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A Selection of Photographs of Stars, Star-Clusters and Nebulae

A geologist and fellow of the Royal Astronomical Society, Isaac Roberts (1829–1904) made significant contributions to the photography of star-clusters and nebulae. By championing reflecting rather than refracting telescopes, Roberts was able to perceive previously unnoticed star-clusters, and was the first to identify the spiral shape of the Great Andromeda Nebula. Roberts' use of a telescope for photographing stars, and a long exposure time, provided greater definition of stellar phenomena than previously used hand-drawings. Although Roberts' conclusions about the nature of the nebulae he photographed were not always correct, the book is significant for the possibilities it suggests for nebular photography. Published in London in 1893 and 1899, the two-volume *Photographs of Stars*, represents the summation of his work with his assistant W.S. Franks at his observatory in Crowborough, Sussex. Volume 1 contains 51 collotype plates of stars, and descriptions of his instruments and methods.

A Selection of Photographs of Stars, Star-Clusters and Nebulae

Together with Information Concerning the Instruments and the Methods Employed in the Pursuit of Celestial Photography

VOLUME 1

ISAAC ROBERTS

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SELECTION OF PHOTOGRAPHS

OF

STARS, STAR-CLUSTERS AND NEBULÆ,

TOGETHER WITH

INFORMATION CONCERNING THE INSTRUMENTS AND THE METHODS EMPLOYED IN THE PURSUIT OF CELESTIAL PHOTOGRAPHY.

BY

ISAAC ROBERTS, D.Sc., F.R.S.,

Fellow of the Royal Astronomical Society; Fellow of the Geological Society; Past President of the Liverpool Astronomical Society; and of the Liverpool Geological Society.

London:

THE UNIVERSAL PRESS, 326, HIGH HOLBORN, W.C.

THE COLLOTYPE PLATES BY THE DIRECT PHOTO-ENGRAVING CO., BARNSBURY, N.

PREFACE.

IT has been my aim, in publishing the photographs and descriptive matter introduced in the following pages, to place data in the hands of Astronomers for the study of astronomical phenomena, which have been obtained by the aid of mechanical, manipulative and chemical processes of the highest order at present attainable, and that such data should be, as regards the photographs, free from all personal errors.

The photographs portray portions of the Starry Heavens in a form at all times available for study and identically as they appear to an observer aided by a powerful telescope and clear sky for observing.

Absent are the atmospheric tremors, the cold observatory, the interrupting clouds, the straining of the eyes, the numbing of the limbs, the errors in recording observations, and the many hardships incurred by our predecessors, of glorious memory, in their attempts to see and fathom the ILLIMITABLE BEYOND.

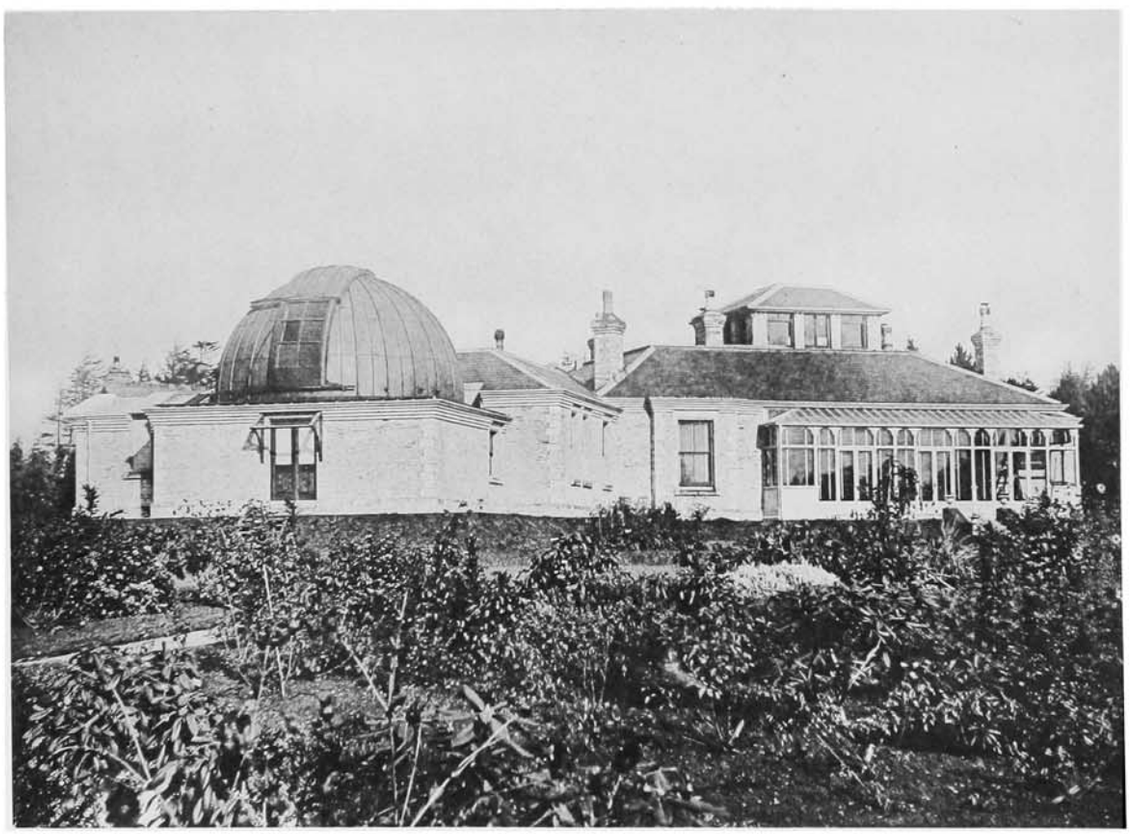
I commend the observations and the photographs herein to Astronomers and Students of the New Astronomy.

