The Southern Double Stars of James Dunlop I: History and Description of the First Published Catalogue Dedicated to Southern Double Stars

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Abstract: The first dedicated catalogue of southern double stars was published in 1829 by James Dunlop. Basing our work solely on the published data, we describe this catalogue, give a biography of Dunlop and a history of the catalogue and look at the data presented. Of the 253 doubles presented, Dunlop himself described one as single and 14 as triples. The smallest separation claimed was ~2 arcsec and limiting magnitudes were ~7 and ~8.5 for each of the two telescopes used. All observations were across the sky and approximately south of the Tropic of Capricorn.

1. Introduction

The Dunlop papers follow three papers (Rümker Papers I, II, and III) previously published in this journal on the double star work of another of the Parramatta astronomers, Carl Rümker (Letchford, White, and Ernest 2017; Letchford, White, and Ernest 2018a; Letchford, White, and Ernest 2018b).

In this Paper we look at the history and description of the first double star catalogue dedicated to the southern sky, namely that of James Dunlop published in 1829 (Dunlop 1829b).

The finding, cataloguing, and astrometric study of double stars dominated the astronomy of the 19th century. In the southern sky, the pioneering double stars work of Sir John Herschel (JH) between 1834 and 1838 is recognized for its accuracy and completeness.

However, some two decades prior to the work of JH, a small but well equipped privately owned observatory was established in the fledgling British Colony of New South Wales (now the State of New South Wales within the Australian Commonwealth) by Sir Thomas Makdougall Brisbane, the 6th Governor of the Colony. For about a decade, the Parramatta Observatory reigned supreme in the southern hemisphere, systematically exploring the deep southern skies for the first time.

The Parramatta Observatory was constructed by Sir Thomas Brisbane (1773-1860), and staffed by two astronomers; Carl Rümker (1788-1862) and James Dunlop (1793-1848). From Parramatta Observatory came dedicated catalogues of stars (Richardson 1835), double stars (Rümker 1832; Dunlop 1829a) and non-stellar objects (Dunlop 1828), as well as numerous other papers on diverse subjects.

2. Brief Biography of James Dunlop

James Dunlop (1793-1848) was born 1793, October 31, to John, a weaver, and Janet née Boyle in Dalry, Ayrshire, Scotland, a small poor rural community (Figure 1). Fourth of seven children, at the age of 14 he started work at a nearby textile factory in Beith owned and operated by a cousin. He resided with an uncle, and at the same time attended night-school. Despite very little formal education, by the time he was 17 he had built his own reflecting telescope. At the age of 22 he married his cousin Jean Service on 1816 June 25. There were no children.

Through mutual acquaintances, while living near Beith, James got to know Sir Thomas Brisbane from Largs, in the same county. This meeting was fortuitous and life-changing for both James and Jean. Brisbane was an aristocrat, educated in astronomy and mathe-

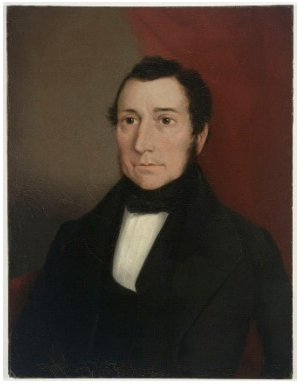


Figure 1: James Dunlop, from Wikipedia (by Joseph Blackler, c. 1843). Held by the Mitchell Library, State Library of New South Wales.

matics at the University of Edinburgh. He had a distinguished career in the Army serving in numerous campaigns under the Duke of Wellington.

In 1821, the year after Dunlop and Brisbane met, Brisbane was appointed Governor of the penal colony of New South Wales on the recommendation of the Duke of Wellington. The southern sky, at least that south of -30 degrees declination, was virtually unexplored and Brisbane decided to set up his own private observatory in the grounds of Government House, Parramatta, about 26 km west of Sydney. Because he knew his official duties would not leave him much time for astronomy, he chose the well-known astronomer Carl Rümker to run the Parramatta Observatory and James Dunlop to maintain the instruments.

James was charged with packing Brisbane's instruments at his Observatory at Largs, and he and his wife travelled with the Brisbane family and Rümker out to Sydney, arriving 1821 November 7. The Parramatta Observatory was completed, and observations commenced 1822 May 2 (Letchford, White, and Ernest 2017). Dunlop learnt the art of astronomical observation from Rümker and Brisbane. Exactly one month after the opening, Dunlop was the first person in the world to sight the return of Enke's comet (Rümker having previously calculated its return position).

The main goal of Brisbane was to publish a catalogue of stars in the southern sky. Rümker and Dunlop set about doing this, with occasional help, as time permitted, from the Governor. This was finally published in 1835 as A Catalogue of 7385 Stars: Chiefly in the Southern Hemisphere, Prepared from Observations Made in the Years 1822, 1823, 1824, 1825, and 1826, at the Observatory at Paramatta, New South Wales, Founded by Lieutenant General Sir Thomas Makdougall Brisbane (Richardson 1835, but known as the "Brisbane Catalogue"). The reductions were completed by William Richardson of Greenwich Observatory.

