

Wide and Faint Double Star Photometry and Measurement with Online Tools – Test Drive with Landolt Standard Stars and Example with ROE 76 in Perseus

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Abstract: Using Landolt standard stars as reference, it is shown that generally available online tools can with moderate efforts deliver reliable photometric results, and with the example of ROE 76 in Perseus it is also shown that measuring of wide double stars is quite possible. By chance ROE 76 also offered the possibility to do some astrometry with online tools.

Introduction

Old fashioned visual double star observers with session plans containing hops from one double to another often visit faint and wide pairs as humble hops between "more interesting" doubles. It is only a question of time until it becomes evident that a good number of these objects are listed with questionable magnitudes in the WDS catalog (as is the case in most star catalogs). They are easy to recognize by the missing second digit in precision, indicating a possibly estimated or old measurement.

It is certainly possible to try to do a better estimating job than the discoverer and in this regard it might even be an advantage to be restricted to a smaller amateur telescope to be aware that the components of a specific double have to be much fainter than listed – else one would be able to resolve it in a humble amateur telescope. Some research can then be done in other star catalogs to check if there might be other magnitude information on the pair. Tycho II usually delivers a value for the primary, or a combined magnitude for both components, and USNO or UCAC4 most of the time give a suggested model fit or aperture photometry magnitude for the secondary if the separation is wider than 2". When lucky, APASS provides a precise measurement of the visual magnitude of the secondary (then listed in UCAC4 as Vmag), but this is not as often as desired. The USNO can then be informed about the

latest observation and the data found elsewhere and (if necessary) get a change in the WDS data to the better, but the magnitude still remains an estimate (with the exception of an existing APASS value). It would then be nice to be able to do some photometry with reasonable effort.

Online telescope providers offer different levels of services and at least some deliver a rather professional quality for making images usable for photometry and other measurements. Such images can then be uploaded to the AAVSO online photometry tool *VPhot*. Prerequisite for using *VPhot* is a valid TIFF-header, good enough image quality for plate solving, usage of a photometry filter (especially V for visual magnitudes), and a definition of the parameters of the used telescope. Some online telescope providers even offer automatic plate solving and upload to *VPhot* so these steps can already be included in the imaging session plan.

After some initial experiments one quickly gets the feeling for selecting the suitable exposure time needed for good results with different levels of star brightness and other factors – long enough to get star disks with a good signal to noise ratio (SNR) and short enough to avoid overlapping of the star disks from primary and secondary. Stacking several images with rather short exposure time is also a good idea to get a better image quality, including better SNR.

Now comes the process of defining the sequence. First, select the objects for photometry. Then comes the

Wide and Faint Double Star Photometry and Measurement with Online Tools – Test Drive ...

critical step to select comparison stars in the field of view. Predefined AAVSO comp stars are rather scarce in some areas; the same goes for AAVSO standard stars. Surprisingly, APASS has no predefined VPhot source for comp stars, but this will hopefully be changed in the near future. SIMBAD might be used to select comp stars but the available catalogs rarely deliver reliable magnitudes for fainter stars.

An alternative is to use UCAC4 objects in the FoV with the given V-mags, assuming that such values are usually from APASS or sources of equivalent quality.

The next step is to select objects of similar quality for check stars to get an impression of how precise the delivered photometry results might be and to define photometry aperture radius and sky annulus. Then, save the sequence, click "Photometry Report", and see what result is obtained. Some adjustments might need to be made when the given measurement error seems too large, the check star indicates a questionable sequence, or some comparison stars seem a bad choice indicated by a red colored background in the target estimate column.

Test with Landolt Standard Stars

To check the quality of the results of such a procedure, I made an image of a group of stars with Landolt standard stars. The Landolt catalog consists of several hundred faint stars near the celestial equator with "approved" magnitudes used by AAVSO as "official" comp stars for photometry.

I selected the star field around TYC0012-00214-1 (Landolt 92 342 = AAVSO comp star #116) in Cetus and made a single image with a 12" f/9.3 RC-scope situated in Siding Spring, Australia with 15 s exposure time using the V filter. Due to the rather low altitude of ~ 32° the air mass was a rather high 1.888, but the image showed as planned four Landolt stars in good quality (Figure 1).