ISAAC ROBERTS.

STARFIELD,
CROWBOROUGH HILL,
SUSSEX,
December, 1893.

Plate 1.

ISAAC ROBERTS' OBSERVATORY.



PHOTOGRAPH

OF

ISAAC ROBERTS' OBSERVATORY

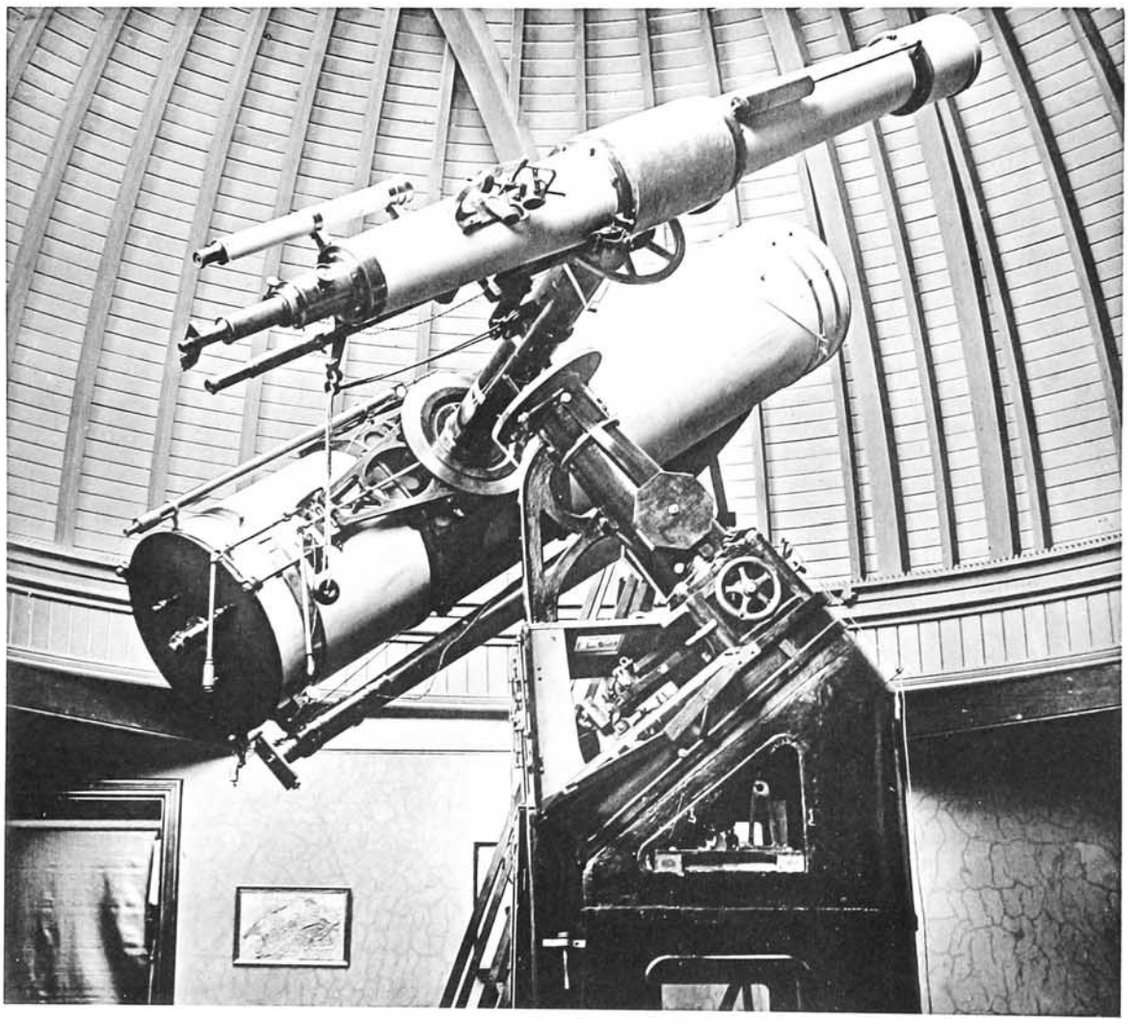
ON THE SUMMIT OF CROWBOROUGH HILL, SUSSEX,

