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THE NUMBER OF THE NEBULAE

Professor Keeler, soon after beginning his program of work with the Crossley Reflector, showed that the number of the nebulae is very much greater than had been supposed. He conservatively placed the number within reach of that telescope at one hundred and twenty thousand. His program comprised the taking of photographs of one hundred and four of the brighter nebulae and clusters located in all parts of the sky within reach of the telescope, *i.e.*, north of declination -25° . The recent completion of this program enables us to revise his estimate.

In fifty-seven of the regions seven hundred and forty-five *new nebulae* have been discovered. Almost all of them are very small and faint. The regions in which no new ones were found were, as a rule, those surrounding the clusters and very large nebulae. There were one hundred and forty-two known nebulae in these regions, making the total number of nebulae observed eight hundred and eighty-seven, an average of eight and one-half per region. As it would take sixty-two thousand such photographs to cover the entire sky the results indicate five hundred thousand as the corresponding number of nebulae within reach

of the Crossley Reflector. This assumes that the small portion observed represents fairly the entire sky. It is well known that the nebulae are much more numerous in some parts of the sky than in others. This is a tendency which, so far as we know, affects large and small nebulae alike. The fact that a considerable number of other subjects than the nebulae (presumably non-nebulous regions) are included in the program, indicates that the portion observed is fairly representative of the whole sky.

Longer exposures, more sensitive plates, and more perfect photographs will undoubtedly reveal some nebulae which do not now appear and others which are confused with the faint stars. It seems probable, therefore, that the number of the nebulae will ultimately be found to exceed a million.

The positions of the new nebulae discovered on the Crossley photographs have been determined, and a catalogue of them will be printed in the volume of reproductions of nebulae and clusters, soon to be issued.

C. D. PERRINE.

June 18, 1904.

OBSERVATIONS OF A RILL EXTENDING THROUGH THE LUNAR VALLEY OF THE ALPS

On the night of April 23, 1904, while showing the regular Saturday night visitors the Moon through the 36-inch refractor, I noticed a rill at several points in the Alpine Valley. The seeing was too poor to make satisfactory observations, but at times the rill could be glimpsed for nearly the whole length of the Valley.

Following are the notes concerning it, made on April 23d and subsequently:

1904 April 23, 8^h 30^m P.S.T. Moon's age, 8^d 6^h.
36-inch refractor, power 270.

Rill extends the entire length of the Valley and very nearly in the middle. Not visible continuously, owing to the changeable seeing, but unquestionable when image is steadiest.

1904 April 24, 8^h P.S.T. Moon's age, 9^d 6^h.
12-inch refractor, powers 150, 300, 500.

Seeing 3. No trace of rill with power of 150. Rill suspected at several points with power of 300, but not certain. Five hundred power too high.

1904 May 6, 16^h 30^m P.S.T. Moon's age, 21^d 14^h.
36-inch, power 520.

Moon's age too great, no trace of rill. Seeing 1-2.

1904 May 22, 9^h P.S.T. Moon's age, 7^d 18^h.
36-inch, powers 270 and 520.

At moments can glimpse rill in middle of valley. Sketch.

1904 May 23, 7^h 35^m to 8^h 30^m P.S.T. Moon's age, 8^d 17^h.
36-inch, power 520.

Rill certainly not wider than micrometer wire, which is one-tenth second. On the Moon this corresponds to a width of six hundred feet.

Cannot detect rill at western end of Valley. Four gaps at A, B, C and D. Seeing poor, 2. The south side of rill is in shade, whereas the north side is very bright. The faintest portions of the rill are not more than half the width of the micrometer wire. The rill immediately west of Plato was compared with the rill in the Alpine Valley. The former was conspicuous at all times, the latter was entirely obliterated except at the moments of best seeing. Sketch.

1904 June 4, 16^h P.S.T. Moon's age, 22^d 1^h.
36-inch, power 520. Seeing 3.

Moon too old. Valley of the Alps in shade, except floor at eastern end. Rill can be traced across this region.

1904 July 2, 16^h P.S.T. Moon's age, 19^d 15^h.
36-inch, power 520.

Seeing is not good enough and the Moon is not old enough to determine the existence of the rill at the

four critical points. Rill can at times be seen for most of its length.

1904 August 30, 15^h 30^m to 17^h 30^m P.S.T. Moon's age, 19^d 23^h.
36-inch, power 520.

Rill at A well seen and is continuous—almost as distinct as to the west of the gap. Cannot trace rill through gap B, but there is a very minute crater about midway of the gap. Suspected the rill to cross the gap through this small crater, but cannot be certain of it.