For reasons which are not entirely clear, Rümker fell out with Brisbane and left the Observatory on 1823 June 16, leaving Dunlop with the bulk of the work. Brisbane and Dunlop became close friends and the Governor rewarded him with a grant of 5,000 acres of land near Gosford, NSW, known as Borra Borra†.

Brisbane was re-called by the British Government and vacated his Governorship on 1825 December 1, to be replaced by Ralph Darling. Because the Observatory was on Government land, Dunlop moved his observing to a small cottage in Parramatta, returning to the Observatory in 1826 March.

Dunlop returned to Scotland in 1827 February 4. The Parramatta Observatory moved into Government hands and Rümker returned to work at the observatory, and on 1827 December 21 Rümker was appointed as Government Astronomer.

Dunlop moved to Brisbane's estate at Makerstoun in the council area of The Scottish Borders, which Brisbane had inherited by marriage to his wife, Anna. Brisbane had built an observatory at Makerstoun. Dunlop continued to work with Brisbane, publishing numerous papers. On 1827 December 20 his paper A Catalogue of Nebulae and Clusters of Stars in the Southern Hemisphere, Observed at Paramatta in New South Wales (Dunlop 1828; Cozens, Walsh, and Orchiston 2010) was read before the Royal Astronomical Society (RAS) by no less a person than John F. W. Herschel. For this major work, Dunlop was awarded the Gold Medal of the RAS on 1828 February 8.

On 1828 May 9 Dunlop's paper Approximate Places of Double Stars in the Southern Hemisphere, observed at Paramatta in New South Wales was read to the RAS and published the following year (Dunlop 1829a). Approximate Places is the subject of this paper. An image of the first nine entries in the Catalogue is presented in Figure 2.

Meanwhile, Rümker was dismissed from his position on 1830 June 18. Dunlop was offered and accepted the position of Superintendent of Parramatta Observatory, and returned there as the sole astronomer. A residence attached to the Observatory was built for him and Jean in 1832.

The state of the Observatory was poor, as is illustrated by this report by Dunlop himself: "Sunday morning between 8 and 9 o'clock, about four or five yards of ceiling fell and broke the table. No other damage." A simple entry in his notebook for 1835 March 17.

Between 1838 and 1847, while still in Government employment, Dunlop failed to submit any reports. According to a letter written by his wife 1837 July 20,

† *see http://www.environment.nsw.gov.au/heritageapp/ViewHeritageItemDetails.aspx?ID=1620196.*

Dunlop had contracted dysentery two years previously and had only recently become infected with tetanus.

A Commission of Enquiry called and asked to see Dunlop's records. Much of it had been literally white anted, including the Observatory itself. The recommendation of the Commission was that the Observatory be closed and the instruments and remaining library packed up by Dunlop and put into storage.

James and Jean retired to Borra Borra in 1847 August and he died on 1848 September 22 aged 44. His body is buried in the churchyard of St Paul's Anglican Church, Kincumber NSW.

Dunlop was awarded numerous accolades. Apart from the Gold Medal of the RAS, he was elected Fellow of the Royal Society in about 1830. He was awarded medals for his work by the King of Denmark in 1833, and the Institut Royal de France in 1835, and elected Fellow of the Royal Society of Edinburgh in 1832, his proposer being Sir Thomas Makdougall Brisbane.

The Catalogue of Scientific Papers, a 19th and early 20th century catalogue of all published scientific papers (Csiszar 2017), listed 9 papers authored by Dunlop; one co-authored with Brisbane, and one with T. Henderson (White and Morley 1868). The main biographies of James Dunlop, from which the above was taken, are those of: John Service (1890), Harley Wood (1966), Elizabeth Brenchley (1980), Cozens & White (2001), and Sharon Rutledge (2009).

3. History of Dunlop's Published Catalogue

Dunlop's double star observations were made from the later part of 1825 until his departure to Scotland on 1827 February 4. Their reduction took place while he was at Makerstoun.

3.1 Telescopes and clocks used and their location

For his double star work, Dunlop used two telescopes: a 46 inch focal length, 3¼ inch achromatic refractor equatorially mounted, made by Banks of London, and housed in the southern dome of the Observatory; and a 9 foot focal length, 9 inch speculum Newtonian reflector made by Dunlop himself which he used at his home in Parramatta. With the Observatory telescope he had the use of filar micrometers which he himself had made, but with his own telescope the positions and distances were "only estimations while passing through the field". Observations with the speculum 9 inch were made at the cottage in Parramatta "about 2s of time east of the Brisbane observatory" (Dunlop 1829a).

The double stars marked with an asterisk in the Catalogue are those measured with the Banks telescope, those without were made with the Dunlop telescope. We continue this nomenclature in the present paper.

123 pairs were "discovered" using the 3¼ inch refractor and 120 were discovered with the 9 inch reflector.

