

## Research Note

# On the usefulness of finding charts

## Or the runaway carbon stars of the Blanco & McCarthy field 37

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**Abstract.** We have been recently faced with the problem of cross-identifying stars recorded in historical catalogues with those extracted from recent fully digitized surveys (such as DENIS and 2MASS). Positions mentioned in the old catalogues are frequently of poor precision, but are generally accompanied by finding charts where the interesting objects are flagged. Those finding charts are sometimes our only link with the accumulated knowledge of past literature. While checking the identification of some of these objects in several catalogues, we had the surprise to discover a number of discrepancies in recent works. The main reason for these discrepancies was generally the blind application of the smallest difference in position as the criterion to identify sources from one historical catalogue to those in more recent surveys. In this paper we give examples of such misidentifications, and show how we were able to find and correct them. We present modern procedures to discover and solve cross-identification problems, such as loading digitized images of the sky through the Aladin service at CDS, and overlaying entries from historical catalogues and modern surveys. We conclude that the use of good finding charts still remains the ultimate (though time-consuming) tool to ascertain cross-identifications in difficult cases.

**Key words.** errata – catalogs – surveys – stars: carbon – Magellanic Clouds

### 1. Introduction

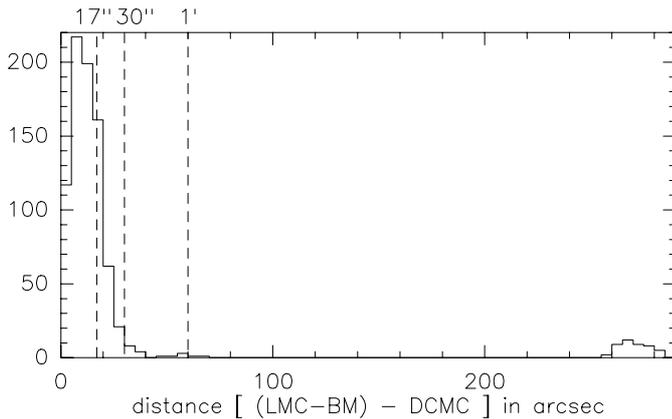
The question addressed in this Research Note is the following: can one cross-identify old catalogues listing inaccurate coordinates with modern ones providing good coordinates using automatic blind matches? Of course one can, one just has to write or borrow rather simple routines and to digitize the old catalogue. But is the error rate acceptable?

Here we give a piece of answer, based on the cross-identification of the carbon star catalogue of Blanco & McCarthy (1990, acronym LMC-BM) with the one of Kontizas et al. (2001, acronym KDM2001), as well as with the DENIS Catalogue towards the Magellanic Clouds (Cioni et al. 2000, acronym DCMC). The sensitivity of both surveys is similar, but Blanco & McCarthy were limited to 49 circular regions of  $\sim 0.12^\circ$ , while Kontizas et al. have surveyed the whole LMC. From the restricted point of view of this article, the main difference between both surveys is the astrometric accuracy,  $\sim 1''$  for Kontizas et al., and better than  $17''$  in Blanco & McCarthy. Moreover, the way the astrometry was performed in Blanco & McCarthy involved much more manual work than in Kontizas et al., leading to a much higher risk of human errors, as will

be seen in Sect. 2. Kontizas et al. have matched (automatically) both catalogues and present the results in their Table 3. During the course of a more general work about cross-identifications in the LMC, we have checked some of their results by looking at the finding charts. This led us to cross-identify the whole Blanco & McCarthy catalogue in the same “old-fashion” way, and to compare it with automatic matches, as presented in Sect. 3. Section 4 lists a few additional errata. Short conclusions are given in Sect. 5.

