ADeLA meeting 2014

Stellar Multiplicity of the Open Cluster ASCC 113

Carlos Alberto Guerrero Peña

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Introduction

- Galactic open clusters are ensembles of stars with low concentration and irregular shape, gravitationally-bound systems formed at the same time from the same original cloud.

- They represent examples of stars of comparable age and intrinsic chemical composition and are important in the study of stellar evolution and star formation.

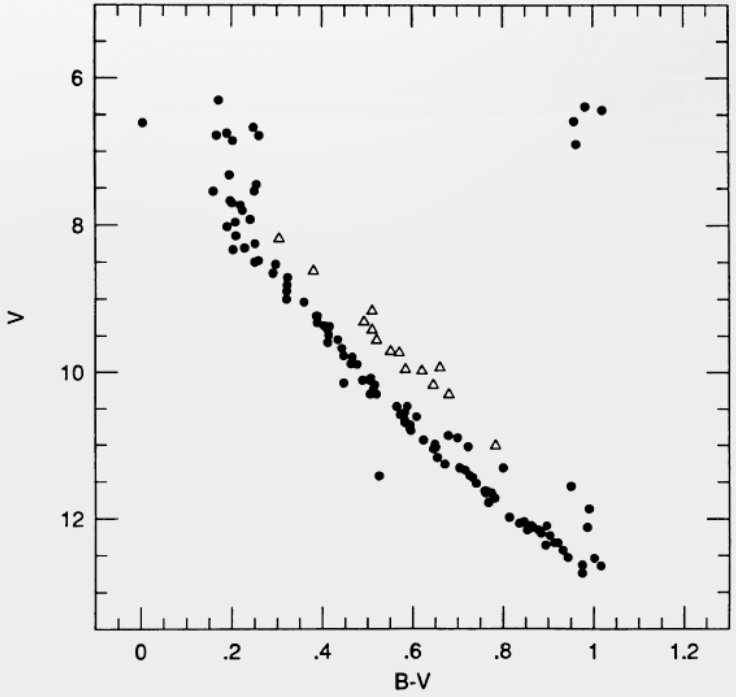
http://antwrp.gsfc.nasa.gov/apod/ap091014.html

Introduction

- Classical photometry : general characteristics of clusters.
- There is an observational problem due to the presence of unresolved binaries or multiple systems (Reid, 1987).
- These combined effects affect the determination of physical parameters: the cluster's distance, reddening and metallicity and age (Jeery 2009).
- Most studied clusters with respect to multiplicity frequencies: αPer, Pleiades, Praesepe, and Hyades.

Open clusters

- The color dispersion among the stars in the CMD along the MS, is due in part from a large population of unresolved binary stars (Daniel et al., 1994).



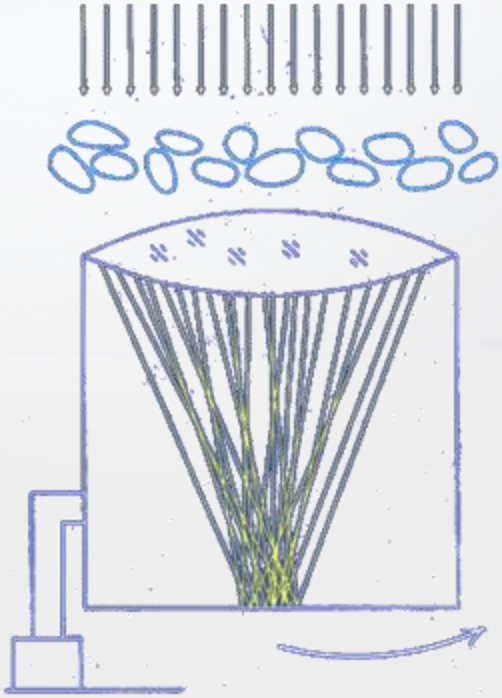
CMD of Praesepe (NGC 2632). Triangles represents possible binary stars.