There were two main clocks in the Observatory for right ascension: a sidereal clock by Hardy of England near the 3¼ inch in the southern dome and a mean time clock by Breguet in the north dome. For his double star work, which Dunlop largely did alone, he used the nearby sidereal clock. The clock he used at home in Parramatta along with his 9 inch, is unknown. It is possible, even likely, that he borrowed one of two other Observatory clocks, one by Barraud and another by Grimaldi†. For a description of the Observatory, see Rumker Paper I (Letchford, White, and Ernest 2017).

3.2 Contemporary Reactions

John Herschel was, at first, effusive in his praise of the work:

"Mr Dunlop has amassed a copious and valuable collection of Southern Double Stars which he is at present occupied in reducing and arranging; and a variety of interesting and curious particulars relative to the magnitudes, colours, and other peculiarities, of all the more conspicuous single ones." (Herschel 1828).

However, after his own observations at the Cape, he wrote:

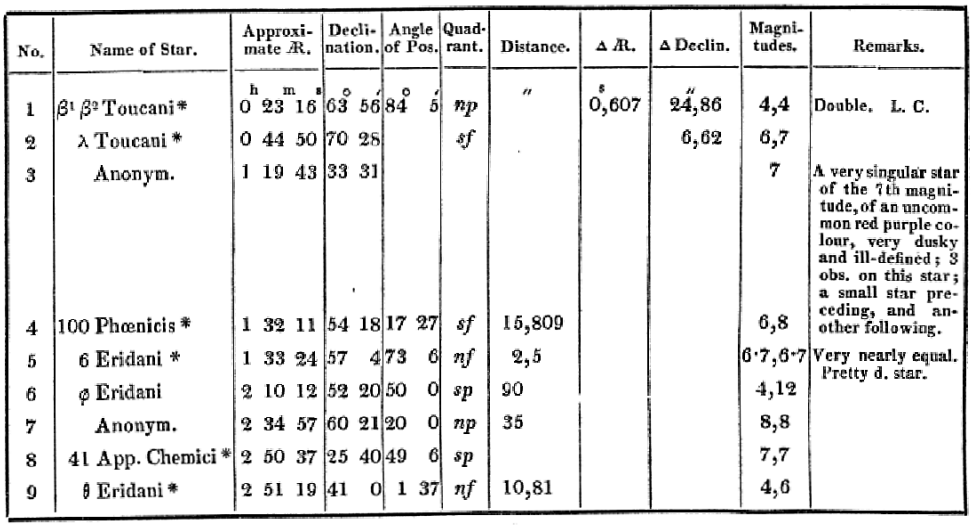
"[I]n comparing my observations with [Dunlop's Catalogue] I have found a star to be double in a different sense from that which caused it to be registered as double therein, - or when, with agreeing places, I have met with such discordances in the descriptions or measures, that it is impossible to suppose the same star to be intended by both observers, - a number has been affixed. … A great many mistakes appear to have been committed in the Catalogue alluded to either in the places, descriptions, or measures of the objects set down in it." (Herschel 1847)

To be fair to Dunlop, Herschel had far superior equipment, was better trained and had more money, to say nothing of his family heritage in astronomy. Also, Dunlop, by his own admission, stated that his double star work was not a high priority. In fact he only observed double stars deliberately during less than ideal weather and in the presence of moonlight:

"The nebulae being a primary object to me, I devoted the whole of the favourable weather in the absence of the moon to that department, and moonlight, in general, was allotted to the observations of double stars" (Dunlop 1829a).

In passing, we also note that Dunlop's A Catalogue of Nebulae and Clusters of Stars in the Southern Hemisphere, Observed at Paramatta in New South Wales (Dunlop 1828) also suffered considerable, and similar,

† *http://www.austehc.unimelb.edu.au/fam/1545.html*



No.	Name of Star.	Approximate R.	Declination.	Angle of Pos.	Quadrant.	Distance.	Δ R.	Δ Declin.	Magnitudes.	Remarks.
		h m s	° ′	° ′		″	s	″		
1	β^1 β^2 Toucani *	0 23 16	63 56	84 5	*np*		0,607	24,86	4,4	Double. L. C.
2	λ Toucani *	0 44 50	70 28		*sf*			6,62	6,7	
3	Anonym.	1 19 43	33 31						7	A very singular star of the 7th magnitude, of an uncommon red purple colour, very dusky and ill-defined; 3 obs. on this star; a small star preceding, and another following.
4	100 Phœnicis *	1 32 11	54 18	17 27	*sf*	15,809			6,8	
5	6 Eridani *	1 33 24	57 4	73 6	*nf*	2,5			6·7,6·7	Very nearly equal. Pretty d. star.
6	φ Eridani	2 10 12	52 20	50 0	*sp*	90			4,12	
7	Anonym.	2 34 57	60 21	20 0	*np*	35			8,8	
8	41 App. Chemici *	2 50 37	25 40	49 6	*sp*				7,7	
9	ϑ Eridani *	2 51 19	41 0	1 37	*nf*	10,81			4,6	

Figure 2. Image of the first nine entries in Dunlop's Approximate Places (Double Star Catalogue). An explanation of the meaning of each column is given in Table 2.

criticism from John Herschel after Herschel's detailed examination of the southern skies from the Cape. Discussion of the validity of the criticism of the non-stellar catalogue is covered in Cozens et al. (2010).