### 2. The case of the Blanco & McCarthy field 37

The case of the Blanco and McCarthy field number 37 illustrates very well the risk of cross-identifications in a “blind way”, that is, on the basis of poor coordinates only. We would like to suggest the reader to visit the Centre de Données astronomiques de Strasbourg (CDS, <http://cdsweb.u-strasbg.fr>), then the Aladin image facility, to type in the coordinates of, for instance, LMC-BM 37-20 (05 43 42 -70 27.5, J2000), and to load the ESO MAMA or AAO DSS2 digitized *R* image. At first view one does not recognize the field of the finding chart. At second view neither. The experience can be made with any star of the field 37,



**Fig. 1.** Distribution of distances between LMC–BM and DCMC positions as derived from the cross-identifications based on finding charts.

the field centered on the coordinates never corresponds to the one of the finding chart. However, if one looks at, for instance, LMC–BM 37–24 (05 44 03 –70:26.1, J2000), one can recognize the field thanks to two bright stars, both very far away from the expected location, more precisely about 50 s (4′) towards the West and 2′ towards the South. It turns out that all the positions of the LMC–BM stars in the field 37 are erroneous by about 4.5′, as well as the position of the field center. (The reason for this error remains unknown.)

Kontizas et al. find 13 cross-identifications in this field, 29% of the total number of C stars found by Blanco & McCarthy. As the shift of the position is about 4.5′, while the search radius of Kontizas et al. was about 1′, it is clear that the 13 cross-identifications given by Kontizas et al. must all be erroneous. They are just random associations. This problem has some consequences on the cross-identifications with field 42 as well, because it is located very close to field 37. Five cross-identifications were missed because the corresponding [KDM2001] star was already associated to an LMC–BM star of the field 37. In reality, Kontizas et al. and Blanco & McCarthy have 30 stars in common in the field 37.

### 3. Finding charts versus automatic blind match

The case of the Blanco & McCarthy field 37 may be considered as an accident. However, Kontizas et al. find a surprisingly large number of random associations in this field. It does occur that two LMC–BM C stars are separated by less than 1′, and sometimes by less than 30′′. Moreover, for various reasons discussed in both catalogues, both surveys are incomplete, especially the one of Kontizas et al. in the most crowded regions (see their Sect. 5.3 and the field 33 in Table 1). It follows that to find a carbon star in both catalogues separated by less than 1′ does not necessarily mean that they are the same star. From the example of the field 37 we thus expected to find some misidentifications in the other fields.

We have cross-identified the 849 C stars listed in the Blanco & McCarthy catalogue with the Kontizas et al. and the DCMC (Cioni et al. 2000) catalogues, using the finding charts. We have proceeded in the following way. We use the CDS Aladin facility. We first load a *R* image (ESO MAMA

or AAO DSS2) centered on the Blanco & McCarthy coordinates. Then, comparing with their finding chart, we mark the carbon star. Finally, using the CDS VizieR database, we superimpose the Kontizas et al. and DCMC (or 2MASS or GSC2.2) catalogues on the digitized image. As in general these catalogues have good coordinates ( $\sim 1''$  accurate), there is usually no doubt on identifying the star, except in very few cases of double stars. In the latter case, we could always identify the carbon star, by comparing the *I* magnitude in Kontizas et al. and in the DCMC, or because one star was much too blue to be a carbon star ( $J - K_S < 0.5$  mag).

Table 1, available electronically only at CDS, summarizes the cross-identifications between the Blanco & McCarthy and Kontizas et al. catalogues, field by field. In total, out of 849 stars, 69.0% are re-discovered in Kontizas et al., and 99.1% are listed in the DCMC. The list of the cross-identifications for individual stars is given in Table 2, available electronically only at CDS. It gives the LMC–BM, [KDM2001], and DCMC identifications. We found some double entries in the DCMC, which are listed as well. Cross-identifications between the DCMC, 2MASS, and the GSC2.2 catalogues are given in Delmotte et al. (2002).

The distribution of distances between the LMC–BM and DCMC positions is shown in Fig. 1. According to Blanco & McCarthy, the accuracy of both their coordinates is expected to be smaller than 12′′, so that the global error on the position is expected to be smaller than 17′′. In fact more than a quarter of the sources have a distance to the DCMC position larger than 17′′. The tail of the distribution reaches 40′′. To this general distribution one has to add 52 particular cases: (i) the 45 sources of the field 37 are shifted by  $\sim 4.5'$  as seen in Sect. 2; (ii) the 4 sources of the field 49 are shifted by  $\sim 50$ – $55''$ ; (iii) LMC–BM 6–20, 38–10, and 42–32, are found 62, 67, and 48′′ away from the DCMC position, respectively. One thus may say that the Blanco & McCarthy positions are erroneous for 6.1% of their sources. Finally, we suspect that there could be an additional error in one finding chart. LMC–BM 3–3, as drawn on the finding chart, corresponds to DCMC J044614.35-675116.8 = 2MASSI J0446143-675116, with  $I - J \simeq 0.5$  and  $J - K_S \simeq 0.35$  mag. This source seems to be much too blue to be a C star. About 40′′ away, there is a C star, [KDM2001] 457. We thus suspect that [KDM2001] 457 and LMC–BM 3–3 are in fact the same star while Blanco & McCarthy would have indicated the wrong star on the finding chart.

