Improved astrometry for the Bohannan & Epps catalogue
(Research Note)

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Submitted 17/8/2012; accepted 5/10/2012

ABSTRACT

Aims. Accurate astrometry is required to reliably cross-match 20th-century catalogues against 21st-century surveys. The present work aims to provide such astrometry for the 625 entries of the Bohannan & Epps (BE74) catalogue of Hα emission-line stars.

Methods. BE74 targets have been individually identified in digital images and, in most cases, unambiguously matched to entries in the UCAC4 astrometric catalogue.

Results. Sub-arcsecond astrometry is now available for almost all BE74 stars. Several identification errors in the literature illustrate the perils of relying solely on positional coincidences using poorer-quality astrometry.

Key words. Astrometry; stars: emission-line; Magellanic Clouds

1. Introduction

Although the use of digital detectors and computer manipulation of images is now ubiquitous, many pioneering surveys were conducted in the days of photographic observations. This is particularly true of the Large Magellanic Cloud (LMC), where precedent ensures that most of the brighter stars are still commonly identified by catalogue numbers from surveys conducted in the photographic era, such as the Henry Draper Extension (Cannon 1936; HDE), the Radcliffe study by Feast et al. (1960; R numbers1), and work by Henize (1956; LHa120-S identifiers for LMC emission-line stars) and by Sanduleak (1970; Sk identifiers).

A difficulty confronting early authors was that the determination of precise equatorial co-ordinates involved time-consuming manual measurements with opto-mechanical plate-measuring machines, and subsequent tedious calculations (as well as requiring a dense, good-quality grid of reference stars). This laborious effort was invariably eschewed in favour of co-ordinates quoted to only ~arcminute precision and, in most cases, provision of supporting finder charts.

In the modern era the identification problem is reversed: in large-scale digital surveys, precise co-ordinates are quickly and routinely obtained, but the task of visually checking many targets against numerous published finding charts is discouragingly burdensome. Cross-identification based solely on co-ordinate coincidences from crude astrometry is not reliable in dense LMC star fields, but has nevertheless proven enticing to a number of authors, as a result, the literature is littered with misidentifications based on approximate positional matches, unverified by checks against original sources.

Heroic efforts by Brian Skiff at Lowell Observatory have greatly improved the situation. His work (unpublished, but incorporated into CDS databases) includes ~arcsecond astrometry for the HDE, Sk, and LHa catalogues, based on careful examination of original sources. There remain, however, two important, extensive surveys of bright Hα emission-line stars in the LMC for which only arcminute astrometry is available: the Lindsay surveys (Lindsay 1963; Andrews & Lindsay 1964) and the Bohannan & Epps study (Bohannan & Epps 1974; BE74).

Lindsay’s papers give co-ordinates to the nearest arcminute, but no finder charts. Plausible identifications of many of the ~800 targets may be possible, based on positional and brightness coincidences, but the absence of finder charts means that secure identifications are now not generally feasible.2 Given the potential for errors, it is the present author’s opinion that the conservative position is to consider Lindsay’s stars lost to science, for the most part.

In contrast, Bohannan & Epps (1974) provided identification charts which should allow secure identification of nearly all their emission-line stars, and hence new astrometry with accuracy and precision suited to cross-identifications in modern large-scale surveys. The purpose of this Note is to report such astrometry.

2. Methods

Bohannan & Epps identified their Hα emission-line stars on images from the Hodge & Wright Atlas (Hodge & Wright 1967). In spite of the small plate scale, this allows subsequent secure identification of nearly all stars in larger-scale digital images. In practice, this identification was normally carried out using CDS’s Aladin tool (Bonnarel et al. 2000) in conjunction with a much magnified pdf copy of Bohannan

1 The CDS uses ‘RMC’ to identify Radcliffe stars.

2 The authors provide cross-identifications with 126 LHa objects; these sources are therefore reliably recoverable (through Henize’s charts and Skiff’s astrometry).
Fig. 1. Left panel: cumulative distribution functions for offsets between interactively measured co-ordinates and adopted UCAC4 positions, for right ascension, declination, and absolute differences. Right panel: cumulative distribution function for offsets between BE74’s positions and the current astrometry.

& Epps (1974) from the NASA Astrophysics Data System. In a number of cases, the original Hodge & Wright Atlas was examined to resolve ambiguities.

