ω Cen astrometry

1 The catalogues

I use the following astrometric catalogues:

- *Ground-based CCD astrometry with wide field imagers. III. WFI@2.2m proper-motion catalog of the globular cluster Omega Centauri*, Bellini, A. et al. 2009, A&A, 493, 959B (359391 objects, $10.8 < B < 25.6$).

- *Third U.S. Naval Observatory CCD Astrograph Catalog*, 21662 object ($6.8 < B < 22.9$) within a circle of 1 degree radius centered on Ω Cen RA: 13 26 45.9 DEC: -47 28 37 (J2000) (the cluster is 36.3' wide).

- *Proper motions in omega Centauri*, van Leeuwen, F.; Le Poole, R. S.; Reijns, R. A.; Freeman, K. C.; de Zeeuw, P. T., 2000yCat..33600472V, VizieR On-line Data Catalog: J/A+A/360/472. Originally published in: *A proper motion study of the globular cluster ω Centauri*, 2000, A&A, 360, 472V (same authors, 9847 objects, $9.6 < B < 16.6$).

Fig. 1 shows the superimposition of the three catalogues.

CataXcorr needs tables with the same columns in the same position and a column with a magnitude (if not available, a fictitious columns is needed). So I build new files with the following columns: ID RA DEC Bmag extracted from the original files (Bellini catalog.dat, van Leeuwen table5.dat , ucac3 ucac3_omegacen_1degradius.dat) where RA and DEC are in decimal degress and I add by hand this line at the beginning of each file:

```
#N  name   RAz  DECz    Bmag
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The new tables are: bellini09.dat, floor2000.dat, ucac3.dat.

2 CataXcorr

I check the coincidences between the three catalogues with CataXcorr. I use ucac3.dat as reference catalogue:
`CataXcorr ucac3.dat bellini09.dat floor2000.dat -mag Bmag -v 4&`
I use *tol radius= 0.05* and *mix radius 0.05* arcsec and *tol mag* inactive. The results are in Table 1. Both catalogues (florr2000 and Bellini09) show a similar scatter with respect to the reference catalogue (UCAC3). This is not very unexpected since we searched for coincidences with the same parameters (*tol radius= 0.05* and *mix radius 0.05*), hence, unless the two catalogues have very different (but smaller of the requested tolerance) accuracy, we expect similar values. If I look for coincident

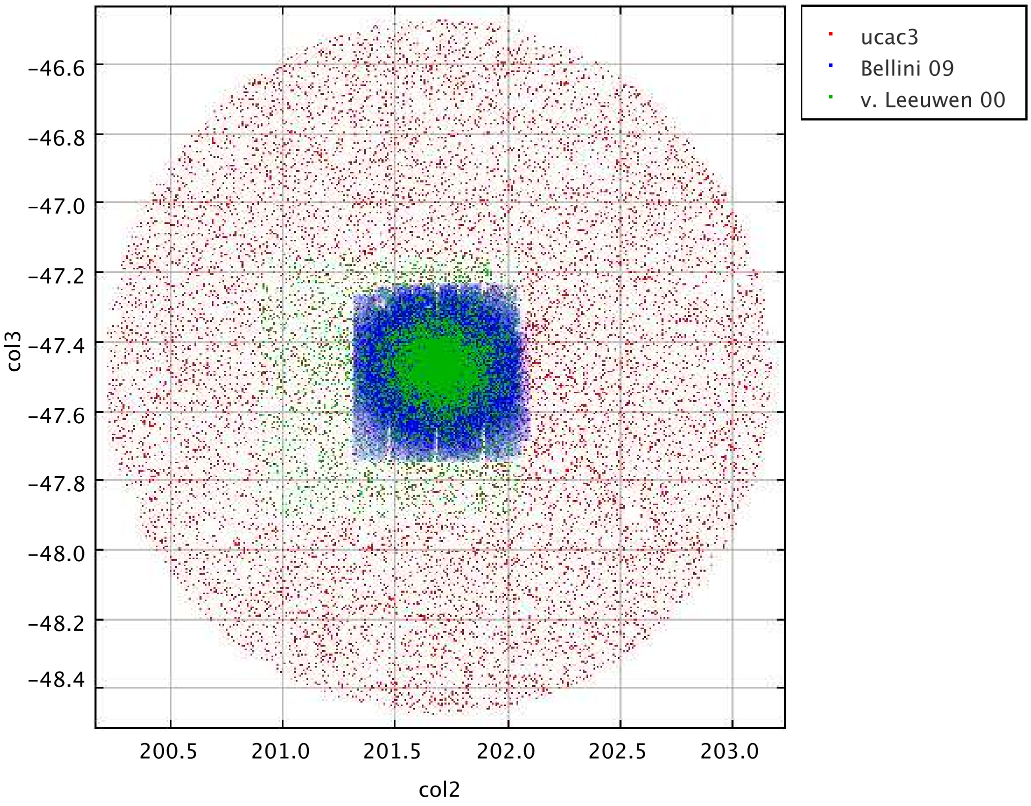

Figura 1: Superimposition of the three astrometric catalogues.

Tabella 1: Catalogues match (with respect to ucac3.dat)

	Xrms [arcsec]	Yrms [arcsec]	N matches
bellini09.dat	0.078	0.078	7584
floor2000.dat	0.083	0.084	7364

tol radius= 0.05, *mix radius 0.05* and *tol mag* inactive.

stars with shallow constraints, the Bellini's catalogue is so crowded and deep that it will very often produce false coincidencies.

I obtain the files florr2000.dat.rot and bellini09.dat.rot. I change the name of the second columns in ucac3.dat (name → nameucac3), florr2000.dat.rot (name → namefloor2000) and bellini09.dat.rot (name → namebellini).

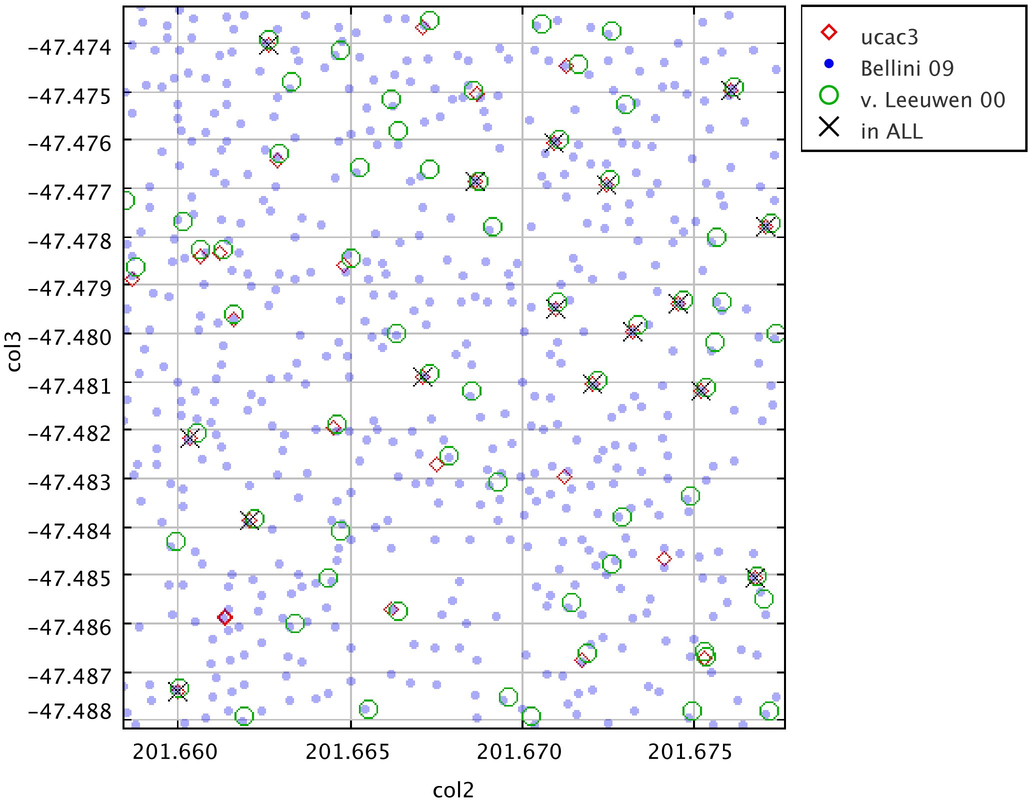

Figura 2: Detail of the catalogue superimposition. Common stars are marked with a cross.

3 CataComb

I use CataComb to extract the stars in common:
`CataComb -c coinc.tab -f nameucac3;namefloor2000;namebellini;RA;DEC;Bmag -filter 1&&2&&3 -o listacoincidenze.txt -v 4`
The output file (listacoincidenze.txt) contains 5030 stars. Fig. 2 show a detail of the superimposition of the three catalogues with the star in common marked with a cross.

4 Comparison of the astrometric catalogues

Once the catalogue with the common stars is ready, I extract their coordinates from the original catalogues and compare them. Table 2 shows the offset between the three catalogues. The results is graphically shown in Fig.3.

Tabella 2: Systematic shifts between the catalogues

	RA [arcsec]	DEC [arcsec]	N matches
Bellini09 - UCAC3	-0.012 ± 0.099	-0.017 ± 0.066	5030
van Leeuwen 2000 - UCAC3	0.367 ± 0.121	0.315 ± 0.079	5030
Bellini09 - van Leuween 2000	-0.380 ± 0.107	-0.332 ± 0.070	5030

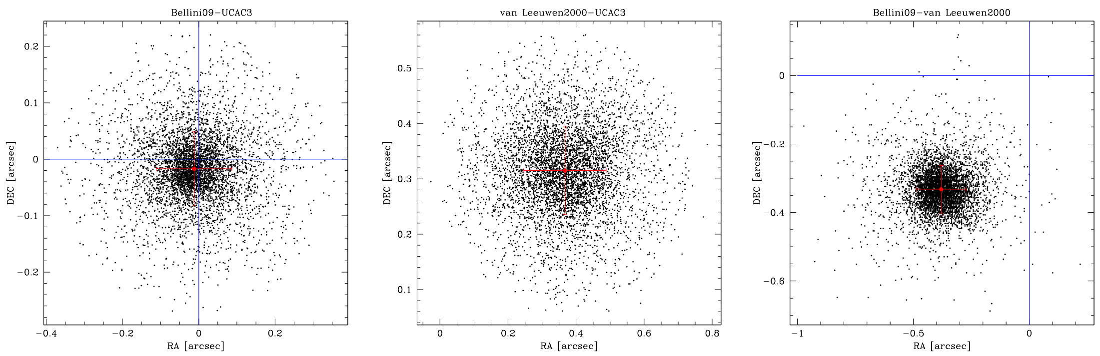

Figura 3: Residuals of the astrometry of the stars in common between Bellini 1999, van Leeuwen 2000 and UCAC3.

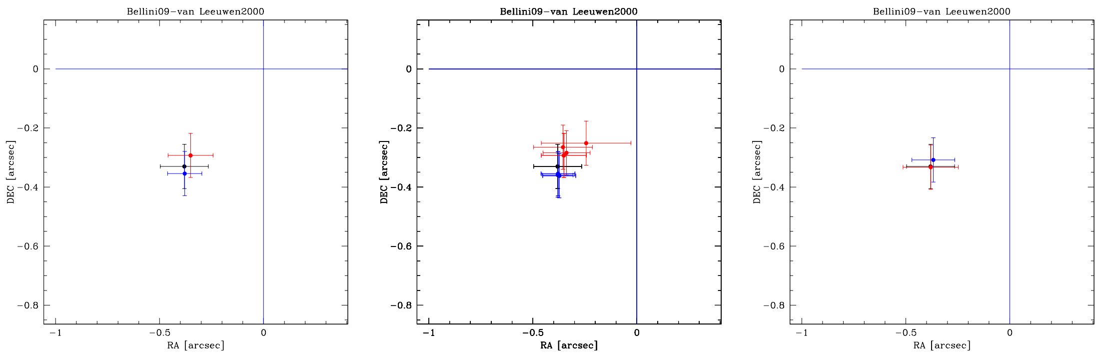

Figura 4: Residuals of the astrometry of the stars in common between Bellini 1999, van Leeuwen 2000.Left: the blue ad red dots show the offset of the blue ($B-V < 0.4$) and red ($B-V > 1.2$) stars. Middle: same plot as the left one but with blue star with $B-V < 0.4, 0.3, 0.2, 0.1$ and red star with $B-V > 1.2, 1.4, 1.6, 1.8$. While the blue star offset do not change significantly with colour, the red stars offset increase with colour. Right: the blue ad red dots show the offset of the bright ($B < 14.5$) and faint ($B > 15.5$) stars. Black dots refers to all stars.

Tabella 3: Internal dispersion of the catalogues

	σ_{RA} [arcsec]	σ_{DEC} [arcsec]	N stars
van Leeuwen 2000	0.090	0.058	5030
Bellini09	0.057	0.038	5030
UCAC3	0.081	0.053	5030

V-019

The dispersions σ_{ij} of the catalogues with respect to one another are used to compute the internal dispersion σ_k of each catalogue, by solving the following equation system:

$$\sigma_{21}^2 = \sigma_2^2 + \sigma_1^2$$
$$\sigma_{31}^2 = \sigma_3^2 + \sigma_1^2$$
$$\sigma_{23}^2 = \sigma_2^2 + \sigma_3^2$$

where 1-UCAC3, 2-Bellini 2009, 3- van Leeuwen 2000, we get the values reported in Table 3.

The results shows that the internal dispersion of the three catalogues is similar, but it is evident a better match between the UCAC3 and Bellini 1999 astrometry, while the van Leeuwen astrometry shows a significant offset with respect to the other two catalogues, of the order of almost 0.4 arcsec. Fig. 4 shows that the offset does not strongly depends on the magnitude, while there is a weak dependecy on colour.