The entire invisibility of the rill at A on previous occasions and its distinctness tonight, as well as the reverse in the region from B to D, (especially from C to D, where absolutely no trace of the rill is to be seen tonight) emphasizes the dependence for visibility of many lunar markings on illumination. The two small craterlets in gap B, so well seen tonight, were invisible on former occasions. Sketches.

Rill in Valley of the Alps

The accompanying drawing is compiled from all the sketches. No attempt has been made to include details except such as are connected with the rill, or craterlets very near to it. Attention may be called to the great number of craterlets strung along the rill in some regions and to the fact that at all the gaps the rill terminates in craterlets.

It is not improbable that by observing this object diligently under good conditions, the rill would be found to cross the three short gaps.

I have examined a number of the negatives of this region of the Moon, taken with the 36-inch refractor, especially those taken with an enlarging lens, but fail to find any trace of the rill upon them.

C. D. PERRINE.

October 16, 1904.

A DIVISION OF THE STARS IN SOME OF THE GLOBULAR CLUSTERS, ACCORDING TO MAGNITUDE

The program of observations for the Crossley Reflector undertaken by the late Professor Keeler, contained the following eight well known globular star clusters:

N.G.C.	R.A.	Decl.
5272	13 ^h 38 ^m	+ 28° 53'
5904	15 13	+ 2 27
6205	16 38	+ 36 39
6218	16 42	— 1 46
6656	18 30	— 24 00
7078	21 25	+ 11 44
7089	21 28	— 1 16
7099	21 35	— 23 38

An exposure of 1^h 30^m to 2^h was required to bring out the faint stars which in telescopes of ordinary size give the appearance of nebosity to these clusters.

The general appearance of these clusters is very similar; they are of nearly the same angular dimensions and the magnitudes of the component stars are remarkably alike.

In each of these clusters, practically all of the stars can be separated into two classes of magnitudes. Perhaps a third of the whole number lie between eleventh and thirteenth magnitude, while almost all of the remainder are very faint, being about sixteenth magnitude. The appearance is that of two layers, one of bright stars superposed upon another of very faint stars.

In his study of the Hercules cluster (M 13) Palmer* notes this division of magnitudes and gives the number of "bright" stars in that cluster as 1016 and of "faint" stars as 4466. No numerical magnitudes are assigned owing, probably, to the difficulty of determining magnitudes with sufficient accuracy from the Crossley photographs. Scheiner† gives the magnitudes of the 833 stars in this cluster catalogued by him as from twelve to fourteen.

From visual observations of the cluster Messier 13 with the 36-inch refractor, I should assign for the brighter stars a range of about two magnitudes, from eleven to thirteen, and of one magnitude, fifteen and one-half to sixteen and one-half, for the faint stars. There is little departure from these ranges for the other clusters. But few stars of magnitudes fourteen to fifteen and one-half are to be found in these clusters.

Photographs of the Omega Centauri cluster obtained at the Harvard College Observatory station at Arequipa,

* The distribution of stars in the cluster Messier 13, in Hercules, *Astrophysical Journal*, **10**, 246, 1899.

† Der Grosse sternhaufen im Hercules, Messier 13, Abhandlungen Akademie der Wissenschaften, Berlin, 1892.

exhibit the same division of the stars in that cluster into two groups, as does the Crossley series. The limits of the area of the faint stars are fully as sharply defined as those of the brighter ones, and the centers of the two groups coincide. We are therefore led to the conclusion that in each case the observed division is in the same group of stars in space. That it is characteristic of all clusters of this type is not certain, but the lack of any exceptions in the clusters observed strongly suggests such an hypothesis.

The clusters under consideration are widely distributed, covering eight hours of right ascension and over seventy degrees of declination. Only one of them (N.G.C. 6656) is in the Milky Way.

In the case of the Hercules cluster, Palmer found that the faint stars appeared to be distributed approximately uniformly in a sphere having a nine minute radius, whereas the bright stars are more numerous near the center of the cluster. This result for one cluster coupled with the general appearance of all the clusters, leads to the belief that the real form of these objects (at least the nine in question) is spherical.

Two hypotheses to account for the peculiar distribution in magnitude suggest themselves.

1st. That it is due to a difference in the size of the stars.

2d. That it is due to a difference in constitution or physical condition.