Other than for a few bright targets, a semi-transparent window of the DSS2 red image from Aladin was overlaid on the pdf, at matching scales; where necessary, an image rotation was also applied, using the GNU Image Manipulation Program. In general, this allowed a positive identification of the BE74 target with a single object on the DSS2 image, for which a position was recorded interactively, and transferred to a data file by copy-and-paste. (With distance moduli of ~18.5, proper motions are negligible for these sources, so differences in epoch of observation are of no importance in this context.)

Correlating the results against UCAC4 (Zacharias et al. 2012) gave a positive match with a single target within 5′ in most cases, with a small systematic offset: \( \Delta \alpha = +0.011 \), \( \Delta \delta = -0.06 \) (UCAC4–Aladin). This offset is presumed to be due to small errors in matching the DSS2 images to the ICRS reference frame, so the interactively recorded measurements were corrected accordingly. After applying this correction, a second pass was made against UCAC4 with a 2′-radius window to get final positions. The results are listed in the Table 1,3 which is the main data product of this Note. Fig. 1 (left-hand panel) shows that the positional differences between corrected interactive measurements and UCAC4 are Normally distributed, and are less than one arc-second in the great majority of cases.

3 Tables 1–3 are available on-line at the CDS.

Of course, in addition to ambiguities and possible errors in the original materials, there is certainly also the potential for misidentifications and mismeasurements in the present work. Cross-checking the adopted positions against BE74’s co-ordinates initially disclosed six faulty results requiring correction in the former (all believed to be due to failures to ‘copy’ a correct position before ‘pasting’), suggesting a residual error rate from this source of better than 1%.

Agreement between the finally adopted positions and BE74’s original co-ordinates is generally satisfactory, with matches to within 1–2′ (Fig. 1, right-hand panel), although some discrepancies remain (cf. Table 2). The current co-ordinates have also been cross-matched to Skiff’s astrometry for HDE, Sk, and LH120-S sources, within a 5′ radius around the interactively recorded positions (Table 3, on-line). Where matches are found, the positional differences are almost all sub-arcsecond (essentially, the differences between UCAC2 and UCAC4 results), giving confidence in the assigned correspondences. In the few cases where larger offsets occured, DSS2 imagery was re-examined; invariably, the differences were found to arise because the BE74 object is not a single point source.

Finally, it is perhaps worth concluding with an explicit comment that, while the positions reported here are precise, they may not necessarily always be accurate, for the reasons just set out. At the least, for critical cases the results in Table 1 should be considered in conjunction with the notes on individual sources given in Table 2.

Acknowledgements. I am grateful to Brian Skiff for correspondence; Jean Guibert for useful suggestions; and the BBC for its broadcast coverage of the 2012 Olympics, which facilitated the measurements reported here. The work relied on tools provided by the GNU/Linux open-source community, NASA’s Astrophysics Data System and, particularly, the CDS, Strasbourg; without these resources, this study would not have been possible.

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Table 2. Notes on individual objects. ‘BE74’ refers to Bohannan & Epps (1974); ‘HW’ to charts from the Hodge & Wright Atlas (Hodge & Wright 1967); ‘RPs’ to emission-line stars catalogued by Reid & Parker (2012; RP12); and ‘DSS2’ to the red Digital Sky Survey images accessed through Aladin. ‘A’, ‘B’ etc. refers to separate entries in Table 1.