IN

Latitude N. 51° 3′ 7″. Longitude E. 0h. 0m. 37s. Altitude, 780 feet 7 inches above the mean level of the Sea.

Plate 2.

ISAAC ROBERTS' TELESCOPES.



PHOTOGRAPH

OF

ISAAC ROBERTS' TELESCOPES.

A Reflector of twenty inches aperture and ninety-eight inches focal length for photographic purposes, and a Refractor of seven inches aperture for eye observations.

The two telescopes are mounted on a Declination axis which is common to both, and one clock, with friction governor, moves them together in Right Ascension, but in Declination they can be moved independently.

CONTENTS.

LIST OF THE PLATES.

LIST OF THE PLATES—*continued.*

A LIST OF THE ABBREVIATIONS ADOPTED IN THIS WORK.

N.G.C.—A New General Catalogue of Nebulæ and Clusters of Stars, by Dr J. L. E. Dreyer. Published in the Memoirs of the Royal Astronomical Society, Vol. XLIX., Part I.

G.C.—Sir J. F. W. Herschel's Catalogue of Nebulæ and Clusters of Stars. Published in the Philosophical Transactions of the Royal Society for the year 1864, Vol. CLIV., Part I.

h.—Sir J. F. W. Herschel's Observations of Nebulæ and Clusters of Stars. Published in the Philosophical Transactions of the Royal Society for the year 1833.

D.M.—Durchmusterung by Argelander. Bonn, 1859.

N.—North. S.—South.

F.S.—Fiducial Star; marked (·), (··), (··), (::).

THE NEGATIVES,

From which the Photographs contained in this Publication have been enlarged, measure 10 centimetres square, and one Equatorial Degree upon them measures 44·2 millimetres.

All the Plates have been enlarged from the negatives by photographic methods, to the scales given in the letter-press referring to each subject.

ARRANGEMENT OF THE PHOTOGRAPHS.

The Plates are arranged in the order of *Right Ascension*, and facing each is the descriptive matter concerning the chief features of the objects, together with particulars which will make them available for scientific investigations.

The Plates are placed so as to represent the objects as they would be seen in an inverting telescope, and therefore the edge next to the printed headings is the *south*, and the lower edge the *north*. The right hand side is the *following*, and the left the *preceding*.

The scales of the Plates are given in the letter-press annexed to each.

EPOCH OF THE FIDUCIAL STARS—THE YEAR A.D. 1900.

CERTAIN stars on each of the Plates are marked with dots, numbering from one dot to four or five, thus (∷), and the co-ordinates of these stars are given for the epoch A.D. 1900.

The computations have been made from the data found in such of the existing catalogues of stars, as could be made available for the purpose; but the degree of accuracy cannot be absolute, for reasons well known, which arise from proper motions, precession, and errors of observation, and the positions of some of the stars available have not been determined with the highest degree of precision. But the indicated stars will serve the purpose of finding on the Plates the positions of the other stars with considerable accuracy by scale measurements.

TABLE

OF

CORRECTIONS TO BE APPLIED TO THE SCALES OF THE PHOTO-PLATES.