The almost complete lack of physical data at present prevents any useful discussion of these hypotheses. Although the first appears to be the most probable yet it is conceivable that this peculiar distribution might result from a difference in constitution of the stars themselves.

The suggestion has been made that an absorbing medium pervades the cluster. It is difficult to see how such an appearance as that noted could result from absorption of the light upon any reasonable assumption as to the character and distribution of such a medium. The result of such absorption in a cluster of globular form should cause a general diminution in the brightness of the stars as we approach the center of the cluster. No such effect is to be detected, however.

In this connection attention may be called to the relation which has been supposed to exist between the nebulae and the star clusters. The belief has been gaining way since photography has shown the real structure of so many of these objects, that they are

but different stages in the process of evolution; that a star cluster has been formed by the condensation of the matter in a nebula.

A study of the nebulae which have been observed with the Crossley Reflector shows that a large proportion are spiral, and that practically all the spirals are lenticular or disc shaped. Many of them are relatively very thin. Now if the globular clusters are really spherical, as seems probable, it is difficult to see how they could have originated from a disc-shaped nebula (spiral?).

As there are other forms, also, of nebulae and star clusters, it is not necessary to assume that the order of evolution mentioned above is the only one. But the natural tendency has been to connect such changes as these with the spirals which, by their appearance, seem to indicate greater systematic internal activity than others.

C. D. PERRINE.

July 17, 1904.

EXPERIMENTAL DETERMINATION OF THE SOLAR PARALLAX FROM SIX NEGATIVES OF EROS, MADE WITH THE CROSSLEY REFLECTOR ON DECEMBER 5, 1900

In order to determine the value of the series of photographs of Eros which were made with the Crossley Reflector, and to test a simple diurnal method of combining the results, six negatives were selected from the exposures of December 5, 1900. Three of these plates were taken in the evening and three in the morning. Each plate had five exposures.

The measures were made on the Stackpole Measuring Engine, using the system of rectangular coördinates. The scale readings were taken to 0".1 and means carried one place further. Distorted images were not measured. One of the plates taken near the meridian was measured and, after combining all the images and correcting for refraction, the results were used as a standard to which the parallax plates were reduced. Twelve comparison-stars were used, the places of which were determined from photographs taken at the Paris Observatory, and very kindly furnished by the Director, M. Loewy.

The reductions were kept wholly in rectangular coördinates. The corrections for refraction were computed from the known constants, and applied, the four remaining plate-constants being determined from the stars.

After correcting the measures for parallax, on the assumption that the solar parallax is 8.80, the observed displacements were compared with the motion of the asteroid during the interval, derived from the eight-place ephemeris computed by Professor Millosevich, (Bulletin No. 9, Conférence Astrophotographique Internationale de Juillet 1900.)

As the parallax component in declination was very small, the parallax is based wholly on the X measures.

Following are the results:

No. of Plate.	No. of Exposure.	P.S.T.*	Motion.				$\Delta\pi$
			Observed.	Ephemeris.	O—E	Factor.	
713	II	5 ^h 43 ^m 35 ^s	} +.011950	} +.011872	} + 78	} 4.00	} +'.020
734	I, II	13 23 25					
713	IV	5 44 20	} +.011960	} +.011882	} + 78	} 4.00	} +.020
734	III, IV	13 24 9					
713	V	5 44 55	} +.011990	} +.011897	} + 93	} 3.99	} +.023
734	V	13 24 55					
715	All	5 50 0	} +.012420	} +.012582	} -162	} 4.03	} -.040
742	All	13 48 0					
721	II	6 7 35	} +.011800	} +.012027	} -227	} 3.85	} -.059
740	I, II	13 41 25					
721	III	6 7 58	} +.012040	} +.012044	} - 4	} 3.85	} -.001
740	III, IV	13 42 9					
721	V	6 8 55	} +.011930	} +.012051	} -121	} 3.85	} -.031
740	V	13 42 55					

*The times are observed times and are for the middle of the exposures.

Giving equation four double weight and combining we have

$$\begin{aligned}\Delta\pi &= -0''.012 \pm 0''.008 \\ \pi_{\odot} &= 8.788 \pm 0.008\end{aligned}$$

The probable error from one equation of condition is $\pm 0''.022$.

It has not seemed justifiable to apply any systematic corrections, nor to include additional unknowns in the solutions. The plates measured are too limited in number to permit of trustworthy investigations of this nature.