On the other hand, UCAC3 B photometry shows a clear mismatch with respect the other two catalogs (see Fig. 5).

Why van Leeuwen's astrometry differs by of almost 0.4 arcsec from Bellini's data and UCA3?

van Leeuwen's data are in the ICRS J2000 system. *For a cluster study like this, the plate reductions are purely differential, with a local definition of the positional and proper motion system with a generally high precision, but with an undetermined accuracy.*

van Leeuwen's coordinates for HD 116663 (also known as HIP 65519) taken as reference star when centering the plates are: RA: 13 25 49.0, DEC: -47 31 30 (201.45416667 -47.52500000 in decimal degrees) (ICRF - International Celestial Reference Frame). The SIMBAD (Hipparcos, Perryman et al. 1997 A&A, 323L, 49P) are RA: 13 25 48.9987 DEC: -47 31 30.342 (201.45416125 -47.52509500 in decimal degrees) (ICRS ep2000, International Celestial Reference System). While in RA the coordinates are almost the same (0.0195" offset) , there is a 0.342" offset in DEC between van Leeuwen's and Hipparcos data. UCAC3 coordinates for HD 116663 are RA 201.4541359 DEC -47.5250928 (ICRS J2000) and the difference with respect

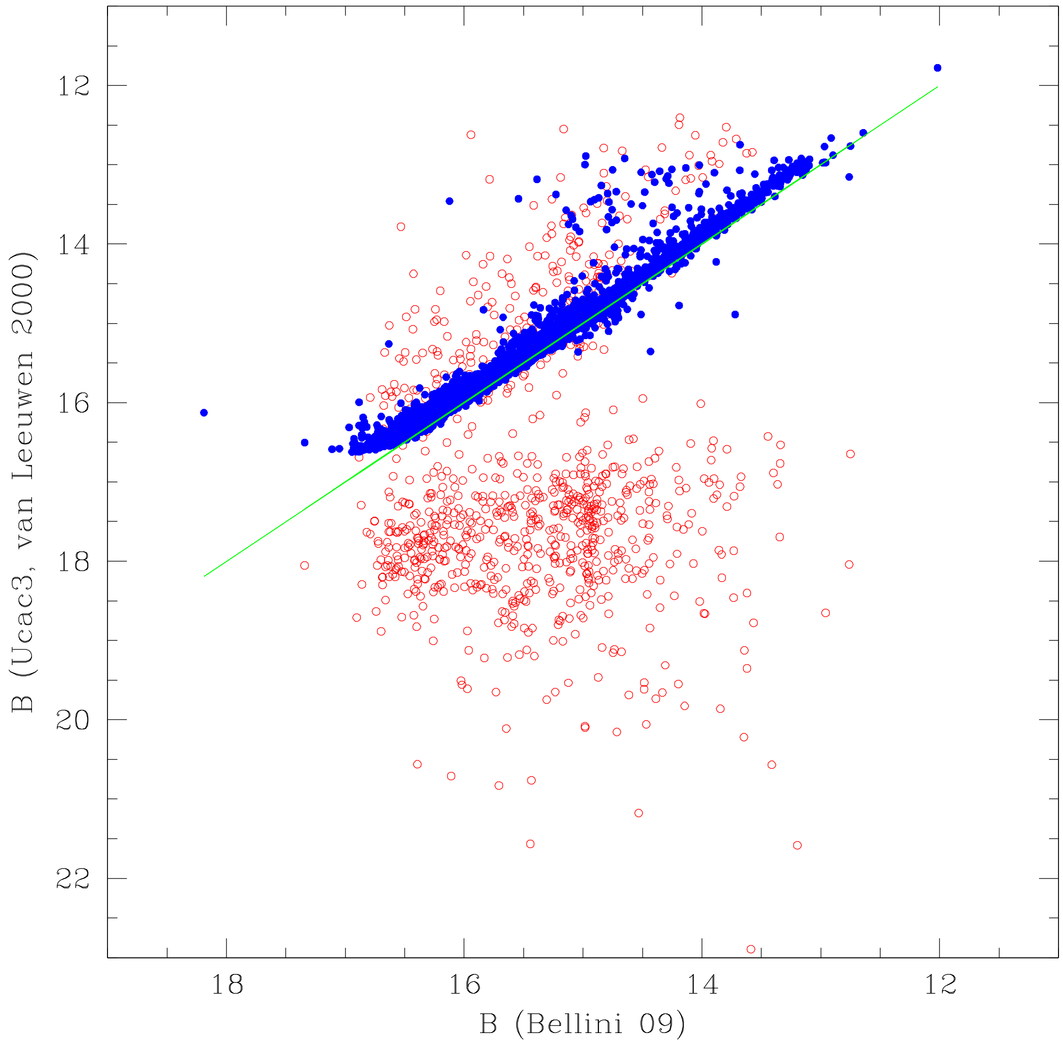

Figura 5: Comparison of the B photometry: UCAC3 B magnitudes (red empty circles) and van Leeuwen B magnitudes (filled blue dots) vs Bellini 09 photometry. The green line shows the place of the perfect match.

to Hipparcos are -0.091" and 0.0079 and the difference with respect to Tycho-2 are -0.27" and -0.028".

I can not look for HD 116663 in table 5 to check its coordinates because it does not belong to the cluster.
I can not check the coordinates of other Hipparcos stars (such as HD 116586 i.e. HIP 65493) mentioned in the paper because their coordinates are not given. van Leeuwen data are calibrated with respect to the Tycho-2 catalogue. I compare the

Tabella 4: Systematic shifts between the catalogues ($13.5 \leq B \leq 16.5$)

	RA [arcsec]	DEC [arcsec]	N matches
Bellini09 - UCAC3	-0.013 ± 0.097	-0.017 ± 0.065	4539
van Leeuwen 2000 - UCAC3	0.368 ± 0.119	0.316 ± 0.078	4539
Bellini09 - Floor 2000	-0.380 ± 0.103	-0.332 ± 0.067	4539

Tycho-2 and Hipparcos coodinates for HD 116663. Tycho-2 coordinates (ICRS) are 201.45421306 -47.52508500 to be compared with the Hipparcos (ICRS) 201.45416125 -47.52509500 I get an offset 0.18" in RA and 0.036" in DEC.

HD 116586 Tycho-2 coordinates (ICRS) are 201.34490972 -47.63325722 to be compared with the hipparcos (ICRS) 13 25 22.7701 -47 37 59.817 i.e. 201.34487542 -47.63328250.

I get an offset 0.12348" in RA and 0.09100799998" in DEC.

Bellini's data are J2000, Epoch J2003.29 and the reference catalogue is the UCAC2 catalog (Zacharias et al. 2004, AJ, 127, 3043) and the re-reduced cartesian position by van Leeuwen et al. 2000, A&A, 360, 472 for the center (always using UCAC2 as reference).
UCAC3 data are ICRS, Ep=J2000.

To make a more robust comparison between UCAC2 (I/289 - obsolete- Zacharias et al. 2004, AJ, 127, 3043) and Tycho-2 (I/259, Hog et al. 2000 A&A 355, 27) I download from the two catalog an area centered on Omega Cen (RA: 13 26 45.9 DEC: -47 28 37, J2000) 1 deg radius. Using 231 common stars I obtain the following coordinates offset (Tycho-2 - UCAC2): 0.17 ± 0.20 arcsec in RA and 0.03 ± 0.10 arcsec in DEC.

We made the same comparison and we computed the internal dispersion again, limiting the magnitude range of the common star, cutting the bright and faint end, to check for possible deviation at very high or very low brightness. We used as reference the Bellini 1999 B magnitude that varies in the range $12.017 - 18.189$ (see Fig. 5). We limited the B range to the interval $13.5 - 16.5$. The results, reported in Table 4 and Table 5 do not change significantly from the value shown in Table 2 and Table 3.

Tabella 5: Internal dispersion of the catalogues ($13.5 \leq B \leq 16.5$)

	σ_{RA} [arcsec]	σ_{DEC} [arcsec]	N stars
van Leeuwen 2000	0.088	0.056	4539
Bellini09	0.055	0.036	4539
UCAC3	0.081	0.054	4539

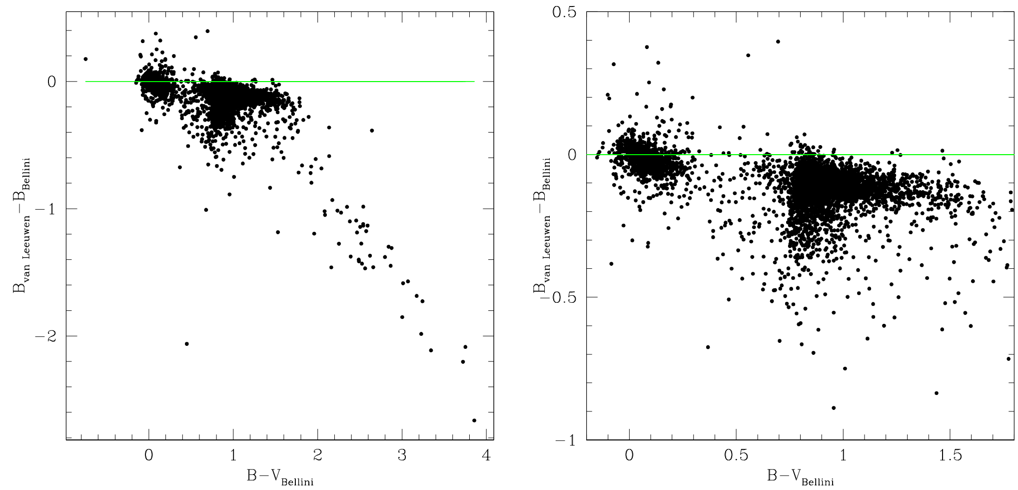

Figura 6: $B_{vanLeeuwen} - B_{Bellini}$ vs $(B - V)_{Bellini}$. Right image is a zoom.

5 Magnitude & Colours trends

We compared the difference between the magnitudes provide by the catalogue by Bellini 2009 and van Leeuwen 2000 versus $B - V$. Bellini 2009 provides B, V, R, I, while van Leeuwen 2000 provides B and B-V, hence we compared the B and V magnitudes, as shown in Fig. 6 and Fig. 7. The comparison shows that the B magnitudes by van Leeuwen match quite well the Bellini's magnitude in the blue but they are brighter in the red. The V magnitudes by van Leuuwen are on average systematically brighter.

Fig. 8 shows the comparison between the B-V colour by van Leuuwen and Bellini. As expected from the previous plot, the B-V by Van Leuuwen is redder in the blue while in the red the colour matches pretty well the Bellini's values (because both B and V by van Leuuwen are brighter than Bellini's magnitudes).

Since we do not know if the colour trend visible in Fig.6, 7 and 8 is due to van Leeuwen's data or Bellini's data, we compare their photometry with other catalogues:

- *CCD Photometry of the Globular Cluster Ω Centauri. II. Stellar Populations and Age-Metallicity Relation*, Soo-Chang Rey 2004 AJ 127 958

- Pancino private communication

The results are shown in Fig. 9, 10, 11, 12, 13, 14.

Fig. 15 shows the difference between B magnitudes by Pancino and van Leeuwen along magnitude. The average differences, computed in the range $13 \leq B, V \leq 14.5$ are 0.02 ± 0.07 and 0.02 ± 0.08 respectively.

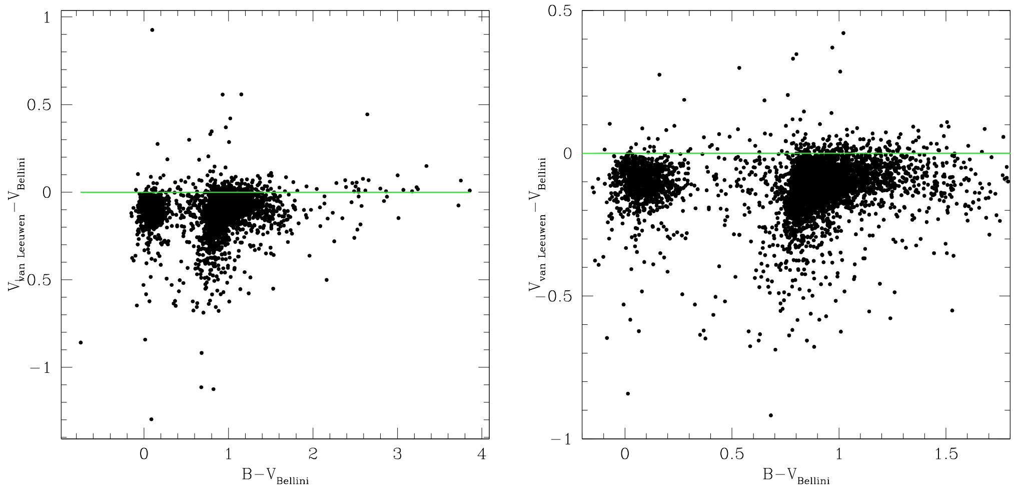

Figura 7: $V_{vanLeeuwen} - V_{Bellini}$ vs $(B - V)_{Bellini}$. Right image is a zoom.

