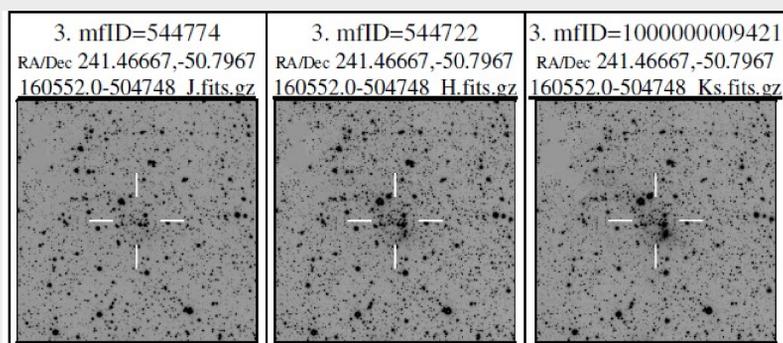


**Figure 2. Images obtained by VISTA in J, H and Ks bands (right to left) centered in RA= 16h 05m 52s DEC= -50 47' 48". and North is up, East is to the right.**

**Photometry:** The PSF photometry was performed on the VSA preliminary reduced images. We used DAOPHOT software (Stetson, 1987) within the Image Reduction and Analysis Facility (IRAF). We also used the Dophot software (Schechter et al. 1993; Alonso-Garcia et al. 2012) for comparison.

The J, H and Ks photometry was calibrated using the 2MASS Point Source Catalog (Skrutskie et al. 2006). Generally, we are using several hundred stars in common to apply a least-squares linear regression (Fig. 3). For the saturated stars (usually Ks ≤ 12 mag) the 2MASS magnitudes were used.
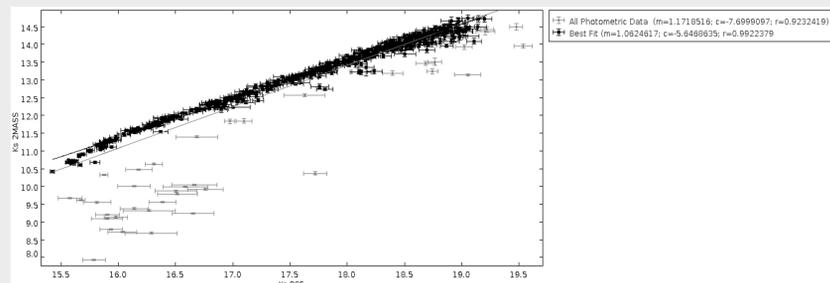


**Figure 3. Calibration of PSF photometry to 2 MASS catalog.**

## Results



**Spectroscopy:** Two of the stars show Brackett series in emission ,and can be classified as YSOs. The other spectroscopically observed objects are evolved red giants (Fig. 4). The analysis yields a reddening and distance modulus for the VVVCL059 cluster of E(J-K)=2.9 and (M-m)=9.5 Kpc.
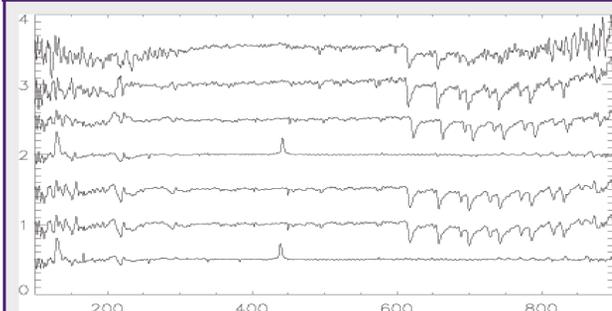
**Figure 4. ISAAC spectra of program stars.**

## Results
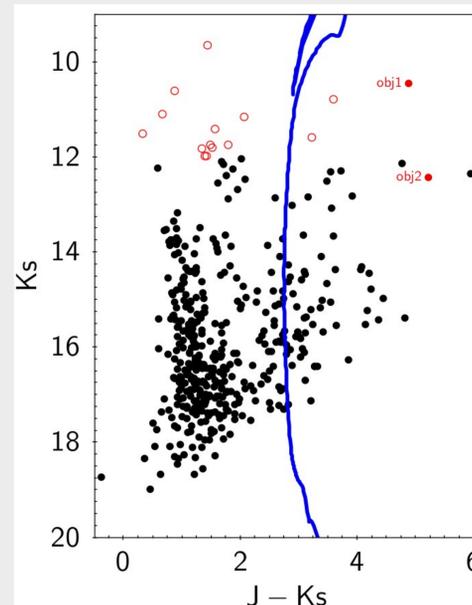


**Figure 5. (J - Ks) vs. Ks color-magnitude diagram for CL 059. Black circles are all stars within the estimated cluster radius, red open circles are 2MASS brillant stars. Stars with spectra are denoted by red circles and are labeled. In blue the best isochrone fit with 25.11 Myr.**

**Photometry:** The (J-Ks) vs. Ks color-magnitude diagram is shown on Fig. 5. The best Padova isochrone fit (Z=0.019, Marigo et al. (2008)) implies an age of 25.11 Myr which agrees with the result of 20-30 Myr derived from the Borissova et al. (2011)

**Proper Motion:** Based on 4 year VVV database, we calculated the proper motion of the stars. As a first approach we retrieved the CASU catalogs in 5x5 arcmin area around cluster taken in 13.04.2010 ( first epoch) and 07.04.2014 (second epoch). The plot of pmRA vs. pmDEC is shown in Fig. 6.

At the distance of the cluster and 4 year database it was not possible to calculate the motion of the cluster, nevertheless, the obtained results can be used to calculate the membership probabilities and clean the color-magnitude diagram.
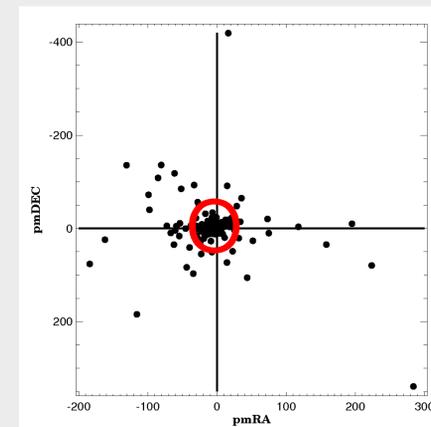


**Figure 6. Proper motion diagram from 2010-2014 epoch**

## Conclusions and Future Work

From spectroscopy, we determine two candidate stars for being member to the cluster. The distance to the stars is 9.5± Kpc, therefore, this is the estimated distance to the cluster.

Also, the reddening is E(J-Ks)=2.9 and the extinction is $A_k$=1.829. From the color-magnitude diagram we determine that the age is 25.11 Myr.

In order to verify this and to derive spectral types and distance from spectra with more accuracy, we are planning to perform an automatic PSF-fitting photometric pipeline for the VVV survey (Mauro et al. 2013) and calculate the relative proper motions of stars including 2MASS images to extend the base between two epochs.
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## References and Acknowledgements

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