4. Description of the Published Catalogue

Dunlop's Approximate Places of Double Stars in the Southern Hemisphere, observed at Paramatta in New South Wales of 1829 presents the positions, and double-star data for 253 pairs mostly south of declination -27 degrees. An image of the first nine entries is given in Figure 2.

Although extensive observational notes made by Dunlop do exist, we have chosen to describe only the data as presented by Dunlop himself for publication. To the best of our knowledge, a dedicated description of the catalogue has never been published. As the first published dedicated catalogue of southern double stars, it deserves wider acknowledgement.

4.1 Equinox of Catalogue and Epochs of Observations

Like Rümker, Dunlop did not publish the equinox or the epoch of any measures in his catalogue. It is impossible to be conclusive without recourse to an extensive inspection of the unpublished notes, but there are two possibilities; either the positions and measures given are equinox of epoch (date) or there is a catalogue equinox.

We do know that Dunlop had a large hand in observing and recording data for the Brisbane Catalogue, A Catalogue of 7385 Stars, published in 1835. Although the reductions for that catalogue were completed by William Richardson of Greenwich Observatory, it would be odd for Richardson to choose, as he did, the Equinox of the Catalogue as B1825.0, some 10 years prior to its publication, unless the data was presented to him with that equinox or at least with that equinox in mind.

We therefore suspect that, if there is indeed a catalogue Equinox for Dunlop's double star catalogue, it is B1825.0.

4.2. Column Headings

Dunlop published data on 253 doubles using 11 columns (see Figure 2). Columns 1-4 are complete (except for a missing declination for DUN 50); columns 5-11 frequently contain incomplete or missing information. Column descriptions are in Table 1.

4.3 Names of the doubles (Column 2)

Table 2 presents statistics on the names (Column 2) Dunlop gave to his doubles.

Table 2: Statistics on the number of different designation types

Name	3 ¼ inch	9 inch
Anonym.	32	89
Bayer-type (e.g. λ Toucani)	41	22
Flamsteed-type (e.g. 100 Phoenicis)	48	21

Table 1: Descriptions of Column Headings in Dunlop's Published Catalogue (see also Figure 2).

Column	Heading	Information
1	No.	General number (1 to 253)
2	Name of Star.	Number or character of the star in Bode's Catalogue with or without an asterisk (*). See section 4.3 for more on Bode's Catalogue.
3	Approximate AR.	Approximate Right Ascension (RA), in hours, minutes, seconds
4	Declination.	Approximate Declination (DE), in degrees, minutes
5	Angle of Posn.	Angle formed by sweeping from the small circle parallel to the equator running through the primary to the an arc of a great circle from the primary to the secondary, in degrees and minutes.
6	Quadrant.	Quadrant of the secondary with respect to the primary. "nf" north following = Quadrant I; "sf" south following = Quadrant II; "sp" south preceding = Quadrant III; "np" north preceding = Quadrant IV; "n" north; "s" south; "e" east; "w" west. For DUN 108, 194 and 211, two quadrants are given since they are triple stars. For our purposes, we chose only the first quadrant given in each case.
7	Distance.	Observed or estimated separation, in arcseconds (")
8	Δ AR.	Observed or estimated difference in RA, in seconds of time
9	Δ Declin.	Observed or estimated difference in DE, in arcseconds (")
10	Magnitudes.	Estimated magnitudes of the stars
11	Remarks.	Dunlop's own comments on selected doubles

For the Bayer-type (Greek letter + Latin name) and the Flamsteed-type (Number + Latin name) designations, Dunlop claimed to have obtained these from "Bode's Catalogue". Johann Elert Bode (1747-1826), a German astronomer, published two editions of his Vorstellung der Gestirne "Catalogue of the Stars"; one in 1782 and a revised and enlarged edition in 1805 (Bode 1782; Bode 1805). Dunlop did not specify which edition he was using, but it was likely the second edition, as it contains stars observed by Nicholas-Louis de Lacaille (1713-1762), a French Catholic permanent Deacon, which Dunlop sometimes noted in his "Remarks" (Column 11).