| BE74 | Notes |
|------|-------|
| 27   | N 120-S70 (cluster). |
| 37   | Identification uncertain. The object marked by BE74 is the northerly of two stars visible on DSS2; the companion is 6° distant, SSE. A brighter DSS2 star (not visible on the HW B chart, but clear on the V chart) is ∼35° E. |
| 44   | Identification uncertain; BE74 co-ords and finder-chart object differ by 2.6′. HDE 269504 (Sk −67 100; B0 Ia according to Fitzpatrick & Bohannan 1993) is the brightest object at the published co-ords. |
| 51   | BE74 mark a triple object on the HW atlas |
| 54   | Assumed to be the brighter ‘A’ (N) component of a pair on DSS2 (unresolved in the HW atlas). |
| 62   | Elongated (multiple?) image on DSS2. |
| 64   | Assumed to be the middle (brightest) of three DSS2 stars. |
| 65   | Assumed to be the brightest (S) of three DSS2 objects. |
| 72   | SW component of multiple object (as per BE74 notes). |
| 74   | Wrongly identified with RPs1077 by RP12 (correct match is BE74 75/RPs1077). |
| 80   | MFW2006 C11 (cluster; Martayan et al. 2006). |
| 84   | Brighter (E) component of double on DSS2. |
| 109  | Recorded as 2 separate objects in UCAC4; barely resolved in DSS2. |
| 127  | ‘A’ is the brighter (W) component of a pair on DSS2 (unresolved in HW atlas). |
| 129  | BSDL 2450 (cluster; Bica et al. 1999). |
| 139  | Identification uncertain; BE74 finder chart and co-ords differ by 8.5′. BE74’s quoted co-ords are in RA sequence (as is usual), but the marked object is out of RA order, and is therefore suspect. The nearest moderately bright star to the published co-ords is UCAC4 116-009443. |
| 143  | Assumed to be brighter W component of pair on DSS2 (unresolved in HW atlas; companion 2′ E). |
| 159  | BE74 identify 159 with the Wolf-Rayet star WS4=BAT99-8 (Westerlund & Smith 1964; Breysacher et al. 1999), but this is not the star marked on the BE74 finder chart (Fehrenbach et al. 1976), which does, however, match LH120-570. |
| 162  | Wrongly identified with RPs1757 by RP12 (RPs1757 is much fainter). |
| 187  | Elongated with RPs1757 by RP12 (RPs1757 is much fainter). |
| 191  | BE74 co-ords wrongly duplicate the entry for BE74 224 (7′ to the south). |
| 199  | Typographical error in RP12; correct match is BE74 277/RPs2160, not BE74 227/RPs2160. |
| 223  | Brighter SW component of double on DSS2. |
| 227  | BE74 finder-chart object is 4′ N of BE74 co-ords. |
| 238  | Elongated (multiple?) image on DSS2. |
| 242  | Wrongly identified with RPs1374 by RP12 (correct match is BE74 242/RPs1373). |
| 246  | Unresolved double in the HW atlas. |
| 250  | Southern object of pair is brighter on DSS2, and matches RPs988 (BE74: “Impossible to tell from which emission arises”). |
| 252  | ID uncertain on BE74 atlas. |
| 260  | Object marked on BE74 finder chart is 5′ N of BE74 co-ords. |
| 268  | ID uncertain on BE74 atlas. |
| 269  | HDE 269828 (cluster). |
| 282  | Not marked on BE74 charts; several possible candidates. |
| 300  | Close double, emission-line (WR) star is W component (Sk −69 223, BAT99-85; Prevot-Burnichon et al. 1981). |
| 306  | Object marked on BE74 chart is 5′ S of BE74. Possible misidentification as Skiff HII120-S134 (Sk −59 117; B0 III according to Fitzpatrick & Bohannan 1993). |
| 322  | MFW2006 C11 (cluster; Kontizas et al. 1998). |
| 326  | Wrongly identified with RPs296 by RP12 (cf. their Fig. 4; RPs296 is much fainter). |
| 332  | Not marked on BE74 charts; several possible candidates. |
| 336  | Not marked on BE74 charts; two plausible possibilities measured (439α is HW 2774). |
| 341  | Elongated (multiple?) image on DSS2. |
| 346  | Wrongly identified with RPs927 by RP12 (RPs927 is much fainter). |
| 348  | Identified with RPs1077 by RP12, but this is a different object to that marked by BE74 (16′ distant). However, RPs1077 is only ∼0.5m fainter than BE74 565; possible misidentification on BE74 chart? |
| 352  | Brighter (brighter) ‘A’ component has elongated (multiple?) image on DSS2. ‘B’ component matches Skiff LH120-S410 astrometry. |
| 354  | Missed identified as BE75 in Simbad at the time of writing. |
| 357  | Identified with RPs870 by RP12, but this is a different object to that marked by BE74 (12′ distant). However, the object marked by BE74 is very faint on DSS2, while RPs870 is almost invisible on HW; possible misidentification on BE74 chart? |
| 360  | ‘A’ component is the only one of three DSS2 objects visible in the BE74 chart; ‘B’ component matches Skiff LH120-S104 astrometry. |
| 364  | Wrongly identified with both RPs873 and RPs874 by RP12 (both RPs objects are much fainter). |
| 368  | Identified with RPs886 by RP12; this is 1.3′ S of the marked BE74 position, but the BE74 object is very faint on DSS2. Possible misidentification on BE74 chart? |
| 370  | Two objects are marked as ’587’ on BE74 chart; N object is actually BE74 582. |
| 374  | Wrongly identified with RPs443 by RP12 (correct match is BE74 596/RPs443). |
| 376  | Nova Mensae 1970b. Co-ordinates reported in Table 1 refer to the finder-chart object marked by BE74, but this is not the nova. |

Ian D. Howarth: Astrometry for BE74 (RN)