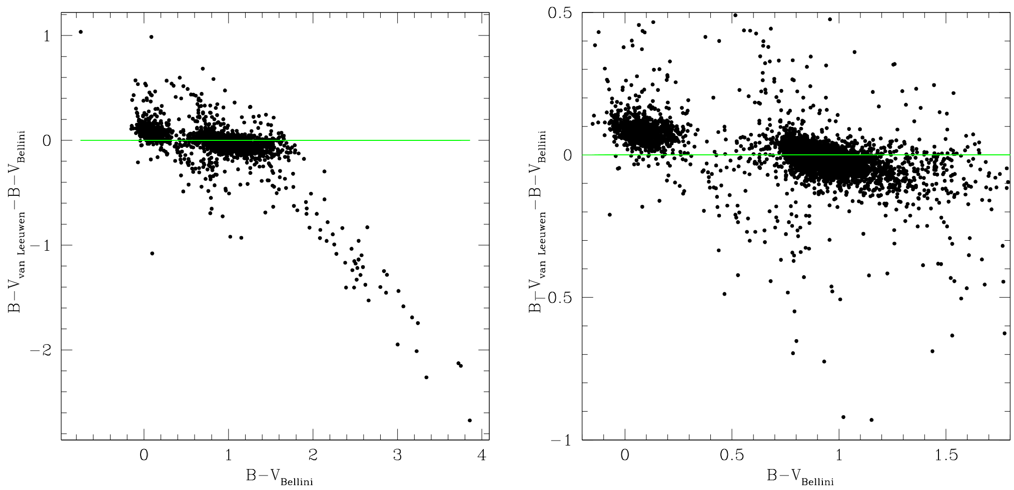

Figura 8: $(B - V)_{van\,Leeuwen} - (B - V)_{Bellini}$ vs $(B - V)_{Bellini}$. Right image is a zoom.

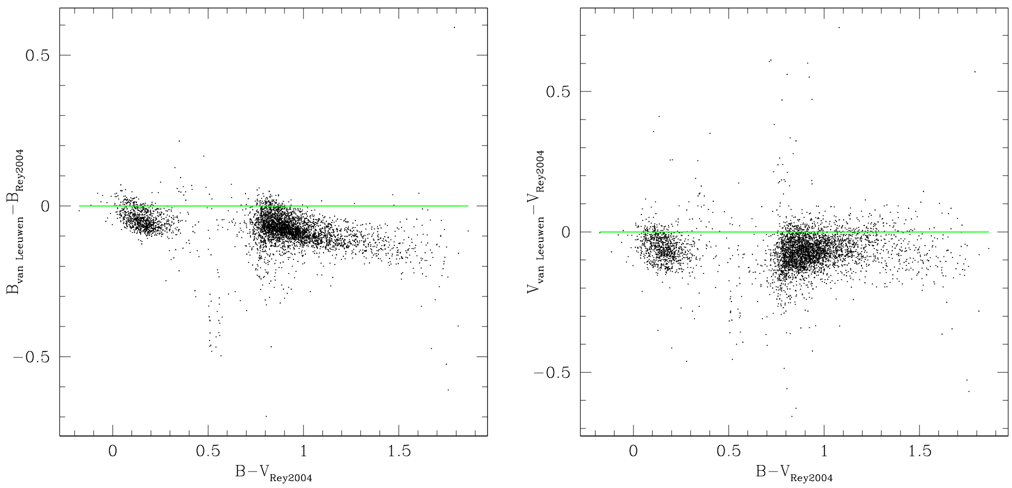

Figura 9: $B_{vanLeeuwen} - B_{Rey}$ vs $(B-V)_{Rey}$ and $V_{vanLeeuwen} - V_{Rey}$ vs $(B-V)_{Rey}$.

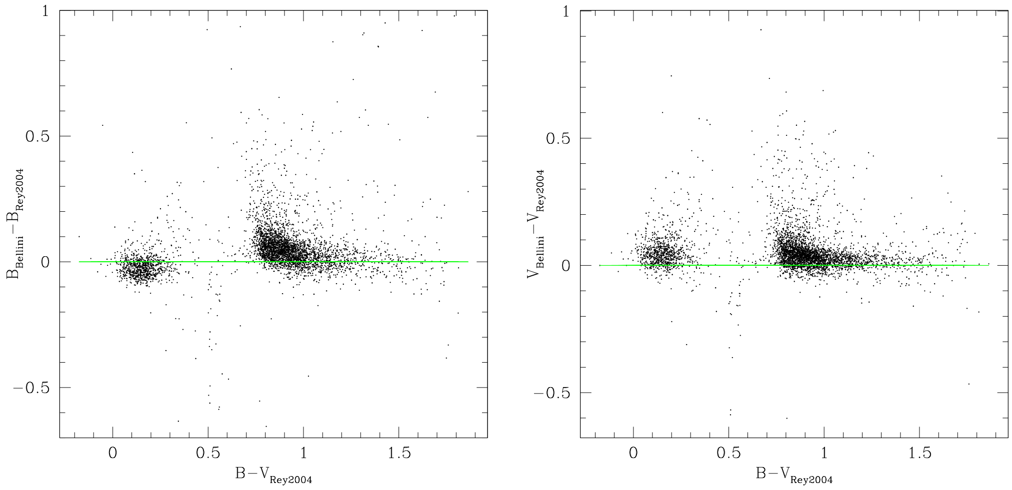

Figura 10: $B_{Bellini} - B_{Rey}$ vs $(B-V)_{Rey}$ and $V_{Bellini} - V_{Rey}$ vs $(B-V)_{Rey}$.

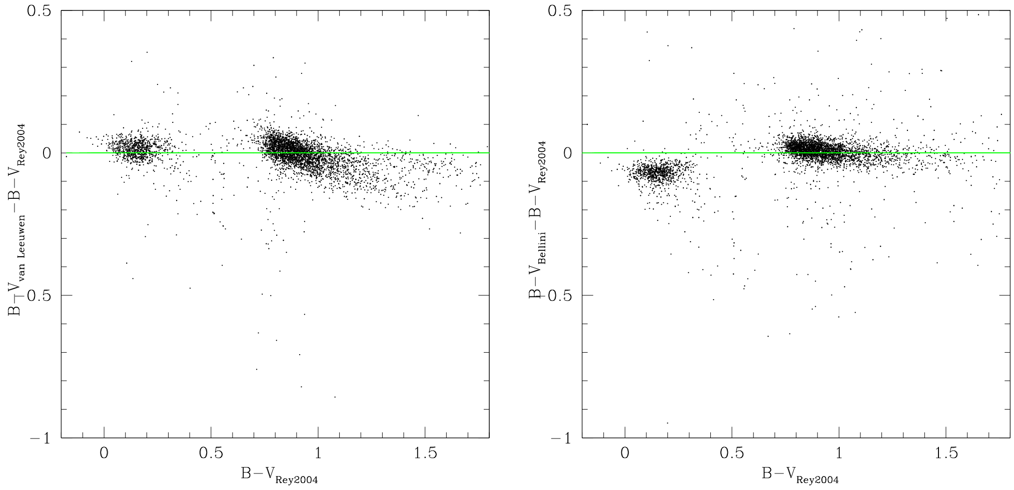

Figura 11: $(B{-}V)_{van\,Leeuwen}{-}(B{-}V)_{Rey}$ vs $(B{-}V)_{Rey}$ and $(B{-}V)_{Bellini}{-}(B{-}V)_{Rey}$ vs $(B-V)_{Rey}$

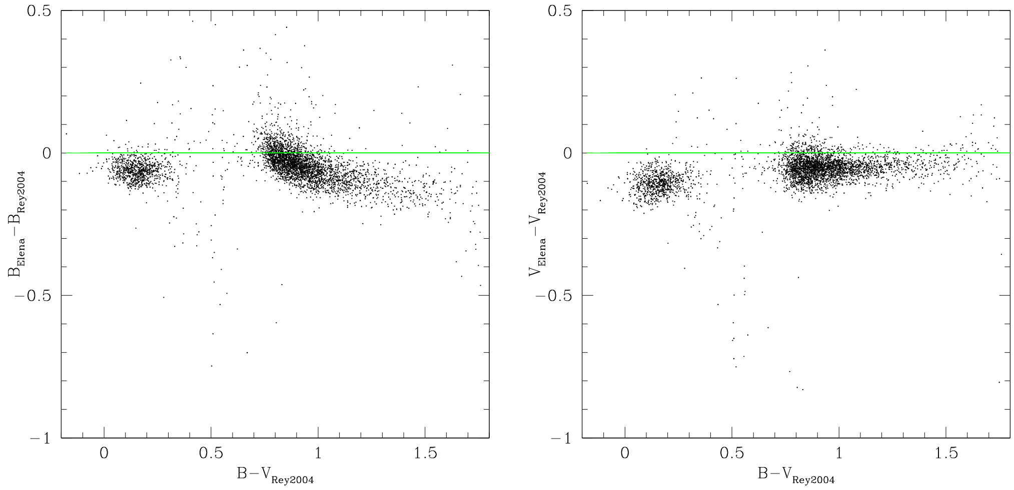

Figura 12: $B_{Pancino} - B_{Rey}$ vs $(B-V)_{Rey}$ and $V_{Pancino} - V_{Rey}$ vs $(B-V)_{Rey}$.

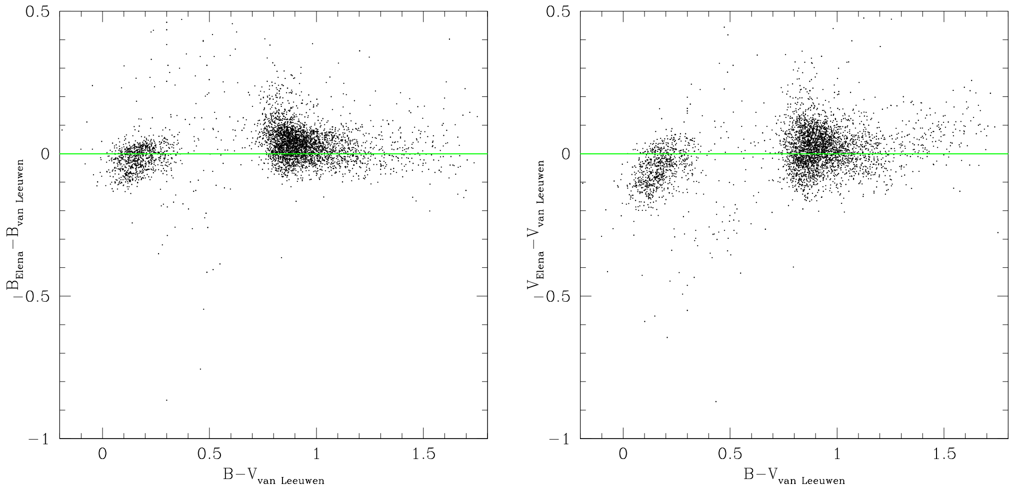

Figura 13: $B_{Pancino} - B_{vanLeeuwen}$ vs $(B-V)_{vanLeeuwen}$ and $V_{Pancino} - V_{vanLeeuwen}$ vs $(B-V)_{vanLeeuwen}$.

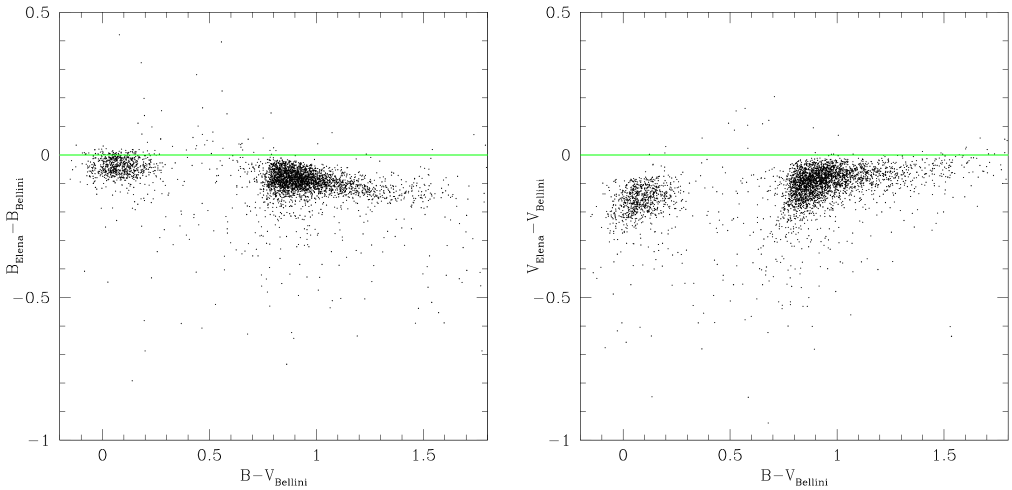

Figura 14: $B_{Pancino} - B_{Bellini}$ vs $(B-V)_{Bellini}$ and $V_{Pancino} - V_{Bellini}$ vs $(B-V)_{Bellini}$.

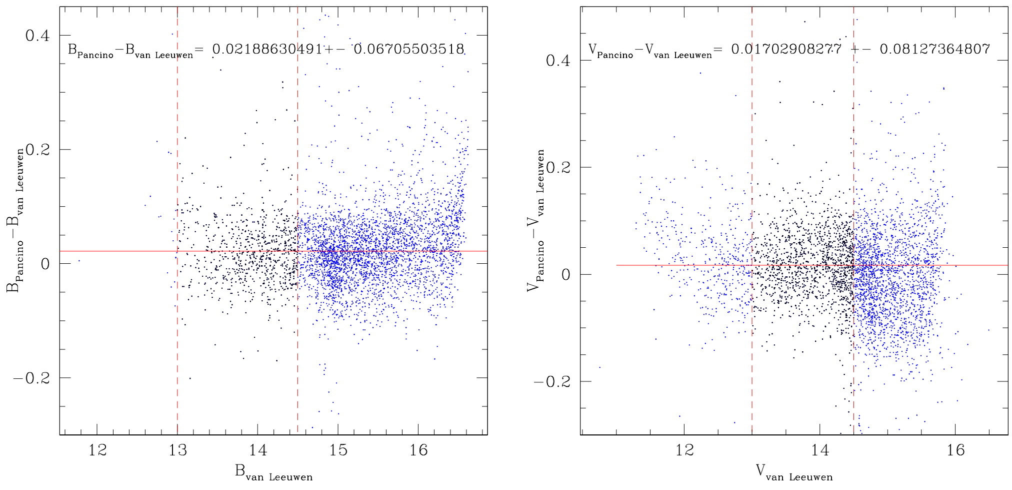

Figura 15: $B_{Pancino} - B_{vanLeeuwen}$ vs $B_{vanLeeuwen}$ and $V_{Pancino} - V_{vanLeeuwen}$ vs $V_{vanLeeuwen}$. The magnitude difference is computed in the interval 13-14.5 in both magnitudes.