4.4 Distribution in the Southern Sky (Columns 3 & 4)

Figure 2 shows the distribution of the Dunlop doubles in the Southern sky. Observations cover all Right Ascensions (Column 3), and are south of declination ~-23o (Declinations in Column 4). In keeping with Dun-

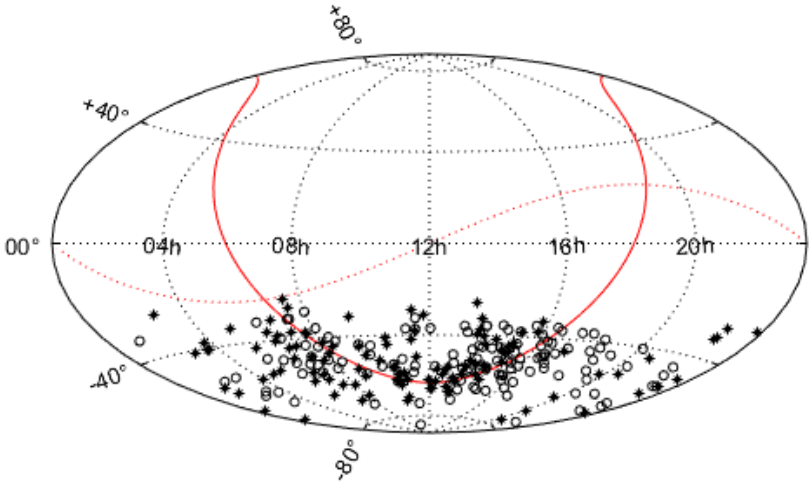


Figure 2. Hammer-Aitoff projection of the whole sky. The symbol '' represents the position of primaries observed with the 3¼ inch refractor, 'o' those observed with the 9 inch reflector at Equinox of Epoch 1825.0. The red dotted line is the ecliptic and the red solid line is the galactic plane.*

Table 3: Ways of calculating Position Angles from Dunlop's Catalogue.

Method	Columns used (see Table 1)	3 ¼ inch (out of possible 110)	9 inch (out of possible 85)	Example (DUN 18*)
1	5, 6	96	81	~ 59.9°
2	4, 6, 8, 9	62	7	~ 56.6°
3	4, 6, 7, 8	21	1	~ 53.5°
4	4, 6, 7, 9	34	1	~ 58.0°
			Mean	~57.0°

lop's own notation, pairs observed with the 31/4-inch refractor are shown as '*' and those observed with the 9-inch reflector are shown as 'o'.

4.5 Position Angles and Quadrants (Columns 5, 6, 7, 8, 9)

Position angles (PAs) in the modern form (measured from N through E, 0° to 360°) were not explicitly recorded by Dunlop. Rather he recorded information such that a modern position angle could be determined in up to four different ways, depending on the information presented for each double. These ways are summarized in Table 3 which should be read in conjunction with Dunlop's Catalogue (Dunlop 1829a). In the following section (section 4.5.1) we explain each method.

PAs were able to be calculated in at least one way for 110 (out of the 121 pairs) for the 3 ¼ inch; and 85 (out of the 132 pairs) for the 9 inch.

4.5.1 How to determine Position Angles from Dunlop's Catalogue

DUN 18* has information recorded in all relevant columns (5, 6, 7, 8, 9) and so we use it as an example. Please refer to Table 1, section 4.2 for explanation of terms.

4.5.1.1 PA Method 1

For DUN 18*, Angle of Posn. = 30° 4', and Quadrant = nf. Therefore:

PA = 90 - 30° 4' ≈ 59.9°.

4.5.1.2 PA Method 2

For DUN 18*, Declination = -53° 46', Quadrant = nf, Δ AR. = 1.137s, and Δ Declin. = 6.659". Therefore:

ΔRA" = 15*cos(-53° 46')*1.137 ≈ 10.08"

Angle of Posn = atan(Δ Declin./ΔRA").180/π ≈ 33.45°.

PA = 90 – 33.45 ≈ 56.6°.

4.5.1.3 PA Method 3

For DUN 18*, Declination = -53° 46', Quadrant = nf, Distance = 12.547", and Δ AR. = 1.137s. Therefore:

ΔRA" = 15*cos(-53° 46')*1.137 ≈ 10.08"

Angle of Posn. = acos(ΔRA"/Distance).180/ π ≈ 36.55°

PA = 90 – 36.55 ≈ 53.5°.

4.5.1.3 PA Method 4

For DUN 18*, Declination = -53° 46', Quadrant = nf, Distance = 12.547", and Δ Declin. = 6.659". Therefore:

ΔRA" = 15*cos(-53° 46')*1.137 ≈ 10.08"

Angle of Posn. = asin(Δ Declin/Distance).180/ π ≈ 32.05°

PA = 90 – 32.05 ≈ 58.0°.