Bolte, M. 1991.

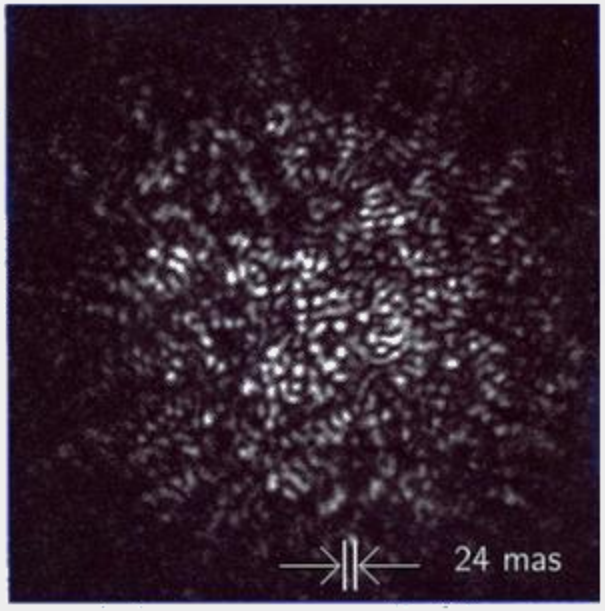
Imaging Through the Atmosphere

- The real limitation of the resolution for ground-based telescopes is the atmosphere.
- By analyzing the interference effects in short exposure images, we can attain diffraction-limited resolution.
- Speckle Interferometry.
- Binary stars.