Fig. 16 and Fig 17 show the difference between the Bellini's and van Leuuwen's magnitudes with respect to the RA and DEC coordinates. As expected from Fig. 6, the B magnitude of the blue star (the HB is marked in blue), are scattered around zero while the other star show bigger differences, especially at the center of the cluster when looking at the distribution in RA. The same effect is visible in the V band, but in this case blue and red stars do not show clear differencies. The magnitude differences along declination seems to show a slight slope

Fig. 18,19, 20,21, 22,23, 24,25, show the difference of the B, V magnitude with the coordinates RA and DEC for different catalogues.

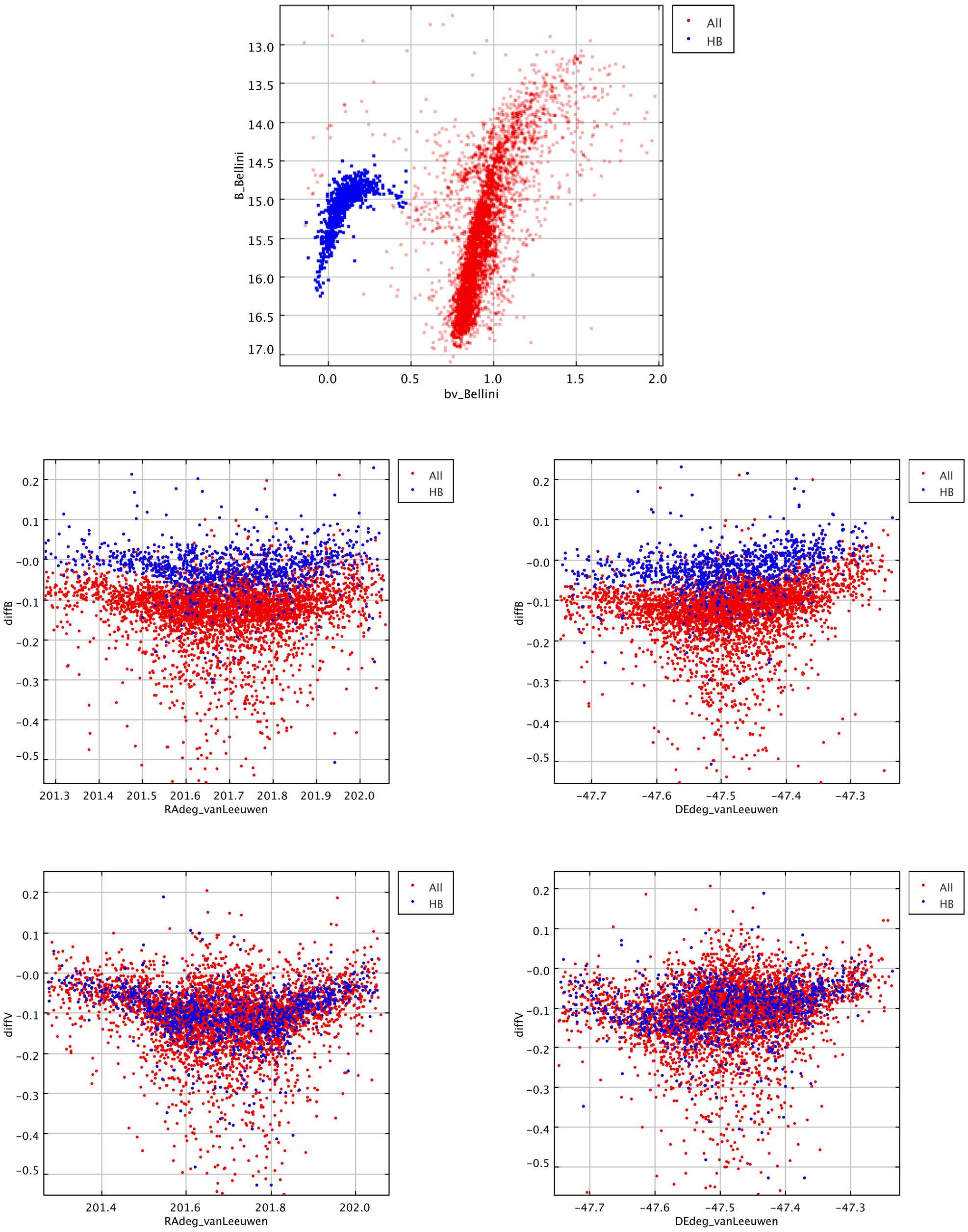

Figura 16: B vs $B-V$; $B_{van\,Leeuwen} - B_{Bellini}$ vs $RA_{vanLeeuween}$ and $DEC_{vanLeeuween}$; $V_{van\,Leeuwen} - V_{Bellini}$ vs $RA_{vanLeeuween}$ and $DEC_{vanLeeuween}$

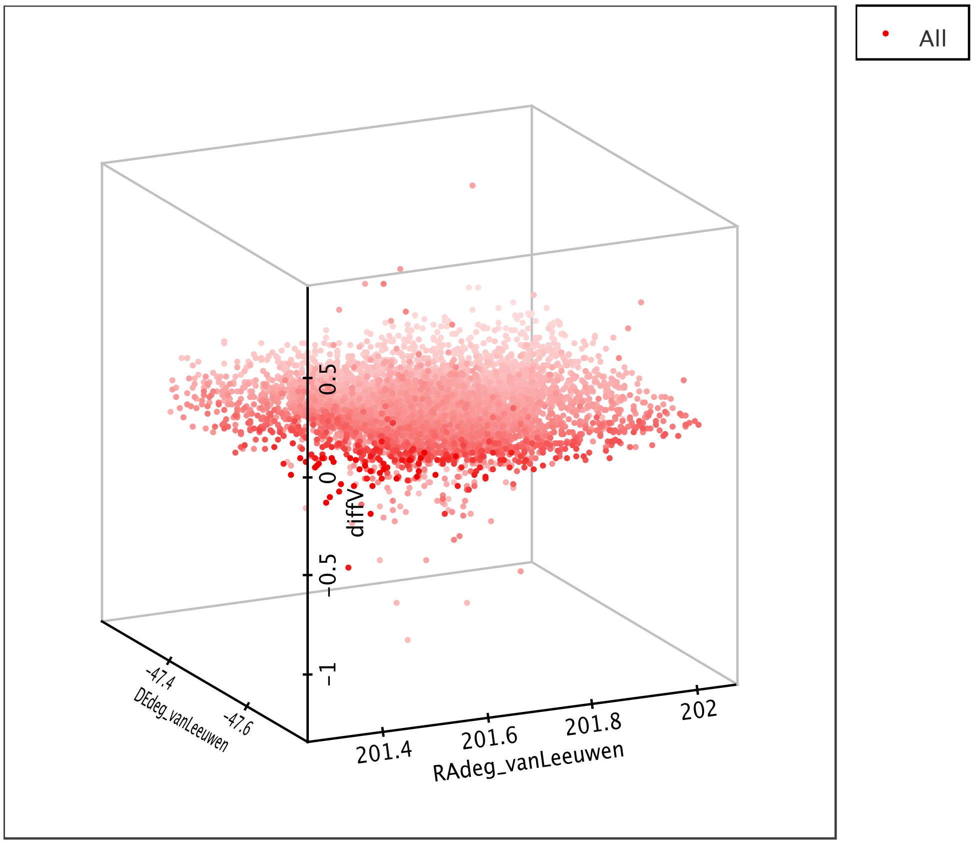

Figura 17: $V_{van\,Leeuwen} - V_{Bellini}$ vs RA and DEC by van Leeuwen

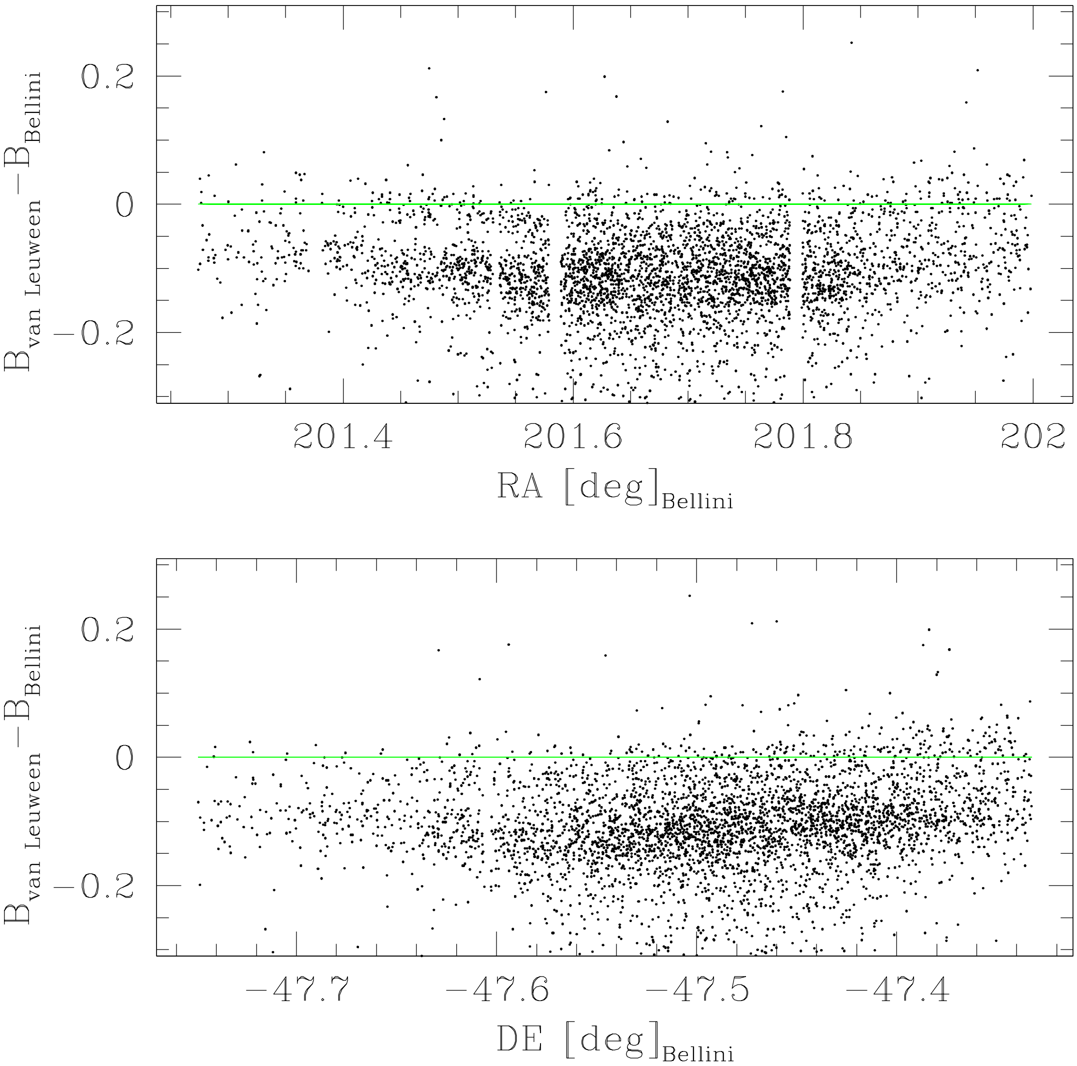

Figura 18: $B_{vanLeeuwen} - B_{Bellini}$ vs $RA_{Bellini}$ and $DEC_{Bellini}$.

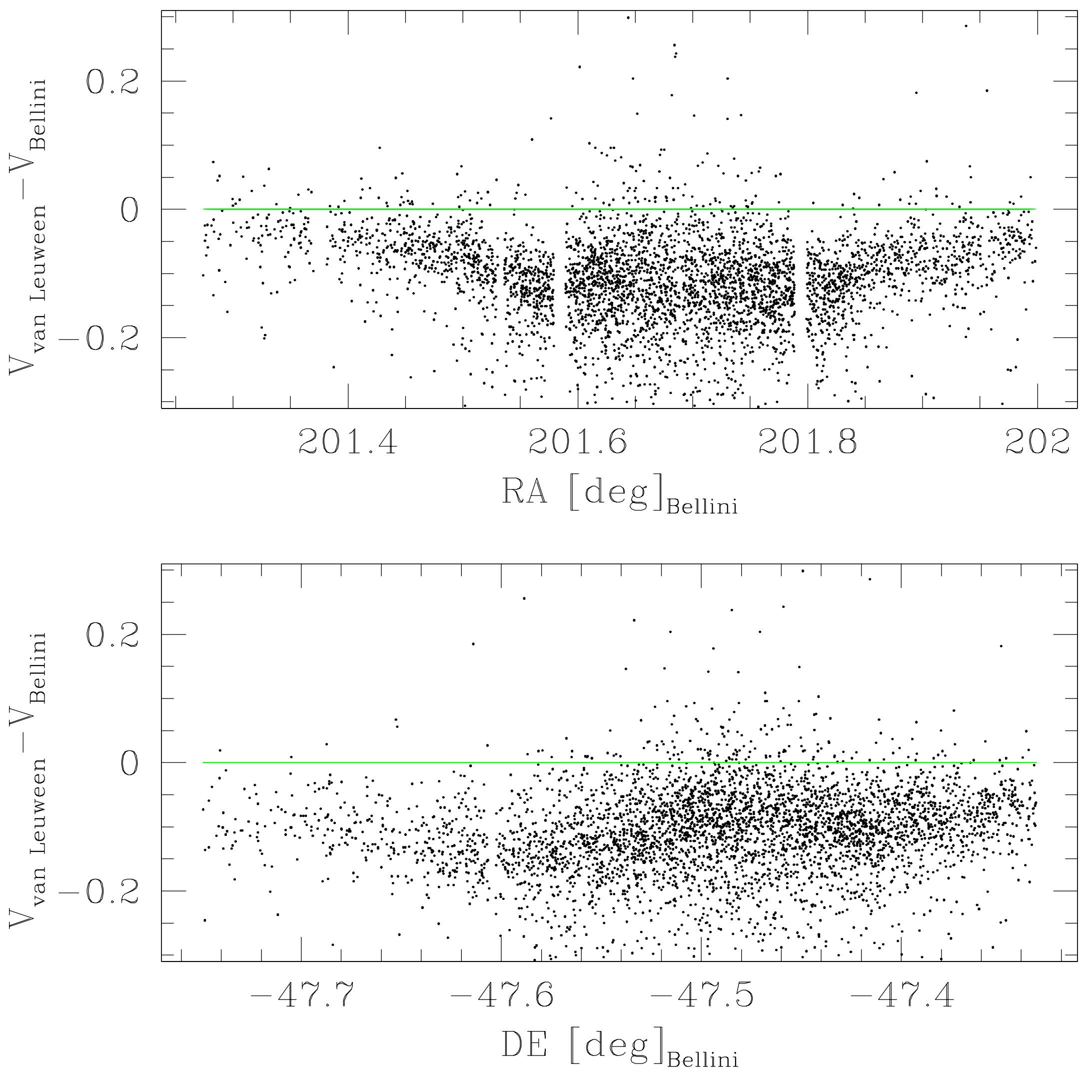

Figura 19: $V_{vanLeeuwen} - V_{Bellini}$ vs $RA_{Bellini}$ and $DEC_{Bellini}$.