4.5.2 Dunlop's Mean Position Angles

Histograms of Dunlop's mean PAs are given in Figures 3 and 4. In each case the PA represented is the average of the possible PA's for each pair. For example, from Table 3, the Dunlop PA for DUN 18∗ is ~57.0°. As expected, the PAs for both telescopes cover the domain 0° < PA < 360°, though we note from Figure 4 a decrease in the number of PAs as the value of the PA

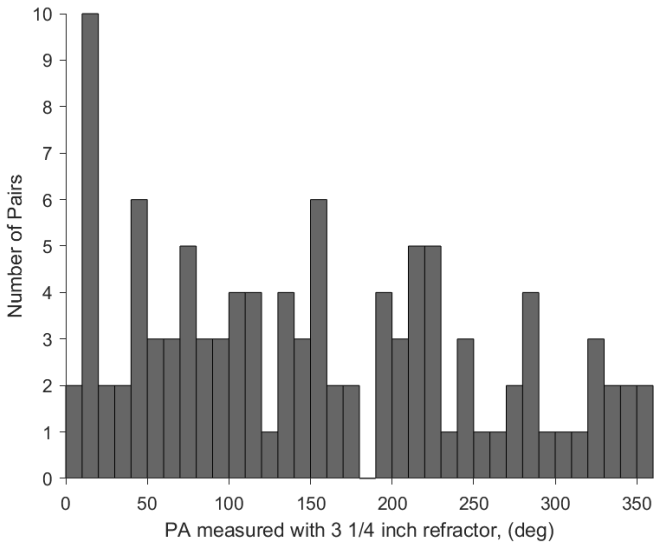


Figure 4: PA measured with the 3 ¼ inch refractor. PAs were calculated using the mean result for each pair taken from the available methods in Table 3.

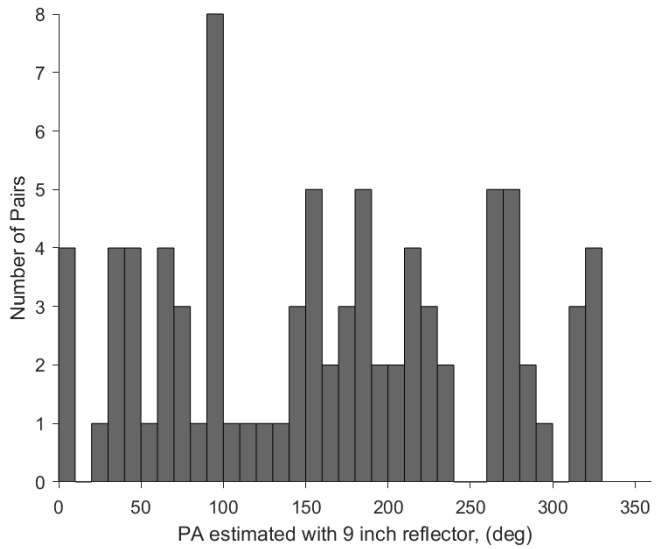


Figure 4. PA measured with the 9 inch reflector. PAs were calculated using the average result for each pair taken from the available methods in Table 3.

increases, for the 3 ¼ inch refractor; and, we suggest, a possible quadrant ambiguity in some values of PA between 10°-20° and 180°-190°.

4.6 Separation and Telescope Resolution (Columns 5, 7, 8, 9)

Separations (Seps) in the modern form (measured in arcseconds) were recorded in column 7 "Distance". However, not all separations were recorded this way. Like the PAs, separation information can be extracted by a combination of other columns. These ways are summarized in Table 4 which should be read in conjunction with Dunlop's Catalogue (Dunlop 1829a). In the following section (section 4.6.1) we explain each method.

Column 7 "Distance" of DUN 17*, 181, 183*, 215 contain two distances separated by an "and"; DUN 141* by an "or". In each case (except for 141*), three stars are involved. For the histograms in Figures 5 and 6, we have used the larger of the two distances to calculate the mean separations of doubles.

4.6.1 How to determine Position Angles from Dunlop's Catalogue

DUN 18* has information recorded in all relevant columns (5, 6, 7, 8, 9) and so we use it as an example. Please refer to Table 1, section 4.2 for explanation of terms.

4.6.1.1 Separation Method 1

For DUN 18*, Distance = 12.547". Therefore:
Sep = 12.547".

4.6.1.2 Separation Method 2

For DUN 18*, Declination = -53° 46', Δ AR. = 1.137s, and Δ Declin. = 6.659". Therefore:
ΔRA" = 15*cos(-53° 46')*1.137 ≈ 10.08"
Sep = √(ΔRA"^2 + Δ Declin.^2) ≈ 12.1"

4.6.1.3 Separation Method 3

For DUN 18*, Declination = -53° 46', Angle of Posn. = 30° 4', and Δ AR. = 1.137s. Therefore:
ΔRA" = 15*cos(-53° 46')*1.137 ≈ 10.08"
Sep = ΔRA"/cos(Angle of Posn.) ≈ 11.6"

4.6.1.3 Separation Method 4

For DUN 18*, Angle of Posn. = 30° 4', and Δ Declin. = 6.659". Therefore:
Sep = Δ Declin./sin(Angle of Posn.) ≈ 13.3"

The smallest separation published by Dunlop was 2 arcsec (DUN 24, 33, 50, 84*, 132*, 170 and 173) for both telescopes. For comparison, the largest mean separations were DUN 125* at ~ 440.0" for the 3 ¼ inch and DUN 72 at ~136.6" for the 9 inch. The theoretical resolution for two stars of equal brightness is 1.4" and 0.5" for a modern $3^1/_4$ inch refractor and the 9 inch reflector respectively.