In the first VPhot run, I selected the two northern stars with given UCAC4 Vmags as targets with three of the Landolt stars (92342, 92250, 92348) as comp stars and one Landolt star (92335) as a check star. This resulted in the photometry results given in Table 1.

This result shows that without any additional actions, like stacking, we get values well within a small error range. The next step in testing this setup is a change in direction using UCAC4 objects with Vmag values as comp stars and checking the results against the Landolt standard values. This resulted in the photometry results given in Table 2.

Again these results seem of very acceptable quality to me with even the worst result less off than 0.1mag and this with only two comp stars for three target stars and no actions at all to enhance the results – at least I

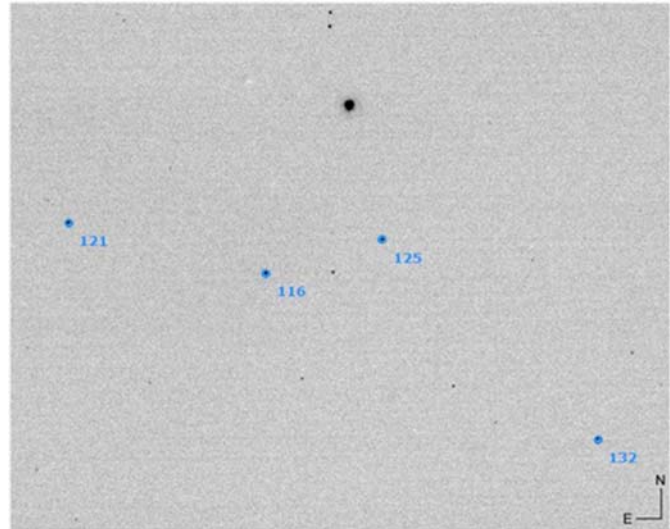


Figure 1. Test image with Landolt stars as AAVSO comp stars marked

Table 1: VPhot photometry results with standard comp stars

Name	Vmag	VPhot	Delta
UCAC4 455-001259	13.251	13.201	0.050
UCAC4 455-001260	12.805	12.855	0.050
Landolt 92335 (check)	12.523	12.559	0.036

Table 2: VPhot photometry results with UCAC4 Vmag comp stars

Name	Vmag	VPhot	Delta
Landolt 92250	13.178	13.088	0.090
Landolt 92342	11.613	11.638	0.025
Landolt 92348	12.109	12.110	0.001
Landolt 92335 (check)	12.523	12.559	0.036

Table 3. WDS values for ROE76

WDS	Comp	PA	Sep	Mags
03340+4048	AB	36	4.5	9.19, 10.3
03340+4048	AC	156	87.4	9.19, 10.58

think that such photometry results are certainly much better than the best possible estimates.

Wide and Faint Double Star Photometry and Measurement with Online Tools – Test Drive ...