Images degraded by the atmosphere

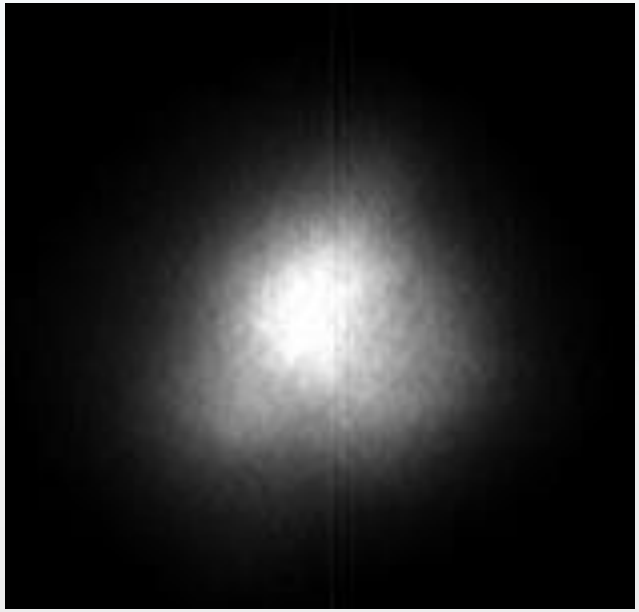


atmosphere
telescope
speckle interferogram

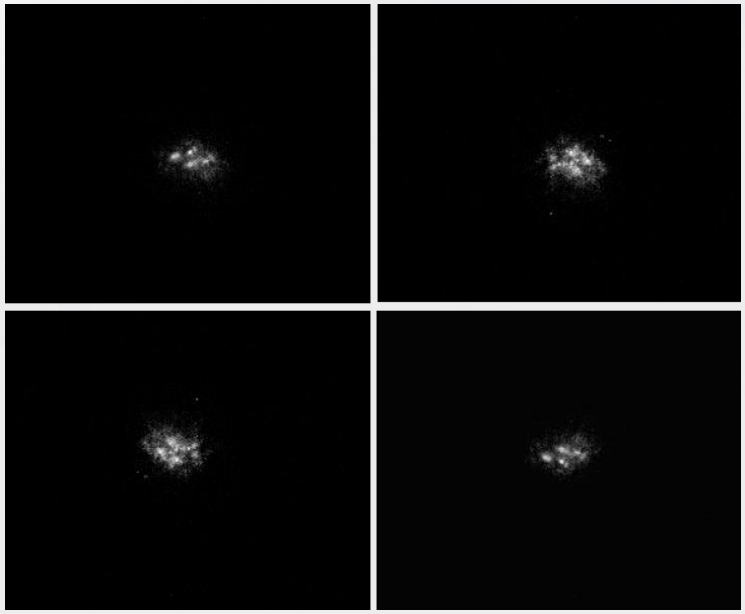


speckle interferogram
6 m telescope, Gamma Ori, λ=550 nm
field of view 1.84 arcsec

Specklegram



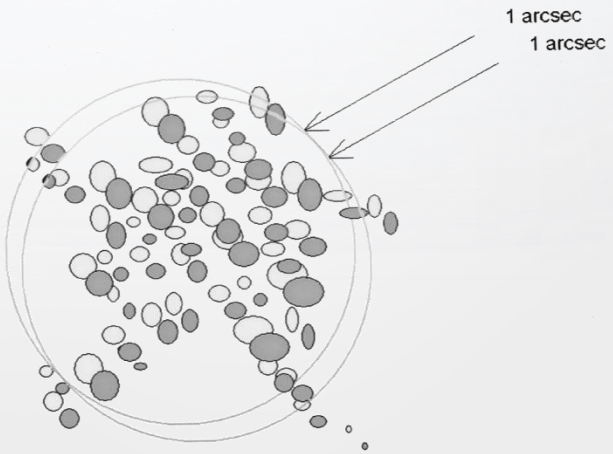
Long-exposure image of +234 00 279 WDS obtained with the 1.5 m telescope of OAN/SPM.



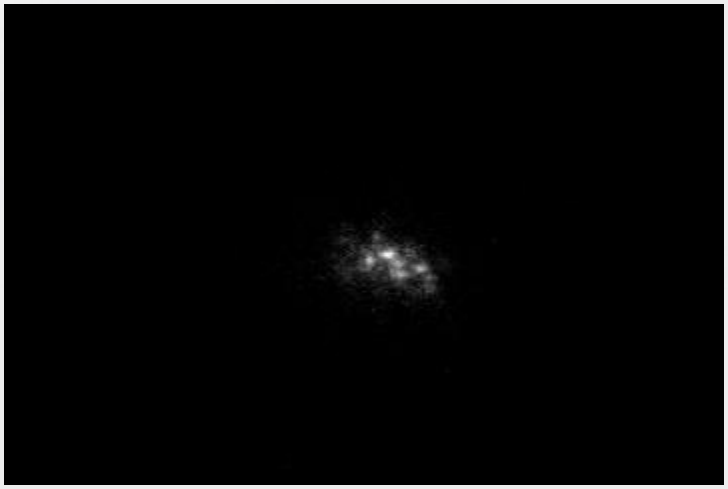
Four consecutive speckle images of the binary star WDS +234 00 279. 500ms between each image.

Orlov et al. 2009, Orlov et al. 2010

Binary star speckle pattern



Pattern of speckles of a binary star.



WDS 00279+234

Speckle Interferometry

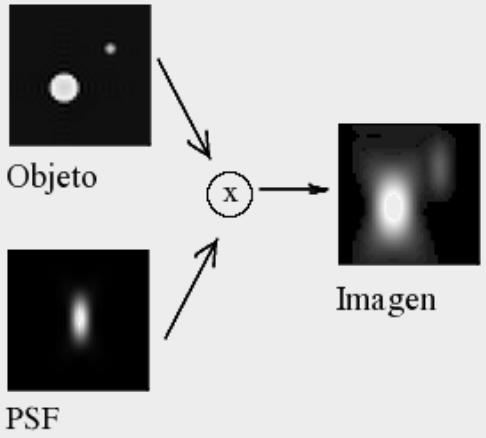
- The image $i(\mathbf{r},t)$ of a source is the convolution between the $p(\mathbf{r},t)$ (brightness distribution of an object passing through the atmosphere) and the brightness distribution of the object:

$$i(\mathbf{r},t) = o(\mathbf{r}) * p(\mathbf{r},t)$$

$$O(\mathbf{u}) = \frac{I(\mathbf{u},t)}{P(\mathbf{u},t)}$$

- By the convolution theorem:

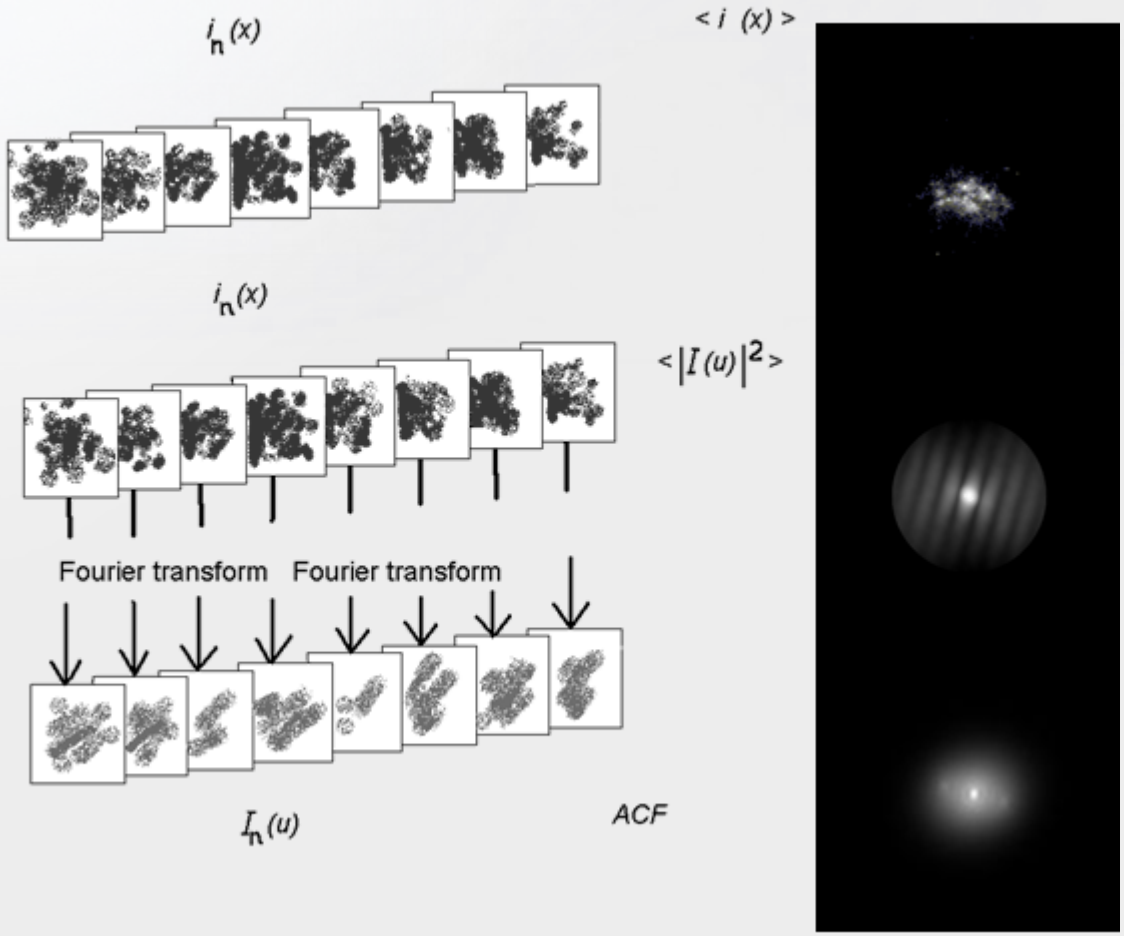
$$I(\mathbf{u},t) = O(\mathbf{u}) \cdot P(\mathbf{u},t)$$



Speckle Interferometry

V (540/90 nm)
R (640/130 nm)
I (800/160 nm)

$\lambda_V / D = 0.053''$,
$\lambda_R / D = 0.067''$,
$\lambda_I / D = 0.088''$.