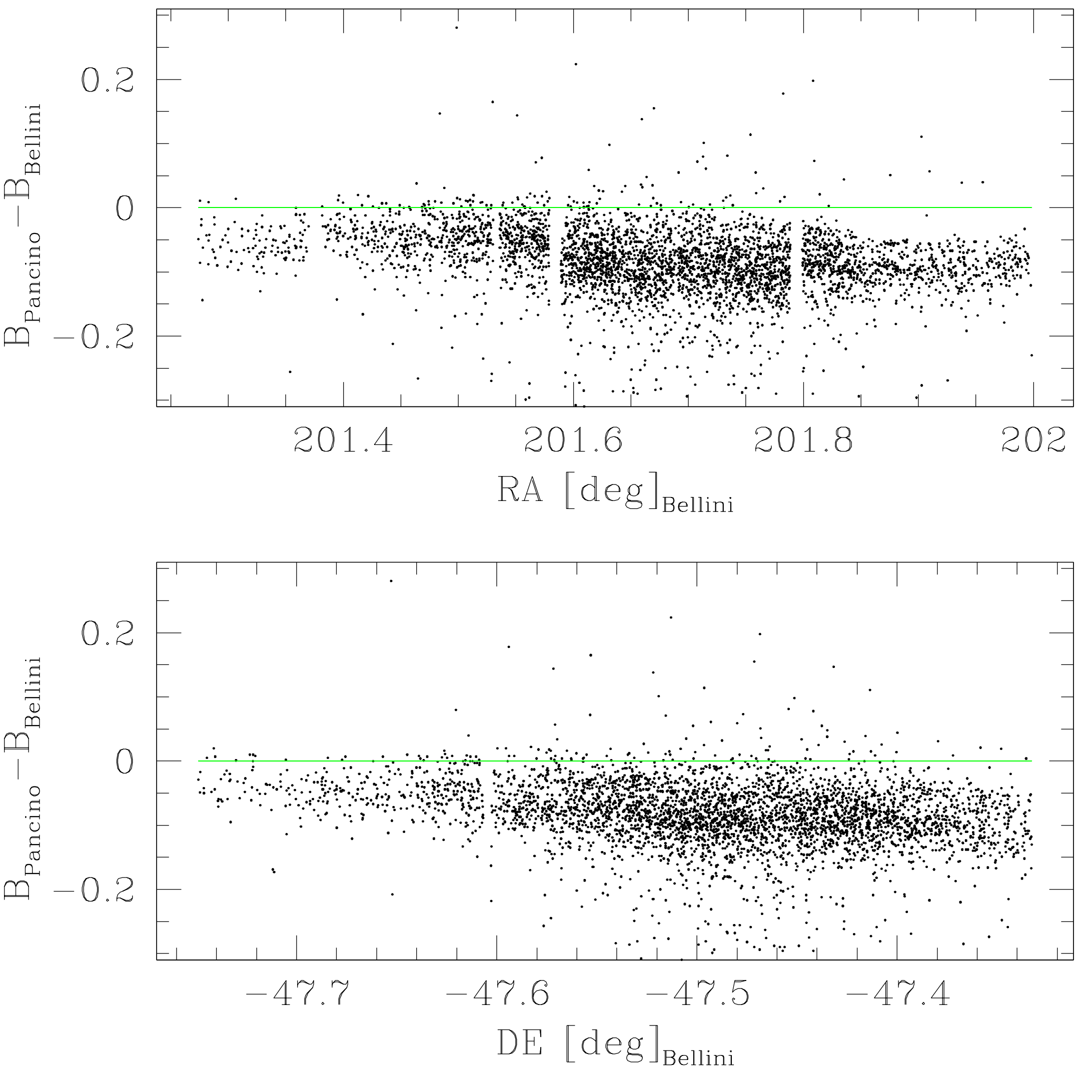

Figura 20: $B_{pancino} - B_{Bellini}$ vs $RA_{bellini}$ and $DEC_{bellini}$.

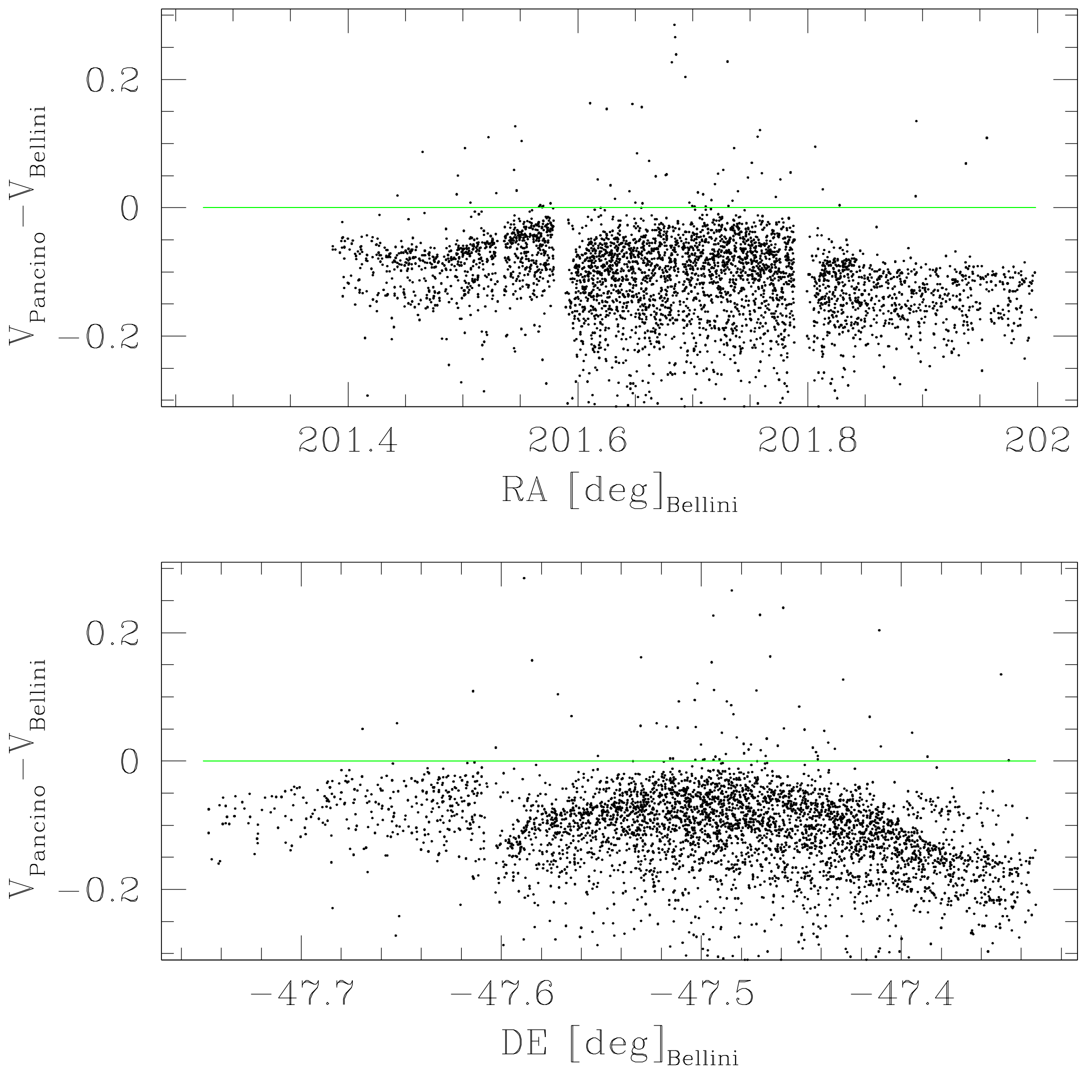

Figura 21: $V_{pancino} - V_{Bellini}$ vs $RA_{bellini}$ and $DEC_{bellini}$.

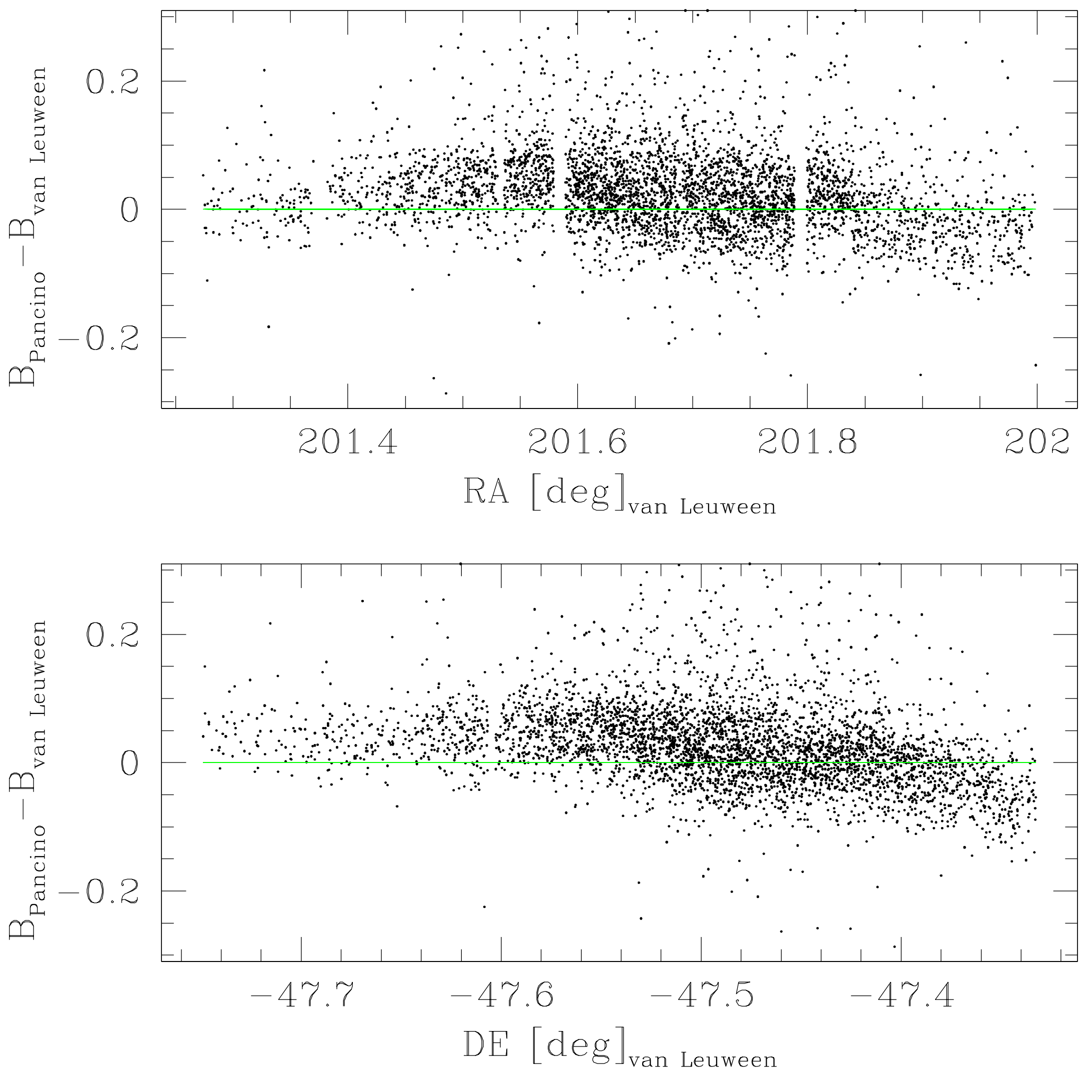

Figura 22: $B_{Pancino} - B_{vanLeeuwen}$ vs $RA_{vanLeeuwen}$ and $DEC_{vanLeeuwen}$.