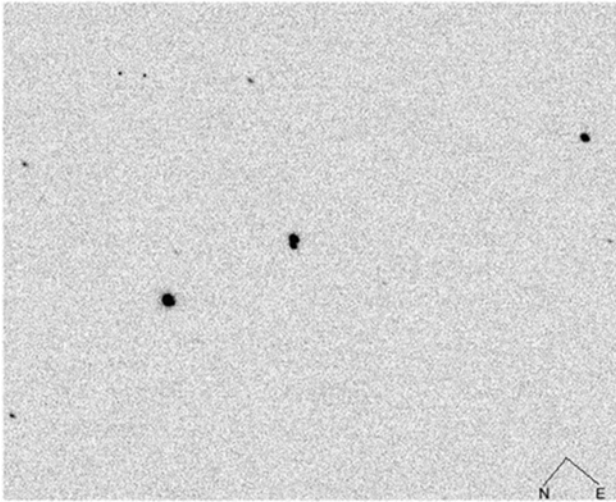


Figure 2. Image of ROE76

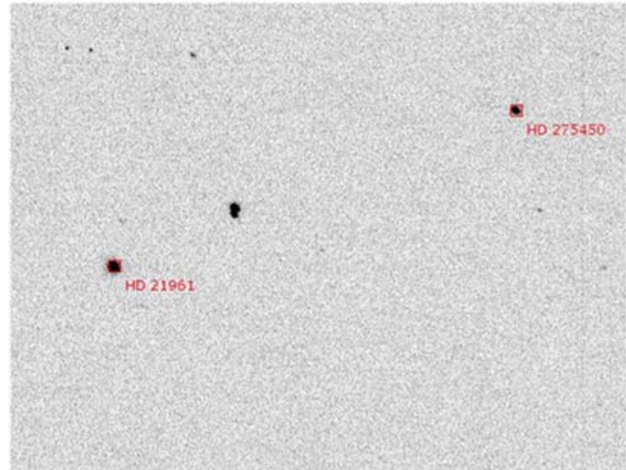


Figure 3. ROE 76 image with SIMBAD objects

Example ROE76 in Perseus

ROE 76 is listed in WDS (on January 31, 2015) with the values shown in Table 3 and with precise RA 03:33:55.460 and Dec 40:49:36.498.

I selected this multiple because the magnitude for B is listed in the WDS with only single digit precision and a quick lookup in the UCAC4 catalog indicated missing objects for B and C. On January 17, 2015, at 7:00 PM I took a single image with a 5 s exposure with a 12" f/8 CDK scope (resolution 0.73" per pixel) located in Nerpio, Spain with V filter at an altitude of about 67° and thus an air mass of only 1.024 and got the image shown in Figure 2.

As a slight complication, this scope delivers images with a horizontal and vertical flip plus about a 45° rotation and there is a glitch in the data transfer between scope and *VPhot* as the image orientation *VPhot* indicates it is off by 90° - this is in this case very important, as a counter check with WDS showing that there is something wrong with the RA+Dec position given in the WDS catalog. The correct orientation of the image could be easily checked by loading SIMBAD data into the image (Figure 3).

To check against the ROE 76 position data given in WDS, I made a star map based on WDS data (Figure 4). Next, I made a star map for the same field of view with the UCAC4 catalog, shown in Figure 5.

This is a clear hint that there might be something wrong with the WDS position data for ROE76. With the help of *Aladin*, I looked at the 2MASS image for HD 21961 and found another confirmation that the WDS data is wrong. Assuming RA/Dec coordinates for A and separation and PA for the components as given, this means a mismatch of positions and objects. AC would then be AB with RA and Dec as given and AB

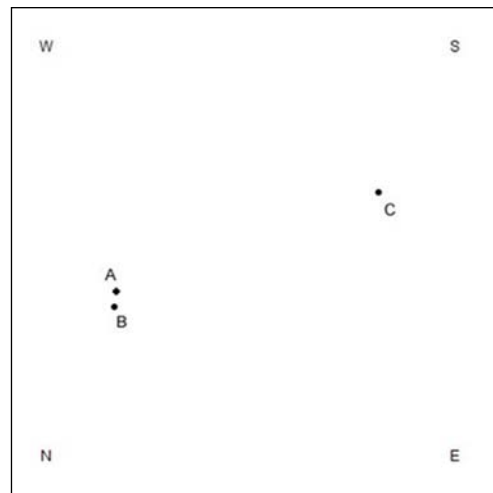


Figure 4. ROE 76 star map according to WDS

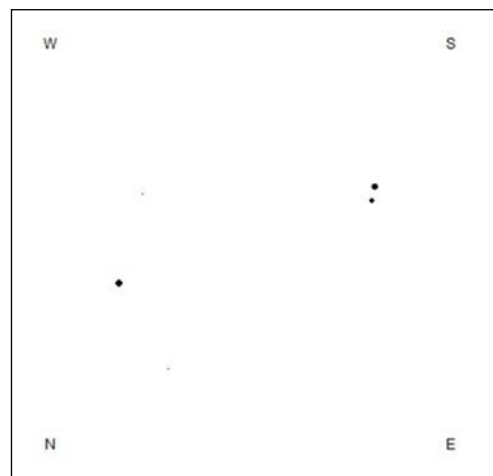


Figure 5. ROE map based on UCAC4

Wide and Faint Double Star Photometry and Measurement with Online Tools – Test Drive ...

Table 4. UCAC4 mags for ROE76 components
(1=Vmag, 2=model fit)

ROE76	UCAC4	WDS mag	UCAC4 mag
A	655-016333	9.190	9.500 1)
B	655-016340	10.300	10.238 1)
C	455-001260	10.580	11.636 2)

would be BC with RA 03:33:58.608 and Dec 40:48:16.848.