Multiplicity fraction in Open clusters

$$f_{bin} = \frac{B + T + C + \cdots}{S + B + T + C + \cdots}$$

- Studies investigating the stellar multiplicity fraction in open clusters are very scarce (Duchêne & Kraus 2013).
- The multiplicity frequency in open clusters varies from 25-30% (Duchêne & Bouvier 2008) to 65-70% (Kähler 1999).
- α-Per, the Pleiades, Praesepe and the Hyades: multiplicity fraction ~20% .

Open Cluster ASCC 113 (Kharchenko 2004)

Right Ascension (2000)	21 12 00
Declination (2000)	+38 35 59
Galactic longitude	82.88
Galactic latitude	-6.65
Distance [pc]	450
Reddening [mag]	0.00
Distance modulus [mag]	8.27
Log Age	8.14

45′ x 45′ field in the direction of the open cluster ASCC 1123.

http://www.univie.ac.at/webda/cgi-bin/ocl_page.cgi?cluster=ascc+113

Cluster Members

- Kharchenko et al. (2005) analysed 239 stars in the direction of ASCC 113.
- Kinematic constraint P_{kin}: takes into account kinematic proper motion.
- Photometric selection P_{phot}: to exclude background co-moving stars.
- Position factor P_s: equal to 1 within the cluster radius and zero elsewhere.

Open Cluster ASCC 113

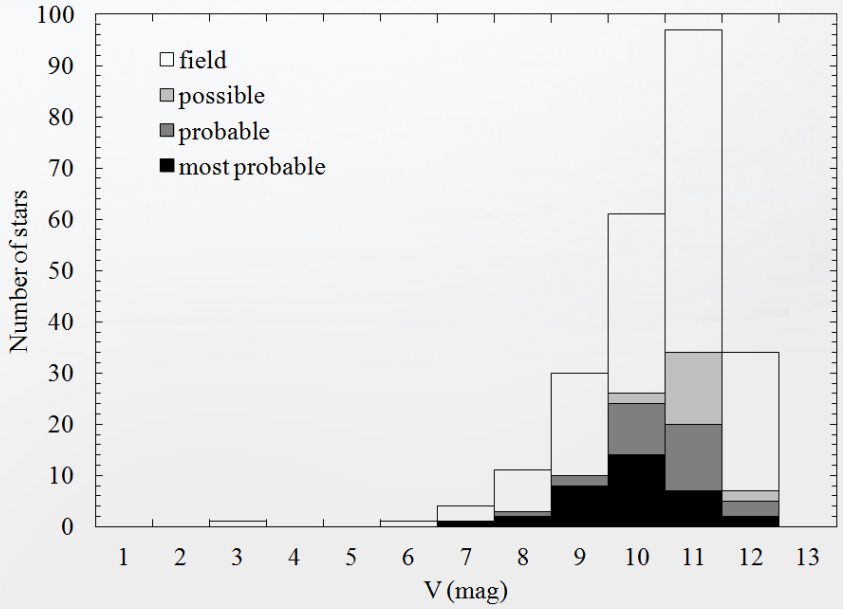


Figure 4. Distribution of the apparent magnitudes of stars in the open cluster ASCC 113 and in the eld around the cluster, separated in 1, 2, 3-σ members and non-members.