To cross-identify 849 objects by looking at the finding charts is not the most pleasing work one could imagine, nor is it the technique one would first think of to cross-identify catalogues. By default one would first make a digitized version of the old Blanco & McCarthy catalogue, and match it automatically with that of Kontizas et al. To compare with the results derived from the finding charts, we have also matched blindly both catalogues. Without knowing the distribution in Fig. 1, and being a little cautious, one would most likely use a search radius of 30′′. We finally matched both catalogues using two radii, 30′′ and 1′. In case of multiple associations, we strictly keep the closest one, checking on both entire catalogues. The results field by field are listed in Table 1. Compared to the finding chart method, an automatic match

leads to 11 (1.3%) and 20 (2.4%) misidentifications using a radius of  $30''$  and  $1'$ , respectively. Among these misidentifications, only 30% are due to erroneous LMC–BM coordinates, all the others are due to the presence of two close carbon stars. The number of missed cross–identifications amounts to 5.4% using  $30''$ , and 3.3% using  $1'$ . For both search radii the total number of errors is about 6%. This is far from being negligible. Misidentifications are especially problematic for individual sources. It could lead to discover strange variables, and derive incorrect physical parameters. Missed cross–identifications lead to a loss of information on individual sources. Both are problematic for statistical purposes because some sources would disappear, or conversely would be counted twice.

In their Table 3, Kontizas et al. give cross–identifications between their catalogue and that of Blanco & McCarthy. According to their Sect. 5.3, they have matched both catalogues. Their results are summarized in the last 3 columns of Table 1. They find a match for 3 out of 4 LMC–BM sources of the field 49, for LMC–BM 6–20, but not for LMC–BM 38–10 (see above), so most likely they used an association radius of about  $1'$ . However, there are some differences between their results and our match with the same radius. In the field 37, we get only 7 misidentifications, while they list 13. The most likely reason is that, in case of multiple associations, they have kept the closest one field by field rather than on the entire catalogue. Out of the 6 matches that we do not find in the field 37, one source is a little more than  $1'$  away from the [KDM2001] position, and the 5 others have a closer association in the field 42 (see also Sect. 2). The other difference is the larger number of missed cross–identifications in the list of Kontizas et al. than found in our match. According to Morgan (private communication) they are due to human errors when compiling the final Table. In total, the number of misidentifications and missed cross–identifications amounts to 2.7 and 7.9%, respectively, in the Table 3 of Kontizas et al.

Finally, out of curiosity, we have also matched the Blanco & McCarthy and DCMC catalogues, using a search radius of  $30''$ , and taking into account some redundant entries in the DCMC which are correctly seen as the same source. Of course, the density of sources in the DCMC (or in 2MASS) is such that it would not be reasonable to just match both catalogues on the basis of the coordinates only. We have then added some colour criteria. Almost all LMC–BM stars have  $I - J > 1.2$  and  $J - K_S > 0.8$ . The last colour criterion is confirmed by the Fig. 5 of Kontizas et al. Even applying this, a match between both catalogues leads to ... a disaster, with 24.8% of misidentifications, and 2.5% of missed cross–identifications. To use a larger radius would not change much the result because only 23 LMC–BM sources do not have a match within  $30''$ .

#### 4. More errata ...

It is not uncommon to find erroneous or missed cross–identifications, or errors on the listed coordinates, in published catalogues. During the course of more general cross–identifications in the Large Magellanic Cloud, we found

a few errors in various papers, sometimes real errors, sometimes probably misprints.