Now comes the topic of magnitudes. First, we can check again UCAC4 as we have now a UCAC4 object for each ROE76 component, Table 4.

For the C component, UCAC4 lists no Vmag (confirmed with negative APASS query), so we have to settle with the model fit magnitude estimation (usually more reliable than the aperture photometry value, in this case a rather odd +10.391). These values indicate a potential problem with the magnitude for C (and not with B, as was the initial idea for this research), so the next step is photometry with VPhot. The image quality may not be perfect as the star disks for B and C are touching (so it might have been better to make several images with shorter exposure time and stack them), but we have to use what we have and it works rather well. We have a good number of UCAC4 comp stars with Vmags available as shown in Table 5. Table 6 gives the results from Vphot.

This result is obviously in a reasonable error range suggested by the values for the check stars and suggests that the WDS mags for A and B are within some error range correct but that C is about 1 mag fainter than listed, as already indicated by the UCAC4 model fit magnitude.

As VPhot offers also a tool for calculating separation and position angle, we can check also these values, with the result shown in Table 7.

Besides the switch of components, these results confirm the WDS values at least for AB with some minor doubts for BC – but we have to consider the lack of precision of the VPhot results depending on image resolution (0.73" per pixel). But as we have now a precise RA/Dec values from UCAC4 we can do precise calculations for separation and PA

Finally, we get the photometry and measurement result for ROE76 shown in Table 8.

Conclusions

The setup with iTelescope and AAVSO VPhot is already in the simple form with single images quite useful for photo- and astrometry for wide faint double stars especially for the determination of the magnitude

Table 5: Comp stars for ROE 76

Object	Vmag
UCAC4-654-015822	11.929
UCAC4-654-015857	10.934
UCAC4-655-016242	10.413
UCAC4-655-016292	12.323

Table 6. Vphot results for ROE 76

Name	Vmag	VPhot	Delta
ROE76A	9.190	9.134	-0.056
ROE76B	10.300	10.431	0.131

Table 7: Separation and Position Angle for ROE76 according to VPhot compared to WDS (with switched components)

Object	WDS		VPhot	
	Sep	PA	Sep	PA
ROE76AB	87.4	156	87.3	155.9
ROE76BC	4.4	36	3.77	38.73

of rather faint secondaries. There is still room for improvements with stacking and other techniques providing better image and data quality and reducing random errors. It would also be useful to do additional photometry with B filter to be able to calculate the B-V color index indicating the degree of reddish tint, making it more demanding for visual resolution.

Acknowledgements

The following tools and resources have been used for this research:

- Washington Double Star Catalog
- iTelescope
- AAVSO VPhot
- AAVSO APASS
- UCAC4 catalog via the Uni Heidelberg website
- Landolt catalog of standard stars
- Aladin Sky Atlas CDS, SIMBAD, VizieR
- 2MASS All Sky Catalog
- AstroPlanner

Many thanks to Ed Wiley and Brian Mason for encouraging me to write this report

Wide and Faint Double Star Photometry and Measurement with Online Tools – Test Drive ...*Table 8: ROE76 photometry and measurement results*

Name	WDS ID	RA	Dec	Sep	PA	M1	M2	Date	N	Notes
ROE76AB	03340+4048	03:33:55.465	+40:49:36.485	87.26	155.87	9.134	10.431	2015.05	1	1)
ROE76BC	03340+4048	03:33:58.608	+40:48:16.848	4.46	35.31	10.431	11.513	2015.05	1	2)

Notes:

1. RA and Dec from UCAC4. Calculation of Sep and PA with the formulas provided by Buchheim 2008. In comparison with the current WDS data per 2015-01-31 this report also includes a change in components with AB instead of AC due to a positional error in the WDS catalog
2. RA and Dec from UCAC4. Calculation of Sep and PA with the formulas provided by Buchheim 2008. In comparison with the current WDS data per 2015-01-31 this report also includes a change in components with BC instead of AB and a corresponding change in RA and Dec due to a positional error in the WDS catalog.

References

Buchheim, Robert, 2008, CCD Double Star Measurements at Altimira Observatory in 2007, *Journal of Double Star Observations*, **4**, 27-31.