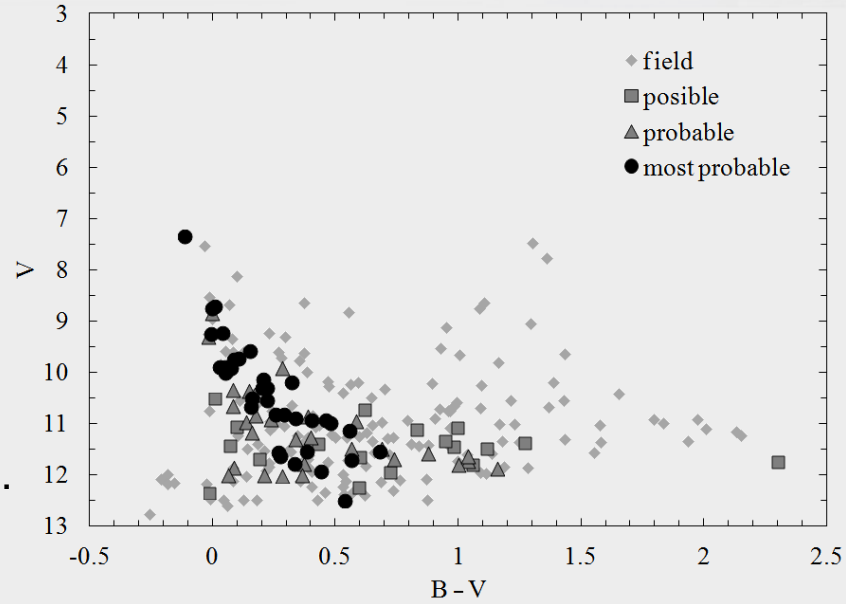
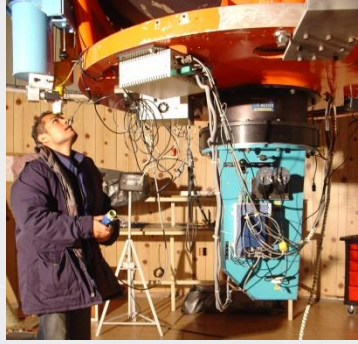


Figure 5. V *vs* (B - V) diagram.

Observations



- We obtained the data during two sets of observations at the 2.1 m telescope of SPM
- We used the EMCCD iXon 885 DU from Andor Technology.
- > 40% of quantum eficiency 400-800
- CCD 1004 x 1002 pixels of 8µm.

Results

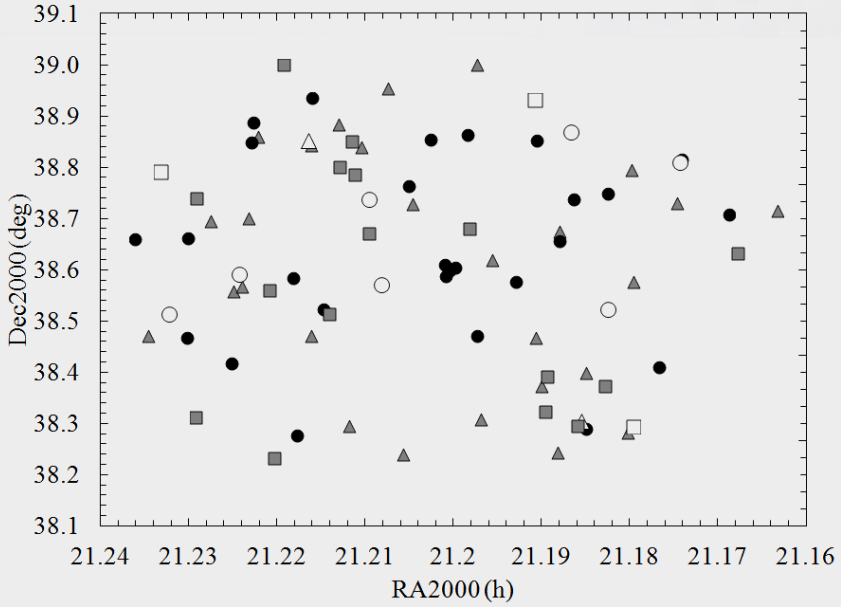
- We were able to resolve systems as close as 0.24″.
- Detected speckle-interferometric companions for 35 of the stars.
- Astrometrically resolved 20 binary stars and two triple stars for the first time.
- Detected new companions in four objects and confirmed ten previously known binaries.