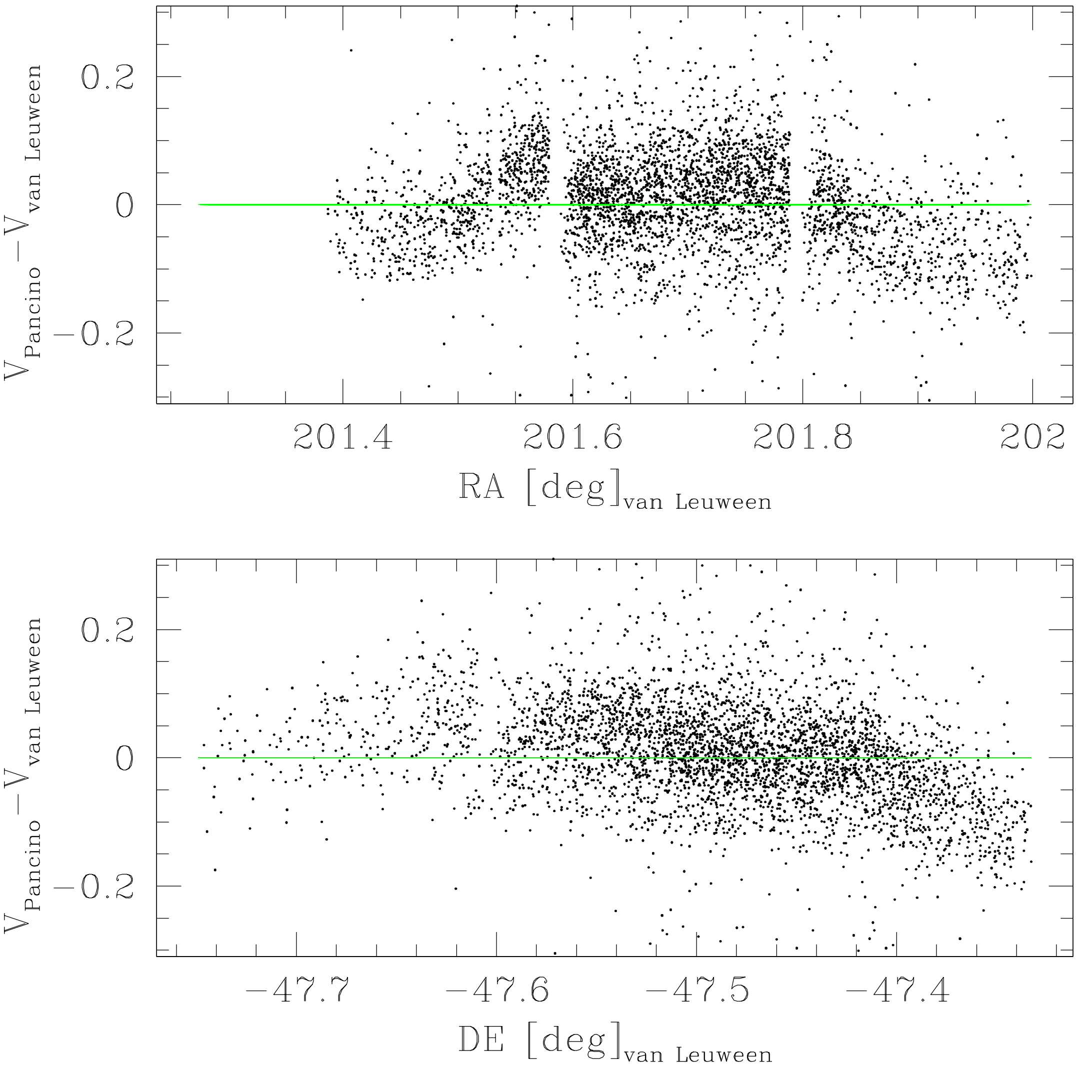

Figura 23: $V_{Pancino} - V_{vanLeeuwen}$ vs $RA_{vanLeeuwen}$ and $DEC_{vanLeeuwen}$.

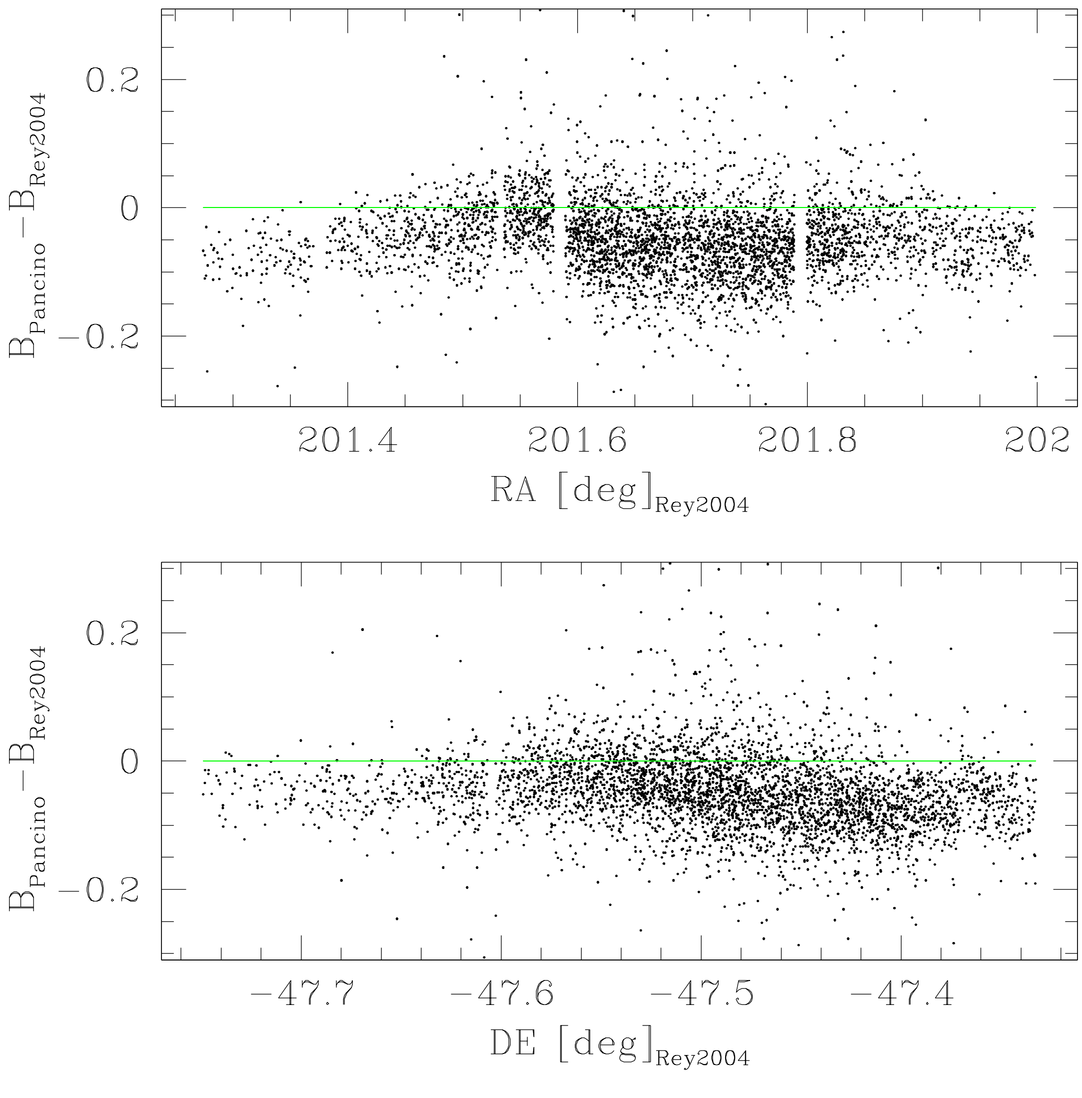

Figura 24: $B_{Pancino} - B_{Rey2004}$ vs $RA_{Rey2004}$ and $DEC_{Rey2004}$.

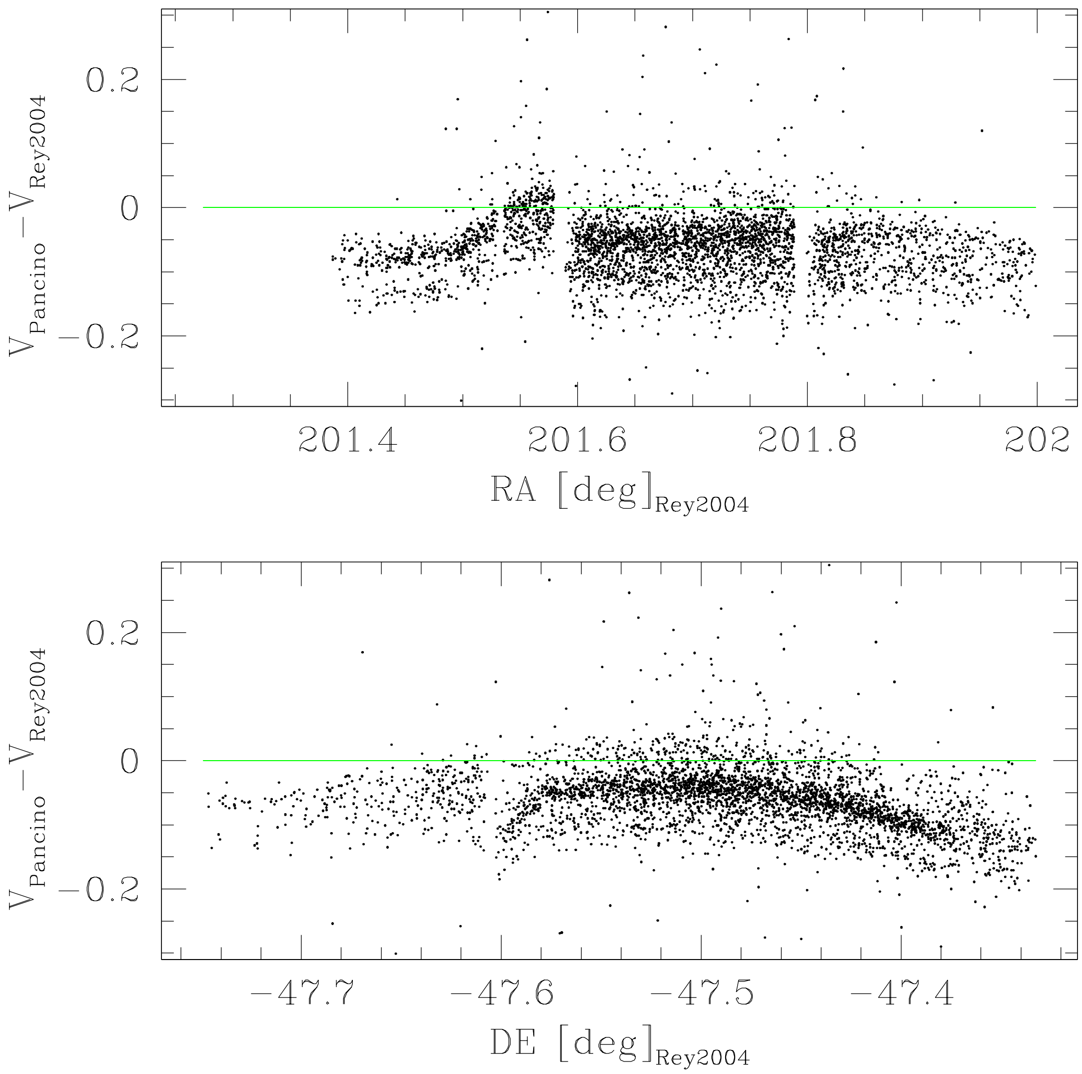

Figura 25: $V_{Pancino} - V_{Rey2004}$ vs $RA_{Rey2004}$ and $DEC_{Rey2004}$.

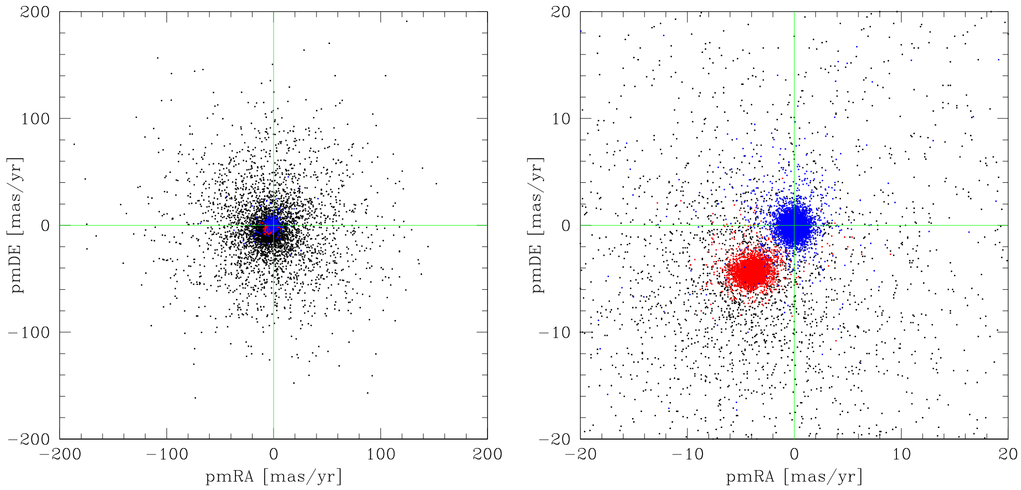

Figura 26: Proper motion $RA \times cos(Dec)$ vs Proper motion in Dec. Black dots: UCAC3, blue dots Bellini 2009, red dots van Leuween 2000. The image at the right is a zoom of the previous one.

6 CMD & Kinematics

6.1 Photometry

How are Bellini's, van Leeuwen's and Pancino's data calibrated? van Leeuwen's data are calibrated by means of four sets of data (Wooley 1999, Lyngå1996, Kaluzny 1996 1997), Mateo unpublished), after their cross calibration (they are both CCD and photometric data).

6.2 Proper motions

Fig. 26 shows the proper motions for the three catalogues.

The offset between the proper motion given by the three catalogues are shown in Table 6 The results is graphically shown in Fig.27. It is evident the fact that, as stated in Bellini 2009, the proper motions are measured relative to the bulk motion of cluster stars, and hence are centered in zero. In fact, the difference between the bulk proper motion of the cluster measured by Bellini 2009 and van Leeuwen 2000 is consistent with the proper motion of the cluster measured by van Leeuwen 2000: $\mu_x = -3.97 \pm 0.41$ $\mu_y = -4.38 \pm 0.41$.