The Collotype photo-processes by which the copying and printing of the plates in this work have been executed, have introduced certain errors in the scales, due to the expansion and contraction of the sensitized films, and to the paper used. Consequently, corrections have to be made to the scales, that they may be applicable, with approximate or practical accuracy, in the measurements of the co-ordinates of the stars. The following is a table of the corrections required :—

Plate	3.—1	millimetre	equals	30·10	seconds	of arc instead of	30 seconds.
,,	4.—1	,,		24·16	,,	,, 24	,,
,,	5.—1	,,		24·32	,,	,, 24	,,
,,	7.—1	,,		24·33	,,	,, 24	,,
,,	8.—1	,,		24·58	,,	,, 24	,,
,,	9.—1	,,		24·27	,,	,, 24	,,
,,	11.—1	,,		24·28	,,	,, 24	,,
,,	13.—1	,,		24·11	,,	,, 24	,,
,,	14.—1	,,		24·22	,,	,, 24	,,
,,	15.—1	,,		23·79	,,	,, 24	,,
,,	16.—1	,,		24·22	,,	,, 24	,,
,,	17.—1	,,		24·24	,,	,, 24	,,
,,	20.—1	,,		24·10	,,	,, 24	,,
,,	21.—1	,,		24·25	,,	,, 24	,,
,,	22.—1	,,		24·11	,,	,, 24	,,
,,	23.—1	,,		24·35	,,	,, 24	,,
,,	24.—1	,,		24·49	,,	,, 24	,,
,,	26.—1	,,		24·42	,,	,, 24	,,
,,	27.—1	,,		24·27	,,	,, 24	,,
,,	32.—1	,,		24·32	,,	,, 24	,,
,,	38.—1	,,		24·11	,,	,, 24	,,
,,	39.—1	,,		24·55	,,	,, 24	,,
,,	40.—1	,,		15·50	,,	,, 15	,,
,,	42.—1	,,		24·10	,,	,, 24	,,
,,	43.—1	,,		32·34	,,	,, 31·7	,,
,,	44.—1	,,		15·26	,,	,, 15	,,
,,	45.—1	,,		24·44	,,	,, 24	,,
,,	48.—1	,,		24·15	,,	,, 24	,,
,,	49.—1	,,		24·51	,,	,, 24	,,
,,	51.—1	,,		24·46	,,	,, 24	,,
,,	52.—1	,,		24·46	,,	,, 24	,,
,,	53.—1	,,		15·45	,,	,, 15	,,

A TABLE

For converting the measured *Right Ascensions* of the Stars shown on the Photographs (which are to the scale of 1 millimetre to 24 seconds of arc) into intervals of time at each Degree in Declination between the Equator and the Pole.

Declination.	1 Millimetre =	Declination.	1 Millimetre =	Declination.	1 Millimetre =
0°	s. 1·60 in R.A.	30°	s. 1·85 in R.A.	60°	s. 3·19 in R.A.
1	1·60 ,,	31	1·86 ,,	61	3·30 ,,
2	1·60 ,,	32	1·88 ,,	62	3·41 ,,
3	1·60 ,,	33	1·90 ,,	63	3·53 ,,
4	1·60 ,,	34	1·92 ,,	64	3·65 ,,
5	1·60 ,,	35	1·95 ,,	65	3·79 ,,
6	1·60 ,,	36	1·98 ,,	66	3·94 ,,
7	1·61 ,,	37	2·00 ,,	67	4·08 ,,
8	1·61 ,,	38	2·03 ,,	68	4·26 ,,
9	1·62 ,,	39	2·05 ,,	69	4·46 ,,
10	1·62 ,,	40	2·08 ,,	70	4·67 ,,
11	1·63 ,,	41	2·11 ,,	71	4·90 ,,
12	1·63 ,,	42	2·15 ,,	72	5·16 ,,
13	1·64 ,,	43	2·18 ,,	73	5·46 ,,
14	1·64 ,,	44	2·22 ,,	74	5·84 ,,
15	1·65 ,,	45	2·26 ,,	75	6·21 ,,
16	1·66 ,,	46	2·30 ,,	76	6·64 ,,
17	1·67 ,,	47	2·34 ,,	77	7·01 ,,
18	1·68 ,,	48	2·39 ,,	78	7·68 ,,
19	1·69 ,,	49	2·43 ,,	79	8·34 ,,
20	1·70 ,,	50	2·48 ,,	80	9·27 ,,
21	1·71 ,,	51	2·54 ,,	81	10·25 ,,
22	1·72 ,,	52	2·59 ,,	82	11·45 ,,
23	1·74 ,,	53	2·65 ,,	83	13·27 ,,
24	1·75 ,,	54	2·71 ,,	84	15·37 ,,
25	1·76 ,,	55	2·78 ,,	85	18·12 ,,
26	1·77 ,,	56	2·85 ,,	86	23·36 ,,
27	1·79 ,,	57	2·93 ,,	87	30·74 ,,
28	1·81 ,,	58	3·01 ,,	88	48·66 ,,
29	1·83 ,,	59	3·10 ,,	89	97·33 ,,

ILLUSTRATIONS

Of the method for determining by measurements from the Fiducial Stars the approximate Right Ascension and Declination of any Star on the Plates.