Stellar Multiplicity

	single	binary	triple	quadruple	quintuple	sextuple	fraction
ASCC 113	27	7	0	0	0	0	20.6
field	125	27	4	1	0	0	20.9

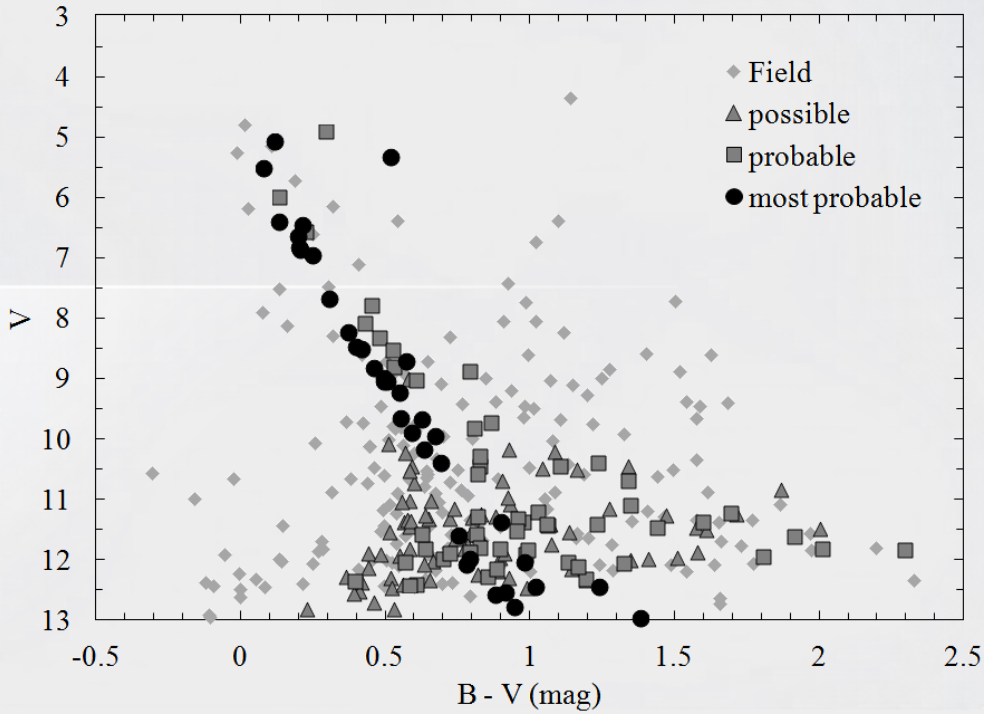
$$f_{ASCC113} = 20.6\% \pm 3\%$$

$$f_{campo} = 20.9\% \pm 1\%$$



Binary stars in the open cluster ASCC 113.

Coma Berenices



	single	bin	trip	quad	quin	sex	sep	oct	fraction
Mel 111	29	8	0	0	0	1	0	0	23.7
field	162	12	0	0	0	0	1	0	7.4

$$f_{Mel111} = 23.7\% \pm 4\%$$

$$f_{campo} = 7.4\% \pm 3\%$$

Conclusions

- The multiplicity fraction of this cluster is statistically indistinguishable form the fraction of the field.
- The multiplicity fraction in open clusters is close to 20%.
- The “binary sequence” in the CMD cannot be explained by blaming “twin binaries" because they are very scarce in our Galaxy.
- There is no evidence of any radial gradient in the superficial distribution of binary stars in these clusters.
- Guerrero et al. 2014a, b.

Thank you for your attention.