curve observed by the writer indicates the preliminary result that the intensity at the limb is about six-tenths of the intensity at the center of the disk.

PRELIMINARY RESULTS OF A COMPARATIVE TEST OF THE 60-INCH AND 100-INCH TELESCOPES OF THE MOUNT WILSON OBSERVATORY.

By George E. Hale.

The close proximity on Mount Wilson of the 60-inch and 100-inch reflecting telescopes renders possible a comparative test of two similar instruments of large aperture. In order to make the results strictly comparable, the observations are preferably made simultaneously, and when these are photographic, the plates employed are taken from the same box and developed together for the same time. Other precautions necessary to eliminate sources of uncertainty are also observed.

The first simultaneous comparative tests of the series (which will be continued as opportunity offers through several months), were made on August 13, 1919. The spectrum of the star ε Andromedae was photographed on Seed 30 plates with the two telescopes, using spectrographs having nearly identical optical constants, mounted at the Cassegrain focus. For the 60-inch the equivalent focal length at this point is 80 feet, while for the 100-inch it is 134 feet. The exposures on ε Andromedae were made by Dr. Strömberg with the 60-inch and by Dr. Merrill with the 100-inch, under good conditions of seeing.

Thirty-three spectrograms were secured for comparison. From twenty of these Dr. Strömberg finds the following mean ratios of exposure-times required to give the same intensities and photographic resolution with the two instruments:

<table>
<thead>
<tr>
<th>Region</th>
<th>λ4000</th>
<th>λ4300</th>
<th>λ4500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.5</td>
<td>3.2</td>
<td>3.3</td>
</tr>
</tbody>
</table>

As the light undergoes three reflections in each telescope, and as the small mirrors cut out nearly the same proportion of light in both cases, the theoretical ratio of exposure time would be \((100/60)^2 = 2.78\). The presence of the plane mirror in the optical train of the spectrograph of the 60-inch telescope, and the fact that the three mirrors of the 100-inch telescope have been more recently silvered than those of the 60-inch, probably accounts for the comparatively high value of the ratio at λ4000 (4.5), as the comparison spectra show no such change of relative intensity with wave-length. But these differences cannot affect the brightness at λ4500 by more than 15%, judging from the constancy of the exposure times for stars of a given magnitude required with the 60-inch throughout the dry summer season. Another comparison will be made after the mirrors of the 60-inch have been resilvered.
A second comparative test, not based upon simultaneous exposures, is afforded by Dr. Merrill’s experience with stars of Class Md. 201 of these interesting objects, brighter than 9.0 magnitude at maximum, are known north of --30°. With the 60-inch nearly all of these stars can be observed for the bright lines with exposures not exceeding two hours. For the great majority, however, exposures of five hours or more are required with this telescope to yield a measureable absorption spectrum with the spectrographs already mentioned. In fact, so few stars can be effectively observed for both dark and bright lines that it would be hardly advisable to enter upon an extensive study of these objects with the 60-inch.

The greater light-gathering power of the 100-inch, however, renders a study perfectly feasible. With this telescope, using the spectrograph mentioned above at the 134 foot Cassegrain focus, Dr. Merrill has obtained good photographs of the absorption spectrum (up to Hγ) of RY Herculis, 8.8 visual magnitude, in two hours, and of brighter stars of the same class with shorter exposures.

Dr. Shapley, who is continuing his investigation of star clusters with the 100-inch telescope, finds a similar gain of about one magnitude. With the small slitless spectrograph* mounted on the double-slide plate-holder at the 134 foot focus of the 100-inch, the exposure times for stars in the globular cluster Messier 11 are about as follows:

<table>
<thead>
<tr>
<th>Photographic magnitude</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>5 minutes</td>
</tr>
<tr>
<td>13</td>
<td>15 &quot;</td>
</tr>
</tbody>
</table>

A further advantage results from the greater scale of the cluster in this focus of the 100-inch (ratio to that of the 60-inch = 134/80), which permits the spectra of closer stars to be photographed separately. This scale may be seen from the accompanying slide, which is a contact copy of a negative of the central part of the globular cluster Messier 13, made by Mr. Pease on August 17 at the 134 foot focus of the 100-inch telescope with an exposure of 30 minutes. It was not feasible to make a simultaneous exposure on the same evening at the 80 foot focus of the 60-inch, but from a comparison with other plates it is evident that with good seeing the 100-inch will give decidedly fainter stars at this focus than the 60-inch, in spite of the severe demands imposed by the greater equivalent focal length of the 100-inch. The large scale of these photographs will permit the magnitudes of stars in the central parts of the cluster to be determined with less difficulty from the Eberhard effect than has been experienced with the 60-inch. Simultaneous cluster photographs made with the two telescopes when the seeing was very poor (1 on a scale of 10) show decidedly

*This spectrograph has a collimator of 18 inches focal length, a 39° prism of O.102 glass, and a camera of 3 inches focal length. This scale is Hγ -- K = 0.9 mm.
better results for the 60-inch, as might be expected from its much shorter focal length.

A few photographs of the moon have been made at the 134 foot focus of the 100-inch by Mr. Pease, with very satisfactory results, but not under conditions of seeing sufficiently good to permit the finest accessible details to be recorded. The accompanying slide of Copernicus, a contact copy of a negative made on August 18, will suffice to illustrate the scale of the negatives and the character of the details registered. The extraordinarily minute structure on the moon which I have seen visually on several occasions with the 100-inch, and the large image available at the 134 foot focus, indicate that this telescope is exceptionally well adapted for lunar photography.

One of the most promising applications of the 100-inch telescope is illustrated by some photographs of Campbell’s star with hydrogen atmosphere, B D + 30°3639. Enlargements were shown of photographs of this star made by Mr. Pease at the 134 foot focus on August 17 with exposures of five and ten minutes respectively. A rift in the hydrogen atmosphere, confirmed by several other plates, is plainly shown. Minute details in several very small planetary nebulae have also been successfully photographed by Mr. Pease at the 134 foot focus.

Hitherto no definite tests have been made in the principal focus of the 100-inch telescope, as the Newtonian "cage" is not yet quite completed. It may be of interest, however, to show a photograph of the Ring Nebula in Lyra, made on July 16 in the principal focus with an exposure of ten minutes. Mr. Pease and Dr. Anderson, who had been examining the figure of the large mirror, were both standing on a small platform mounted temporarily in the middle of the unfinished focal plane "cage." During the exposure, made by Mr. Pease with a double-slide plate-holder supported in the focal plane, they were carried with the instrument by the driving-clock. Naturally these circumstances were not favorable to good seeing, steadiness of the tube, and accurate guiding, but it is doubtful whether finer details of structure than those shown in this photograph of the Ring Nebula have ever been obtained with the 60-inch under the most perfect conditions. It should be noted that the nebula was out of the axis of the large mirror, which was not then in adjustment. As the Newtonian "cage" and observing platform are nearly ready for use, a real test of the performance of the 100-inch at its principal focus should soon be feasible.

LIST OF SLIDES.

(1) Dome of 100-inch telescope, from 150-foot tower.
(2) 100-inch telescope.
(3) Spectra of ε Andromedae, with 100-inch telescope (exposure 4 minutes), and with 60-inch telescope (exposure 12 minutes).
(4) Spectra of ε Andromedae (photographed with 100-inch telescope (exposures 2 minutes, 6 minutes, and 10 minutes).
(5) Star cluster M 13 Herculis, photographed in 134-foot focus of 100-inch telescope, with exposure of 30 minutes. (Scale of original negative.)