Required the R.A. and Dec. of a Star (x), with a bright companion 44·3 millimetres *south following* F.S. (·), and 108·4 millimetres *north preceding* F.S. (··) on plate 4.

The measurements are made by the direct application of a millimetre scale, or by extending the points of a dividing compass from the centre of the Fiducial Stars to the centre of the selected Star (x), and then reading off the distance on the scale, and are here given for the purpose of identifying the star referred to on the Plate, which will be at the intersection of arcs with radii 44·3 and 108·4 millimetres, but they are not required in the determination of its co-ordinates.

PLACES OF THE FIDUCIAL STARS ON PLATE 4.

F.S. (·)	R.A. 0h. 47m. 7·5s. ...	Dec. N. 60° 33·9′ ...	Magnitude 5·0
,, (··)	,, 0h. 50m. 45·6s. ...	,, ,, 59° 49·3′ ...	,, 6·3
,, (·:)	,, 0h. 51m. 16·1s. ...	,, ,, 60° 53·1′ ...	,, 7·0
,, (::)	,, 0h. 53m. 57·5s. ...	,, ,, 59° 58·3′ ...	,, 7·2

TO FIND THE RIGHT ASCENSION.

It will be observed that the R.A. of F.S. (··) = 0h. 50m. 45·6s.

,, ,, ,, ,, ,, ( ) = 0h. 47m. 7·5s.

0h. 3m. 38·1s. =

218·1 seconds (the difference between them in R.A.), and by referring to the Table Dec. 60°, which is, omitting fractions, the Declination of the F.S. (·) nearest to the Star (x), it will be seen that one millimetre is equal to 3·2 seconds of time, therefore,

$$\frac{218{\cdot}1}{3{\cdot}2} = 68{\cdot}15 \text{ millimetres.}$$

Take this distance between the points of the dividers; place one point on the centre of F.S. (··), and extend the other point towards the *preceding* side; at the same time place the rule with its edge in *north* and *south* direction to bi-section with both F.S. (·) and the disengaged point of the dividers.

The edge of the rule is then on the meridian (0h. 47m. 7·5s.) of the F.S. (·), and whilst the rule is firmly held in this position, measure the distance of Star (x) from it,

which will be found to be 12·2 millimetres. Then 12·2 × 3·2=39 seconds of time, being the distance in R.A. of the Star (x) from F.S. (·), and 0h. 47m. 7·5s.+39s = 0h. 47m. 46·5s.=the required R.A. of the Star (x).

TO FIND THE DECLINATION.

The scale of the Plate is one millimetre to 24 seconds of arc, and this applies to most of the Plates.

Dec. F.S. (∴)=60° 53·1′
„ „ (·)=60° 33·9′

$$19\ 2 = \frac{1152''}{24''} = 48 \text{ millimetres—}$$

the difference in Declination between the two F.S. Take this distance between the points of the dividers and place one point on the centre of F.S. (∴), and extend the other point towards the *south;* at the same time place the rule with its edge in the direction of a parallel of Declination and bi-secting both F.S. (·) and the disengaged point of the dividers.

The edge of the rule is then on the parallel of Declination of F.S. (·), and whilst the rule is firmly held in this position, measure the distance of Star (x) from it, which will be found to be 41·8 millimetres. Then 41·8 × 24″=16·7 minutes of arc.

Therefore Dec. F.S. (·)=60° 33·9′—16·7′=0° 17·2′, the required Declination of the Star (x), and its position is in R.A. 0h. 47m. 46·5s.; Dec. N. 60° 17·2′. Refraction has not been taken into account in these illustrations, but, if required, the correction could be applied in the usual way.

Methods for determining mathematically the co-ordinates of stars on a photograph have been explained by Sir R. S. Ball and Dr. Rambaut in the *Trans. of the Irish Academy*, vol. 30, part 4, January, 1893; and by Mr. H. H. Turner in *The Observatory*, vol. 16, p. 373, November, 1893.