Tabella 6: Systematic offsets between the proper motions of the three catalogues

	RA [mas]	DEC [mas]	N matches
Bellini09 - UCAC3	2.59 ± 31.90	3.26 ± 32.40	4621
van Leeuwen 2000 - UCAC3	-1.23 ± 31.97	-1.05 ± 32.42	4621
Bellini09 - van Leuween 2000	3.81 ± 2.36	4.31 ± 2.08	4996

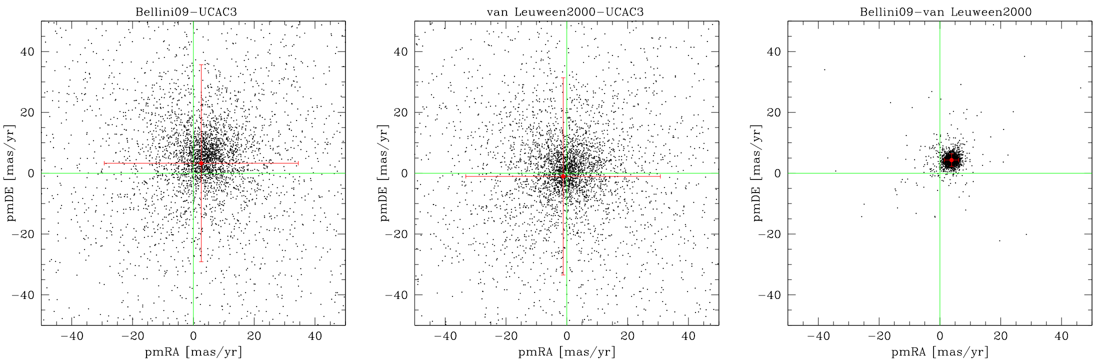

Figura 27: Residuals of the proper motions of the stars in common between Bellini 1999, van Leeuwen 2000 and UCAC3.

7 MP, Mint and RGB-a proper motions

I check if the sub-populations MP, Mint and RGB-a show different kinematics, based on Bellini's data.

I select objects with $\sigma\mu_{\alpha cos(\delta)}$ and $\sigma\mu_\delta \leq 5$ mas/year. The RGB is shown in Fig. 28 with MP, MInt and RGB-a shown in different colours. Fig. 29 and Fig. 30 show that while MP stars proper motions are scattered around zero, MInt shows a hint of asymmetry, with $\mu_{\alpha cos(\delta)}$ with a faint tail towards negative values and μ_δ with a faint tail towards positive values and RGB-a $\mu_{\alpha cos(\delta)}$ more strongly skewed and extended towards negative values and μ_δ more strongly skewed and extended towards positive values, with asymmetric distributions. The results are shown in Table 7. Anyway we point out that a cloud of sources with negative $\mu_{\alpha cos(\delta)}$ and positive μ_δ is visible in all plots, but it is negligible in the MP and MInt if compared to the huge number of sources with proper motions scattered around zero. If the clouds was composed by field stars we would expect motions $\mu_{\alpha cos(\delta)}$ and μ_δ opposite the the bulk motion of the cluster (Bellini's values are relative to the bulk motion of Omega Cen), hence centered on $\mu_{\alpha cos(\delta)} \sim \mu_\delta \simeq +4$mas, but it is not our case.
It seems that the percentage of stars with negative $\mu_{\alpha cos(\delta)}$ and positive μ_δ increase going from MP to MInt to RGB-s.
The 3 sub-populations do not show significant differences in the RA DEC distribu-

Tabella 7: Centroid and Weighted Average Proper motions for different RGB subpopulations

	$< RA >$ [deg]	$< DEC >$ [deg]	$< pmRA >$ [mas]	$< pmDEC >$ [mas]	N star
Bellini09	201.70 ± 0.17	-47.49 ± 0.11	0.1 ± 4.6	0.3 ± 4.7	359391
error5	201.70 ± 0.17	-47.49 ± 0.10	-0.1 ± 2.5	0.3 ± 2.3	103246
MP	201.70 ± 0.12	-47.48 ± 0.07	-0.1 ± 2.1	0.0 ± 1.1	2432
MInt	201.70 ± 0.11	-47.49 ± 0.06	-0.2 ± 1.8	0.2 ± 1.8	482
RGB-a	201.70 ± 0.13	-47.49 ± 0.09	-0.6 ± 2.0	1.2 ± 2.8	122

tion (see Table 7) and the high proper motion stars in the RGB-a sample do not show a correlation with their RA DEC position (see Fig. 31): High proper motions RGB-a stars are homogeneously dispersed in the RA DEC space, with no central concentration... is it strange? Are they fields stars?

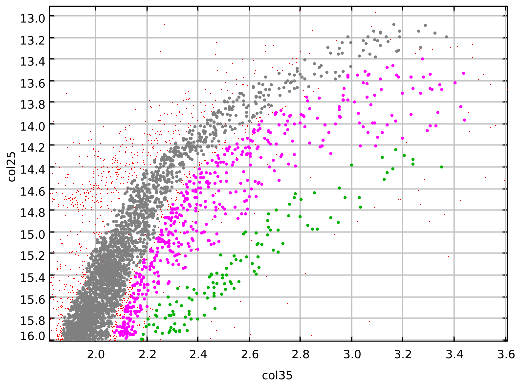

Figura 28: RGB sub populations MP (gray), MInt (magenta) and RGB-a (green) in the B vs. B-I plot.

Fig. 32 shows the correlation of the proper motion with the V magnitude for the 3 subpopulations (MP, MInt, RGB-a) using Bellini's data. Fig. 33 shows the correlation of the proper motion with the B-V colour for the 3 subpopulations (MP, MInt, RGB-a) using Bellini's data. RGB-a data shows a bigger scatter of the data, but there is not a systematic shift of the whole sample with respect to MP and MInt.

We make the same analysis with Van Leeuwen data. In particular extract from Van Leeuwen's catalogue 3 subsamples with the stars in common with the tree samples MP, MInt and RGB-a extracted from Bellini's catalogue. The 3 subsamples are shown in Fig. 34 (this is similar but not identical to Fig. **??** because the 3 branches are best visible in B-I but only B-V is provided by van Leeuwen's catalogue).

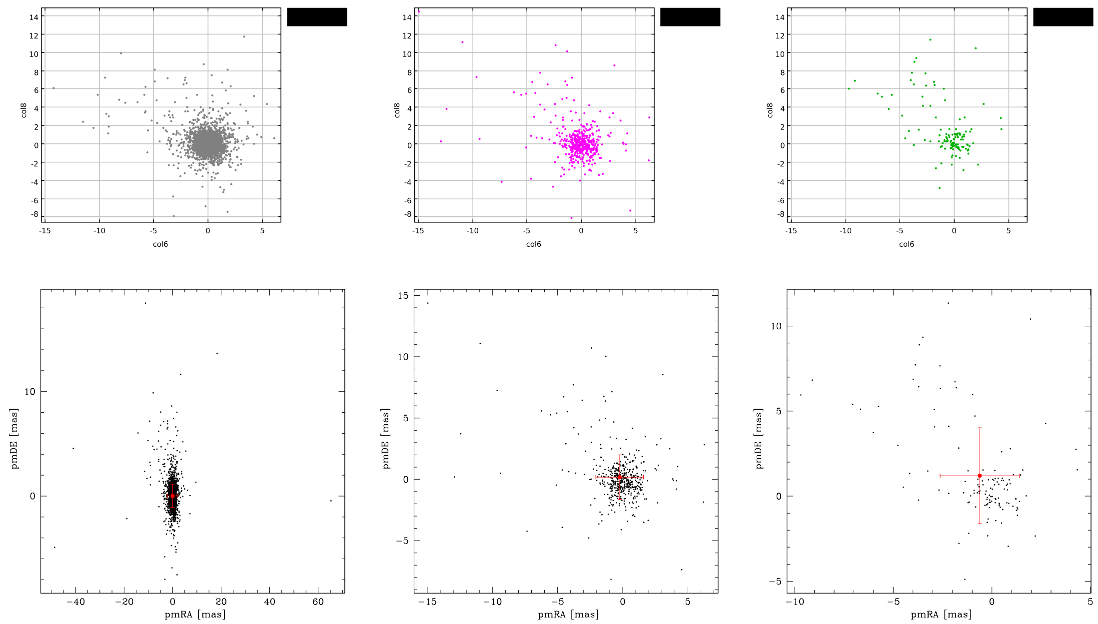

Figura 29: Proper motions of MP (gray), MInt (magenta) and RGB-a (green) (RA and DEC proper motions in x and y respectively)

Fig. 35 shows the correlation of the proper motion with the V magnitude for the 3 subpopulations (MP, MInt, RGB-a) using van Leeuwen's data selected as desribed above. Fig. 36 shows the correlation of the proper motion with the B-V colour for the 3 subpopulations (MP, MInt, RGB-a) using van Leeuwen's data selected as described above. RGB-a data shows a bigger scatter of the data, but there is not a systematic shift of the whole sample with respect to MP and MInt.

Fig. 37 shows that RGB-a stars have a slightly different distribution in the proper motions plane both in Bellini's and van Leeuwen's catalogue.

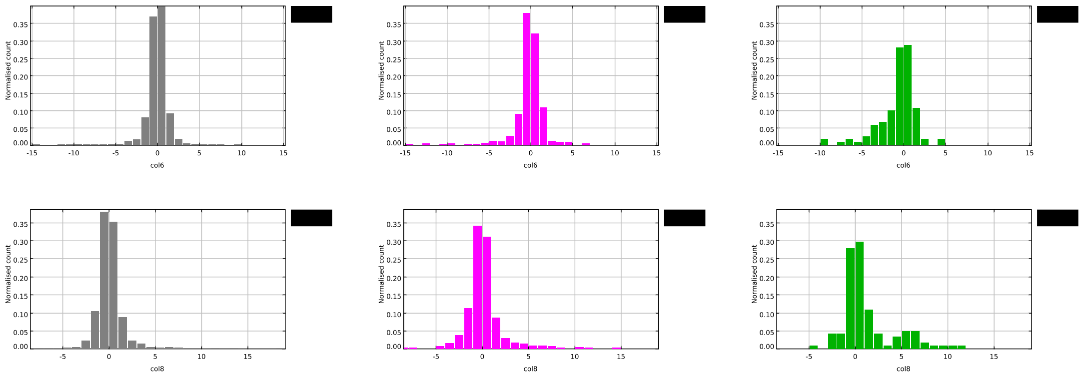

Figura 30: RA (top panels) and DEC (bottom panels) Proper motions histograms (normalized to unity for better comparison) of MP (gray), MInt (magenta) and RGB-a (green)

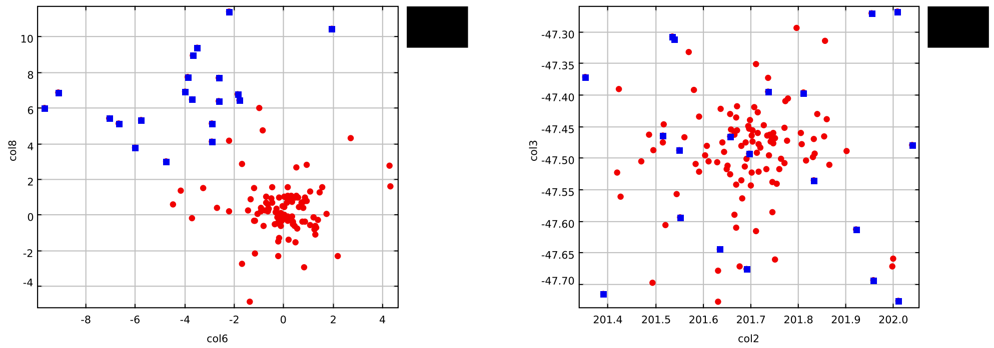

Figura 31: Left: RGBa proper motions; Right: RGB-a RA and Dec.

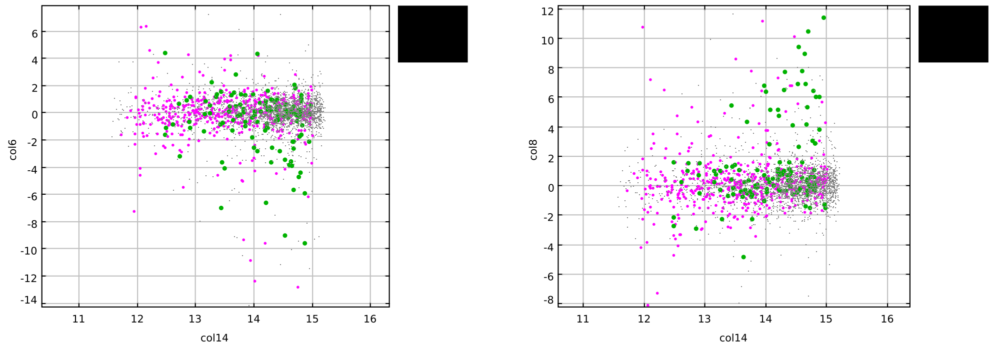

Figura 32: $\mu_{\alpha cos\delta}$ (left panel) and μ_δ (right panel) vs V mag. MP data are plotted in gray, MInt in magenta and RGB-a in green. (Bellini's data)

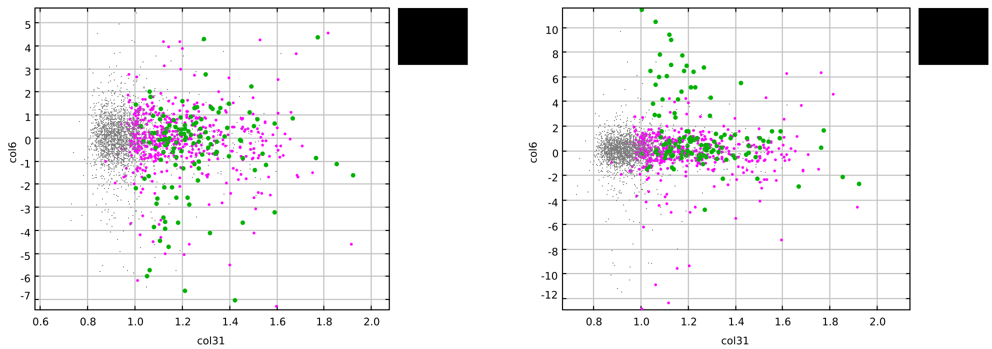

Figura 33: $\mu_{\alpha cos\delta}$ (left panel) and μ_δ (right panel) vs B-V . MP data are plotted in gray, MInt in magenta and RGB-a in green. (Bellini's data)

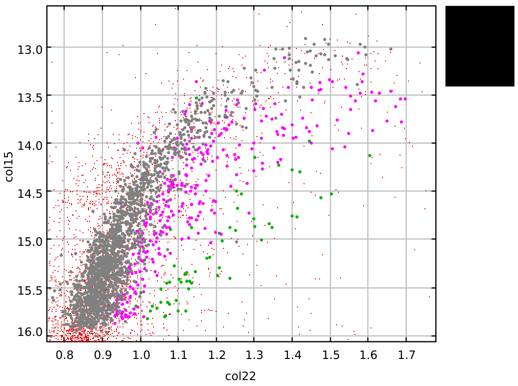

Figura 34: RGB sub populations MP (gray), MInt (magenta) and RGB-a (green) in the B vs. B-V plot.

