insemination by artificial or natural means, thereby minimizing the amount of error introduced in experimental work by the use of females in unknown physiological condition. In critical experiments by using for an indicator a vasectomized male, homozygous for one color factor, and for the later insemination sperm from a male homozygous for another color factor, one will have a definite breeding test showing whether or not, by any accident, the vasectomized male was able to transfer sperm to the female.

PHOTOGRAPHIC MAGNITUDES OF STARS IN THE SELECTED AREAS OF KAPTEYN

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A casual experience with the details of astronomical investigation reveals, in the number of the stars, a serious difficulty to be overcome in undertaking any discussion of the development and structure of the stellar universe. Telescopes of even moderate size bring before the observer stars to be counted by tens of millions, while those shown by instruments of the highest power are many times more numerous. Since the individual examination of all these objects will not be seriously considered, the question arises as to a rational limitation of the program of observations. Fortunately, the problem is not as hopeless as it seems, for very important and illuminating facts are to be derived from a minute percentage of the total number of stars seen in our telescopes, provided only that the objects chosen for study be representative of the collection as a whole.

Kapteyn, in 1906, showed that by proper restriction and selection we might hope to obtain, within a comparatively few years, a fairly comprehensive notion of the salient features of the structure of the universe. His well-known 'Plan of Selected Areas,' published in that year,\(^1\) formulates in a definite way the investigations to be undertaken in order that we may acquire an adequate knowledge of stellar positions, distances, proper motions, radial velocities, spectra, and magnitudes, both visual and photographic, which are the data essential for a consideration of the questions of structure and development.

The principle of selection adopted by him involves the detailed examination of all objects within the reach of observation, situated in certain small areas uniformly distributed over the sky. About two hundred such selected areas are included in the list; the center in each case
is definitely marked by a star of more than average brilliance, but the boundaries are elastic and may be adapted to the special requirements of any given problem. In order that the accidental irregularities of distribution may not too greatly influence the results, each region, in dealing with stars of moderate brightness, will cover one or two square degrees; but for the very numerous fainter objects, sufficiently comprehensive data can be obtained from much smaller areas, including, in some cases, only a small fraction of a degree.

Kapteyn thus avoids the task impossible of execution and sets one that is more appropriate to our limited capacities. We occupy ourselves with what in effect is a sampling of the contents of the heavens, and, because of that underlying regularity presupposed by all our science, accept with some confidence its inferences and deductions as to the totality of the universe of stars.

But with even this much restricted plan, the actual labor still is very great, beyond the resources of any single institution, and subdivision and coöperation have therefore been necessary. Various observatories and numerous individuals have devoted themselves to special programs of observation, with the result that data are now rapidly accumulating.

In accordance with this plan several investigations, for which the equipment of the Solar Observatory is peculiarly adapted, have been undertaken at Mount Wilson. One of these, with which this note is particularly concerned, relates to the determination of photographic magnitudes.

In any scheme of sidereal research, measurements of stellar brightness are an important element; for a knowledge of stellar distribution and of the concentration of stars toward the galactic plane, they are essential; for the statistical discussion of stellar distances, they furnish criteria of the greatest value; and when both photographic and visual (or photovisual) magnitudes are known, we have immediately available values of the color which, for the fainter stars at least, are of much importance, since they afford, for objects inaccessible to spectroscopic observations, a hint as to physical condition not to be obtained by any other means.

In every photometric research a precise knowledge of the scale of magnitudes is an essential feature, and for the Mount Wilson investigation this primarily was the requirement. Professor Kapteyn had previously been furnished with photographs of an hour's exposure, with the 60-inch reflector, on each of the selected areas on and north of the parallel at $-15^\circ$ declination; and for the reduction of these photographs sequences of standard magnitudes were required. Although
standards for the faint stars were especially desired, brighter objects have also been observed in order to facilitate comparisons with other photometric systems.

A simple means of deriving a sequence of standards is to transfer to the region in question, by means of intercomparison photographs, the standards already established at the Pole. But in the present case this method could not be used; the range of brightness to be covered was too great, and the limiting magnitude to be attained too faint.

Separate determinations of the scale were accordingly undertaken for each area, and, as a means of greater precision, these were based on all the stars shown on the photographs used. We have, therefore, for each region a large number of magnitudes, instead of merely sequences of standards. The labor was thereby somewhat increased, but, besides the greater accuracy, there is the advantage of a complete utilization of the data of observation.

To establish the photographic scale of magnitudes, the relation between the brightness of a star and the size of its photographic image must be found. This can be reliably accomplished by means of successive exposures, of constant duration, made on the same plate with light of different intensities. The variations in intensity, which must be known, can be produced through a change in the effective aperture of the telescope by adding diaphragms or screens of wire gauze. Individual stars will therefore show two or more images, with differing dimensions corresponding to known differences of magnitude. When once the images on any photograph have been completely measured, a simple interpolation process quickly gives the relative magnitudes of all the stars. To determine their absolute values, a zero-point correction must be added, whose value has to be derived from other data.

If the scale is to be established over a considerable range of magnitude, photographs of both long and short exposure will be required; and to reduce the influence of the various errors, which in photometric work are always numerous and troublesome, several separate determinations will be made, preferably with diaphragms and screens which change the intensity by different amounts. The program adopted for each of the Selected Areas is shown in the Table.

<table>
<thead>
<tr>
<th>NO. PLATES</th>
<th>APERTURE IN INCREAS</th>
<th>DURATION OF EXPOSURES</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>60, 32, 32, 60</td>
<td>15m</td>
</tr>
<tr>
<td>1</td>
<td>60, Screen, Screen, 60</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>60, 32, 14, 9, 9, 14, 32, 60</td>
<td>2</td>
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This arrangement of exposures admits of six separate determinations of the scale, and a possible maximum of sixteen different values of the
magnitude of a given star, though the average number is only five or six; for the faintest stars there are naturally but two—those derived from the full-aperture images of the two plates of long exposure.

It was planned originally to include only the 115 Selected Areas on and north of the Equator, and the 460 plates necessary for the derivation of relative magnitudes in these regions have nearly all been taken. The measures are also well advanced, and for 80 regions the reductions, up to and including the relative magnitudes, are complete. It now seems desirable to include the 24 areas at $-15^\circ$, and these accordingly will be added to the program.

To reduce the relative magnitudes to absolute values on the international system, it is convenient to rely upon the North Polar Standards, for which precise results are known. To determine the various zero-point corrections, two series of intercomparison photographs have been made: first, comparisons of each area with the adjacent areas of the same zone of declination, and second, duplicate comparisons of six equidistant areas in each zone with the region of the Pole. By means of the zonal comparisons, the magnitudes of each zone can be brought to a common zero-point, which, through the polar comparisons, can finally be referred to the international standard. Since the intercomparison exposures are of only two minutes duration, the photographs are rapidly accumulated. All but 50 of the 302 plates required for the original program have been obtained.

Since these photographs have not yet been reduced, the lower limit for the magnitudes is not accurately known, but probably it is not far from 17.5 on the photographic scale. The range of brightness is always such as to include the central star of the area and usually is eight magnitudes or more. The field is that of good definition, with the full aperture of the 60-inch mirror; its diameter is 23' and its area about one-ninth of a square degree. The number of stars shown in such a field on the plates of fifteen minutes exposure varies from 40 or 50 in high galactic latitudes to 2000 or 3000 in the star clouds of the Milky Way. The total for the Areas on and north of the Equator should be 55,000 or 60,000.

1 Published by the Astronomical Laboratory at Groningen.