In determining the motion of the asteroid from the ephemeris, the times were corrected for planetary aberration. As the comparison stars were symmetrically distributed about Eros, the uncertainties in refraction and the extremely small effects of differential stellar aberration are completely neutralized.

From the seventy-two positions of the twelve comparison stars the following probable errors are found for the position of a star upon one plate, being on the average the means of four exposures:

$$\begin{aligned}\text{P.E. in X} &= \pm 0''.08 \\ Y &\pm 0.09\end{aligned}$$

The measures on good images can usually be reproduced within 0''.02 or 0''.03 from four settings. Accidental discordances of 0''.25 in any image are to be expected, however, discordances which are, perhaps, due to distortions of the photographic film. In the plates measured there seems to be no evidence that these discordances are other than accidental.

This method of determining the parallax by purely differential means, using rectangular coördinates, is extremely short and simple, and appears to sacrifice nothing in accuracy.

C. D. PERRINE.

June 18, 1904.

[Note added September 12, 1904:—Since this paper was written, Mr. Hinks' results have been received. His work confirms the above in a very satisfactory manner.

C. D. P.]

PHOTOGRAPHIC OBSERVATIONS OF THE NINTH SATELLITE OF SATURN

The following observations of Pickering's new satellite of Saturn are from the first photographs made with the new mounting for the Crossley 3-foot mirror. The focus of the telescope was determined on the night of November 5th, and on the following night an exposure was made which showed the new satellite. It was photographed on the succeeding four nights also. Following is a list of the plates secured:

No. of Plate.	Date.	P.S.T.	Duration.
	1904		
1345	November 6	6 ^h 33 ^m to 8 ^h 20 ^m	1 ^h 47 ^m
1346	" 7	6 32 8 32	2 0
1347	" 8	6 23 8 23	2 0
1350	" 9	6 30 8 30	2 0
1351	" 10	6 30 8 30	2 0

The image of Phoebe on the first plate is faint and diffuse. On the later plates it shows distinctly as a short trail. An exposure of a half hour under good conditions will be sufficient to give a measurable image. The image of Saturn is badly over-exposed on all the plates, and too large for accurate settings. It was measured on the first plate, however, and its position is included. Instead of the usual custom of determining position—angle and distance, I have, therefore, determined the absolute positions of the satellite referred to six catalogue stars. Following are the resulting coördinates of Phoebe for 1904.0 freed from the effects of refraction. The necessary corrections for parallax are attached but not applied.

POSITIONS OF PHOEBE FOR 1904.0

Plate No.	Date 1904	P.S.T.	α	δ	Parallax.	
					α	δ
1345	November 6	7 ^h 26 ^m 5	21 ^h 8 ^m 22.734	—17° 40' 46".86	+0.016	+0".72
1346	" 7	7 32	8 29.862	—17 40 13.16	.018	.72
1347	" 8	7 23	8 37.168	—17 39 35.58	.017	.72
1350	" 9	7 30	8 44.929	—17 38 56.66	.019	.71
1351	" 10	7 30	21 8 53.161	—17 38 16.00	+0.020	+0.71

SATURN

1345	" 6	7 26.5	21 9 50.067	—17 33 32.76	+0.016	+0.72
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MEAN PLACES OF COMPARISON STARS FOR 1904.0

*	α	δ	Authority.
1	21 ^h 7 ^m 33.33	—17° 34' 22".4	Washington A.G. Zones
2	8 24.67	—17 57 38.5	" "
3	8 46.97	—17 40 4.7	" "
4	9 23.62	—17 36 57.7	" "
5	9 36.11	—17 58 17.7	" "
6	21 9 44.42	—17 44 33.6	" "

A comparison of the observed position of Saturn with that in the American Ephemeris gives the following residuals, observed—ephemeris

$\Delta\alpha$,	—0".052
$\Delta\delta$,	—0".29

The observations of Phoebe have been compared with Pickering's ephemeris in *Annals H. C. O.*, Vol. LIII, No. III, page 72. The positions of Saturn used in computing the angles and distances were obtained from the photograph on November 6th, and from the American Ephemeris on the subsequent dates. Following are the residuals, observed—ephemeris

	p .	s .
November 6	0".0	—1".4
7	—0.1	—1.4
8	0.0	—1.4
9	0.0	—1.4
10	0.0	—1.4

Phoebe is of about the 17th photographic magnitude. This series of plates also contains images of Iapetus, Hyperion, Titan and Rhea, which are far enough from the planet to be seen distinctly. Their positions will be published later.

C. D. PERRINE.

November 28, 1904.