(Text continues on page 358)

Table 4: Ways of calculating Separations (Seps) from Dunlop's Catalogue.

Method	Columns used (see Table 1)	3 ¼ inch (# possible Seps)	9 inch (# possible Seps)	Example (DUN 18*)
1	7	60	77	= 12.547"
2	4, 8, 9	66	9	~12.1"
3	4, 5, 8	54	4	~11.6"
4	5, 9	69	5	~13.3"
			Mean	~12.4"

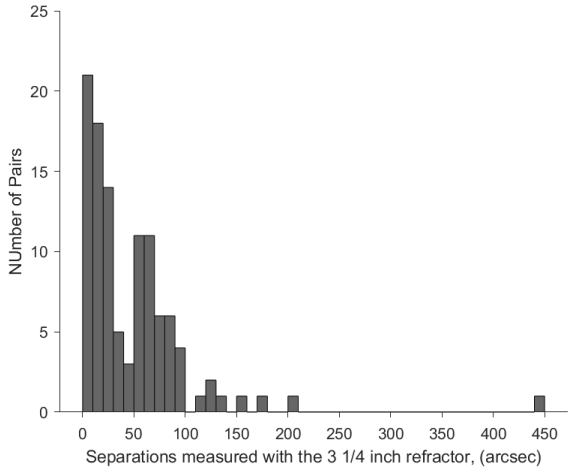


Figure 5. Mean separation measured with the 3 1/4 inch refractor. The smallest separation is ~2.0", the largest ~440.0". Median Separation is ~32".

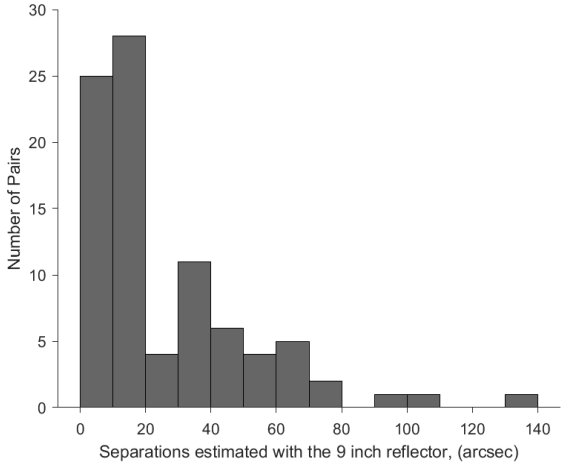


Figure 6. Mean Separation measured with the 9 inch reflector. The smallest Separation is ~2.0", the largest ~136.6". Median Separation is ~14".

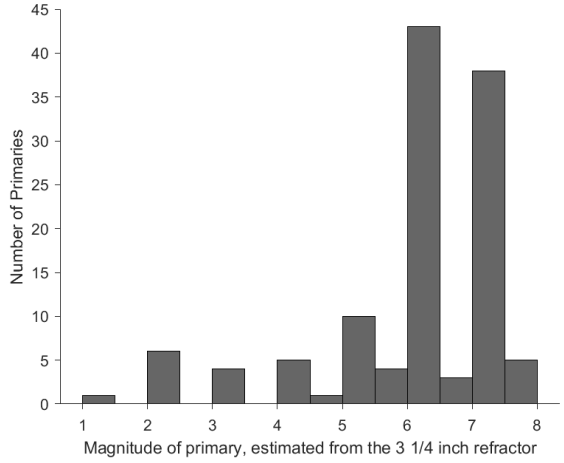


Figure 7. Estimates of magnitudes of primaries through the 3 1/4 inch refractor.

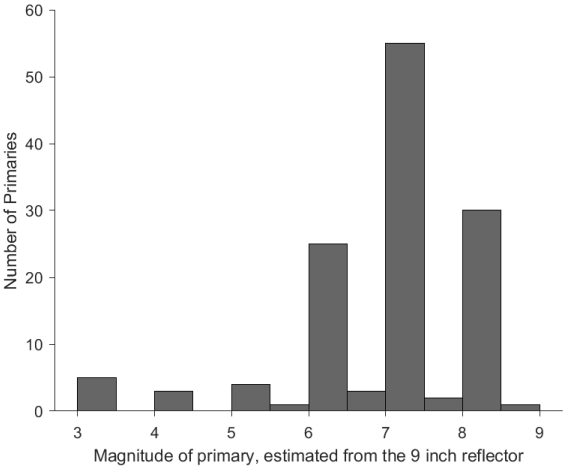


Figure 8. Estimates of magnitudes of secondaries through the 3 1/4 inch refractor.