In the catalogue of M supergiants and suspected giants of Westerlund et al. (1981), the listed coordinates are in general better than  $5''$ , with a tail in the distribution up to about  $20''$ . We however found 5 stars in the list of the M supergiants with erroneous coordinates (i.e. in disagreement by more than  $1'$  with the finding chart location). These sources are: WOH S 66, S 151, S 156, S 199, and S 212. Like in the case of Kontizas et al. with the Blanco & McCarthy field 37, we find that the erroneous coordinates of Westerlund et al. have led to at least one misidentification in the literature. We have checked on finding charts that WOH S 66, SP77 30–6 (Sanduleak & Philip 1977), RM 1–45 (Rebeiro et al. 1983), and DCMC J045421.73–684524.1 are the same star. Remarkably, the coordinates listed by Westerlund et al. for WOH S 66 are in excellent agreement with those of Hughes (1989) for SHV 0454257–684856, alias DCMC J045414.33–684414.2. It follows that WOH S 66 was misidentified with SHV 0454257–684856 in Loup et al. (1997). The IRAS source IRAS 04544–6849, LI–LMC 153 (Schwering & Israel 1990), is more likely associated to the SHV star than to the M supergiant. For sure, the object observed with ISO in Trams et al. (1999) was the Long Period Variable (SHV) star and not WOH S 66.

Old catalogues, though in principle checking carefully the cross–identifications on finding charts, do not all escape the problem. For instance Sanduleak & Philip (1977) have erroneously identified SP77 46–59 with HV 2650, while the SP77 star is actually HV 996. Similarly, SP77 51–7 is HV 5916, while Sanduleak & Philip give HV 591. This latter case is probably a misprint.

The Blanco & McCarthy catalogue has a few mistakes as well. In particular, it associates twice SP77 30–20, once with LMC–BM 9–13, and once with LMC–BM 9–23. A careful check of the finding charts shows that LMC–BM 9–13 is not associated to any SP77 star, that SP77 30–20 is LMC–BM 9–18, and that LMC–BM 9–23 is SP77 30–21. The last case is very likely a misprint. Blanco & McCarthy also forgot some associations. In particular, their fields 16 and 15 (“Bar West”, published earlier by Blanco et al. 1980, acronym BMB) overlap. They provide 15 cross–identifications between both fields. Detailed checks show that they missed three additional cross–identifications: BMB–BW 37 = LMC–BM 16–16, BMB–BW 38 = LMC–BM 16–20, and BMB–BW 54 = LMC–BM 16–26.

#### 5. Conclusions

In practice, depending on the quality of the finding charts and on problems arising, and using modern facilities like Aladin at CDS, it is possible to check 20 to 50 finding charts per day, including lunch and coffee breaks. To use finding charts to cross–identify the DCMC, 2MASS, and GSC2.2 catalogues, each containing a few million stars towards the LMC only, one would need an army of Benedictine monks working day and night over 10 years. It is fortunately not required either because, in general, the three catalogues provide coordinates more accurate than  $1''$ . Thus, a match based on coordinates, plus some

additional validation criteria, allows one to reach an acceptable error rate (Delmotte et al. 2002).

On the other hand, not all astronomical objects have good coordinates yet, especially those discovered in old catalogues. Most of them have been reobserved in modern catalogues, however the observations of these modern catalogues do not necessarily allow to determine the nature of the object. Thus it is important to keep our knowledge, and then to cross-identify properly old and modern catalogues. For instance, many planetary nebulae discovered in the Magellanic Clouds have been detected by 2MASS. But from the 2MASS data, it is impossible to set any selection criteria to find planetary nebulae. Most of them just look like faint blue stars, or overlap with the large population of RGB stars, like millions of others sources. In such a case it is obvious that to cross-identify old catalogues of planetary nebulae with 2MASS must be done with the finding charts. Carbon stars are a better case because they are red objects which are much less numerous than faint blue stars. However, as shown in this Research Note, even this is not so straightforward. Misidentifications in the literature are also a problem for compilation databases such as SIMBAD and NED. Matching procedures are continuously improved, but case by case examination by an expert often remains necessary, as demonstrated in this Note. Among others, the contribution of B. Skiff, in this respect, is specifically acknowledged by the CDS.

To conclude, if one of the catalogues has poor coordinates (accuracy worse than  $5''$ ), if one is not looking at an empty region of the sky, if the objects do not have extraordinary colours or physical properties, and are not shining like the lighthouse of Alexandria, there is no other way to make cross-identifications than to go back to the finding charts. Yes, it is time-consuming.

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