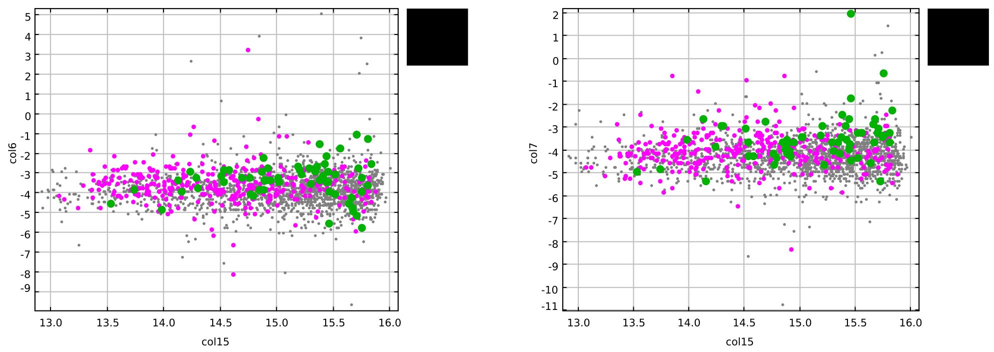

Figura 35: *pmRA* (left panel) and *pmDE* (right panel) vs B mag. MP data are plotted in gray, MInt in magenta and RGB-a in green. (van Leeuwen's data)

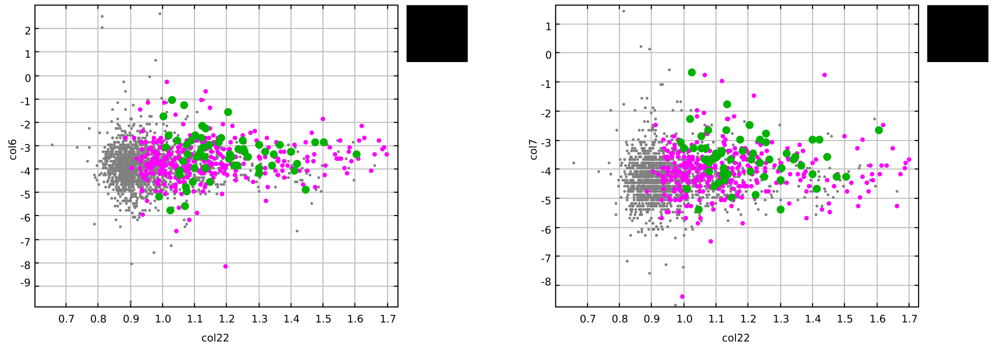

Figura 36: *pmRA* (left panel) and *pmDE* (right panel) vs B-V . MP data are plotted in gray, MInt in magenta and RGB-a in green. (van Leeuwen's data)

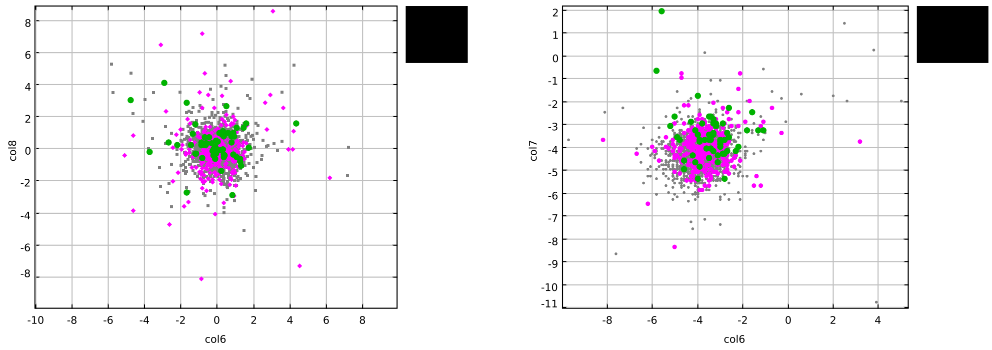

Figura 37: Proper motions for Bellini (left panel) and van Leeuwen (right panel) for MP data (1645 stars, gray), MInt (337 stars, magenta) and RGB-a (67 stars, green).

We point out that RGB-a stars seems to have a different velocity distribution in Bellini's and van Leeuwen's catalogues, see Fig. 37. In Particular in the latter there is and offset with respect to the bulk of the cluster. Fig. 38 and 39 show a direct comparison of the proper motions of the stars in common between Bellini and van Leeuwen.

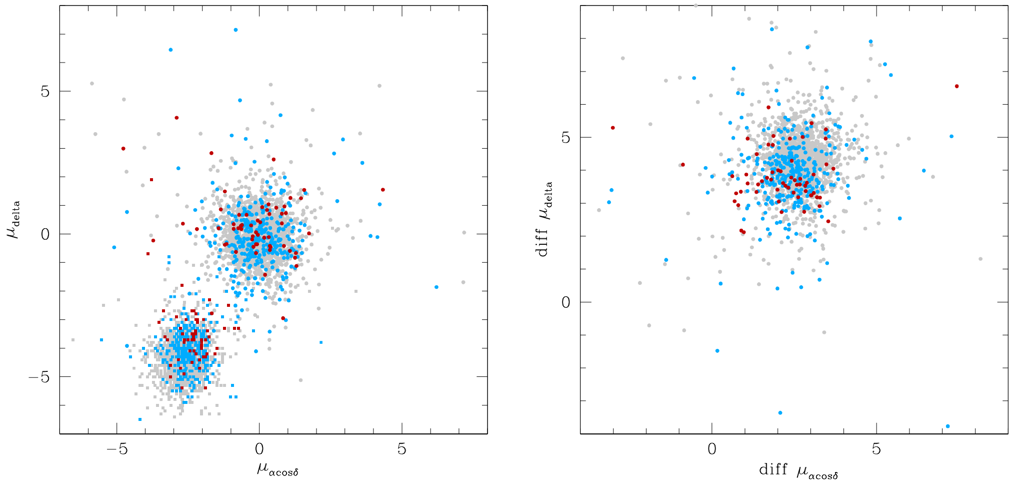

Figura 38: Left: μ_δ vs. $\mu_{\alpha cos\delta}$ for Bellini's data (dots) and van Leeuwen' data (squares); Right difference between Bellini's and van Leeuwen's proper motions. Grey: MP; light blues: Mint; red: RGB-a.

In Bellini's data the RGB-a stars seems to have proper motions more similar to the bulk of the cluster. Fig. 40 show a possible correlation of the proper motion differences with colour.

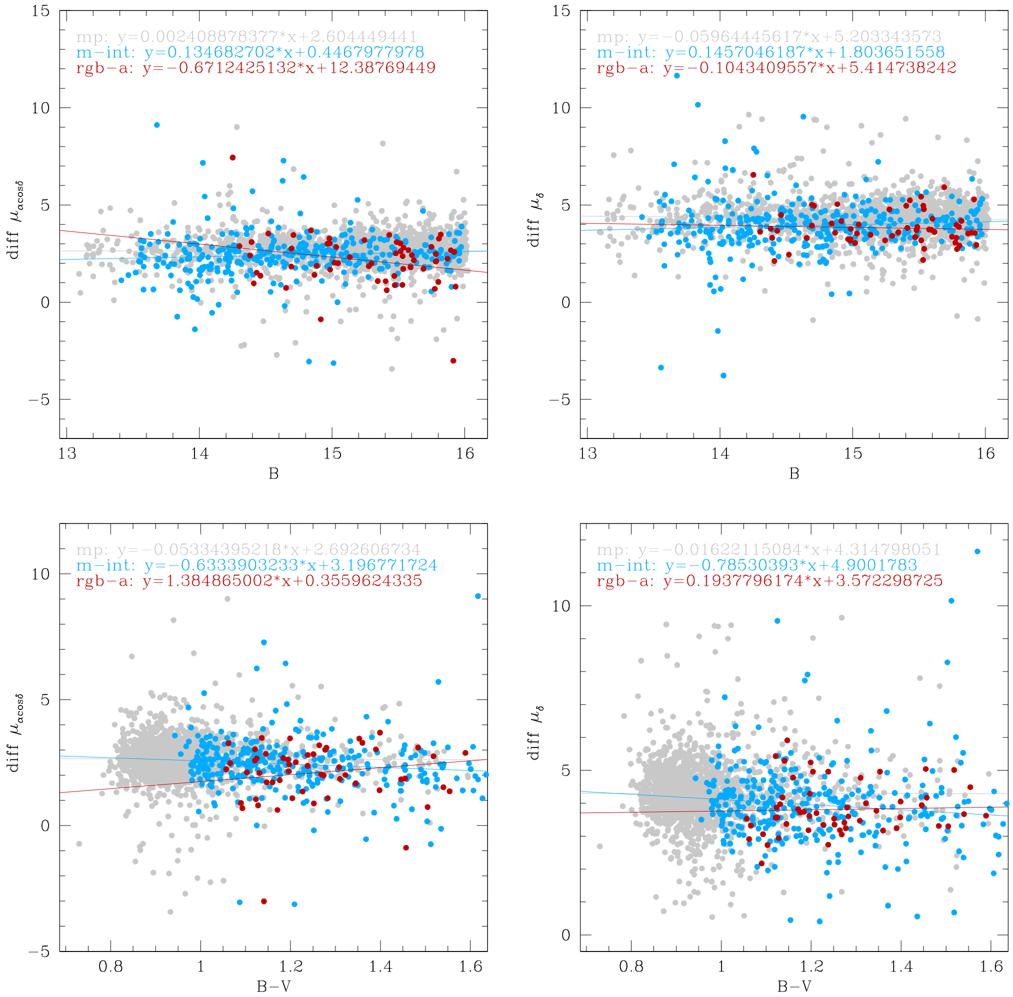

Figura 39: Upper panels: $\mu_{\alpha cos\delta}$(Bellini)- $\mu_{\alpha cos\delta}$(van Leeuwen) vs B(Bellini) (left) and μ_{δ}(Bellini)-μ_{δ}(van Leeuwen) vs B(Bellini) (right). Lower panels: $\mu_{\alpha cos\delta}$(Bellini)-$\mu_{\alpha cos\delta}$(van Leeuwen) vs $B-V$(Bellini) (left) and μ_{δ}(Bellini)-μ_{δ}(van Leeuwen) vs $B-V$(Bellini) (right).Grey: MP; light blues: Mint; red: RGB-a.

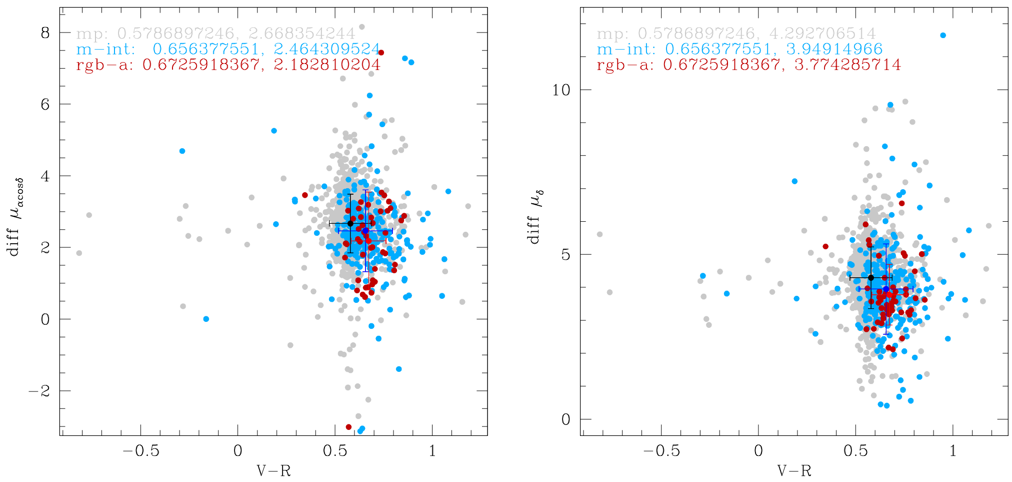

Figura 40: Left $\mu_{\alpha cos\delta}$(Bellini)- $\mu_{\alpha cos\delta}$(van Leeuwen) vs $V - R$(Bellini). Right: μ_{δ}(Bellini)-μ_{δ}(van Leeuwen) vs $V - R$(Bellini).Grey: MP; light blues: Mint; red: RGB-a. The mean proper motion for each subsample is shown too.