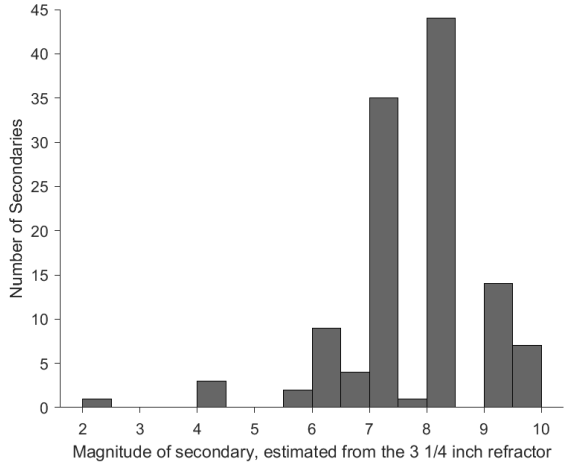


Figure 9. Estimates of magnitudes of primaries through the 9 inch reflector.

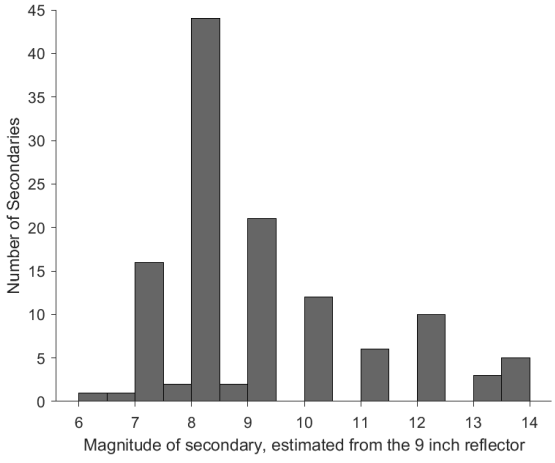


Figure 10. Estimates of magnitudes of secondaries through the 9 inch reflector.

(Continued from page 356)

4.7 Magnitudes (Column 10)

Column 10 contains magnitude estimates for up to three stars. Magnitude statistics are summarized in Table 5. Histograms for primary and secondary magnitudes estimated through the 3 ¼ inch and 9 inch are presented in Figures 7 - 10.

The faintest primary star catalogued with the 3¼ inch was (reported to be) magnitude 10 (on Dunlop's estimation) and the faintest secondary reported with the 9 inch was magnitude 14.

These magnitudes are, in the opinion of the authors, too faint for the period 3¼ inch refractor and the home-made 9 inch speculum. There is debate, especially amongst amateur astronomers, about the magnitude limit that modern telescopes can reach, and this has been studied by many (e.g. Schaefer, 1990). An experienced young observer using a modern 80 mm refractor and 230 mm reflector at 100 magnifications may 'see' magnitude 13.5 and 15.1 respectively. However, measuring the position of a faint star is a very different thing to 'glimpsing' it in the eyepiece. These modern seeing limits are very much overestimated and the instruments at Parramatta observatory were not "modern", and the reflector contained a speculum metal mirror, the reflectance of which was perhaps 70% at best. Magnitude estimates by early telescopic observers are notoriously overestimated, and it was not until 1905 that the modern rational Pogson scale became standard (Jones 1968).

Given these caveats, the magnitude estimates by Dunlop should be treated with considerable care. Nevertheless, the limiting completeness magnitudes of ~7 and ~8.5 for the 3 ¼ and 9 inch respectively, are readily acceptable.

4.8 Remarks (Column 11)

Brief notes are given for 36 pairs from the 3 ¼ inch and 43 from the 9 inch. Some statistics on recurring themes in the Remarks Column are summarised in Table 6.

Table 5: Statistics on magnitude information.

Component	3 ¼ inch (# measures)	9 inch (# measures)
Primary	120	129
Secondary	120	123
Tertiary	2	8

From Table 6 it is noteworthy that Dunlop chose to inject subjective remarks into his catalogue with words such as "pretty" and "beautiful". More importantly, he included one single star (DUN 3) in what was supposedly a double star catalogue.

5. Conclusion

There can be no question that Dunlop's publication of the first dedicated catalogue of southern double stars is a major achievement and should be acknowledged as such. Nevertheless its production was not rigorous by today's standards. There are large amounts of missing or incomplete data, subjective comments on some pairs, and even the deliberate inclusion of a single star. Most disappointing were the discrepancies in recording measures from which position angles and separations for each double can be made (in up to four ways each) - none of them agreed - and so averages were used for analysis. Of the 253 doubles presented, 120 were observed from the Paramatta's Observatory's own 3 ¼ inch refractor; 132 from Dunlop's own self-made 9 inch reflector. The smallest separation claimed was ~2 arcsec. As for Herschel's criticisms, they may be justified in some cases, but were unfair considering he had access at the Cape to a telescope much superior to any Dunlop used, to say nothing of his own skills and resources.

Acknowledgements

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Table 6: Statistics on the Remarks (Column 11)

Contents of Remarks	3 ¼ inch (num of Remarks)	9 inch (num of Remarks)
Number of Remarks	36 (out of possible 121)	43 (out of possible 132)
"L. C." (de Lacaille)	15	5
"pretty"	4	8
"beautiful"	3	1
"triple", "triangle", "three"	4	10

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