25. COMMISSION DE PHOTOMÉTRIE STELLAIRE

Président: M. F. H. Seares, *Mount Wilson Observatory, Pasadena, Cal., U.S.A.*

Membres: MM. Baade, J. Baillaud, Beljawski, A. Bemporad, Bennett, Bergstrand, Danjon, Dufay, Fesenkov, Mme Payne Gaposchkin, MM. Graff, Greaves, W. K. Green, Guthnick, Hall, Hassenstein, Hellerich, Hertzsprung, Holm, Spencer Jones, Lindblad, Malmquist, Pannekoek, F. E. Ross, Rougier, Sampson, Schilt, Shapley, Šternberk, Tremblot, Vanderlinden, van Rhijn, von Zeipel.

Comment by members of the Commission has been invited on the following memorandum:

Zero Point of Photographic Magnitude and Colour Index

The committee of the Carte du Ciel in 1910 adopted the following convention:[*] That for Ao stars between magnitudes 5·5 and 6·5 the mean photographic magnitude should equal the mean Harvard visual magnitude. As a corollary, the colour index of Ao stars would then be zero.

The zero point of the photographic magnitudes of the International Polar Sequence was fixed as nearly as possible in accordance with this definition;[†] but it was by no means certain that the magnitudes thus adopted for the few stars of the Sequence represented the zero point defined by all the Ao stars specified.

For Ao stars of the Draper Catalogue north of +80° declination recent Mount Wilson data based on the polar standards[‡] give a mean colour index of −0·04 mag. From a large number of stars in regions seemingly unaffected by selective space absorption the colour index for Ao is −0·14 mag.[§] The polar region therefore shows a mean colour excess of 0·10 mag.;[||] the original definition of zero point is not satisfied and, if it is to be retained, requires further specification.

The inconsistency could be removed by restricting the definition to Ao stars in unobscured regions and applying a zero-point correction to the international photographic standards. It is difficult, however, to say that any given Ao star is certainly unaffected by selective absorption. Further, the determination of the zero-point correction required to satisfy the amended definition would be troublesome. In addition to the usual photometric complications, the photographic magnitude of an Ao star is affected by Balmer-line and continuous hydrogen absorption, possibly to the extent of 0·10 or 0·15 mag. The amount may vary from star to star, and, in any case, depends in a complicated manner upon the colour sensitivity of the instrumental equipment. Finally, to proceed as suggested would

[*] *Astr. Nach.* **186**, 40, 1910.
[†] *Mt Wilson Contr.* No. 97, p. 16; *Ap. J.* **41**, 221, 1915. *Trans. I.A.U.* **1**, 78, 1922.
[‡] *Trans. I.A.U.* **1**, 71, 1922.
[§] The basis for this estimate (from magnitudes on international system, stars in regions supposedly free from obscuration) is:

	m
Eros comparison stars, Ross and Zug, *Astr. Nach.* **239**, 289, 1930	−0·15
Eros comparison stars, Seares, Sitterly, and Joyner, *Mt Wilson Contr.* No. 415; *Ap. J.* **72**, 311, 1930	−0·14
Seares, 19 Selected Areas, spectra by Humason	−0·14
Stebbins and Whitford, unpublished photoelectric measures	−0·15

[||] *Mt Wilson Comm.* No. 119, p. 4; *Proc. Nat. Acad. Sci.* **22**, 330, 1936; also Shapley and Jones, *Harv. Bull.* No. 905, p. 14, 1937.

entail all the disadvantages following from a change in standards already used for many investigations.

Since the original definition was arbitrary and there is no noteworthy advantage in a zero colour index for Ao stars, it is recommended that the definition be abandoned and that the photographic magnitudes of the Polar Sequence stars (1922 values) themselves be accepted as a definition of the zero point of the international photographic scale.

This recommendation avoids the difficulties mentioned and merely continues a practice already established by sixteen years' usage. It makes no restrictions as to which stars of the Sequence shall be used, the implication being that the selection will include those best suited to any investigation in hand and enough of them to reduce the final accidental error to a negligible quantity. The effect of any residual errors of scale revealed by future refinement of the standards can be cared for as need arises.

It is necessary only to recognize that the colour index of normal Ao stars will no longer be zero, but instead, what observations based on the polar standards prove it to be, a value probably not far from the -0.14 mag. already mentioned.

Colour indices corresponding to other spectral types should also receive careful attention, since the normal relationship of colour to spectrum is essential for determinations of colour excess in obscured regions. Early-type stars should be examined for small intervals of spectrum, since the effect of hydrogen absorption produced by the atmospheres of these stars varies rapidly with type and appears to a quite different degree in photographic magnitudes determined with different instruments.

(A series of standard spectral types for stars in regions as free as possible from absorption would be helpful in the unification of observational results, and the Commission may wish to consider the appointment of a committee to give this matter attention.)

STANDARDIZATION WITH ALUMINIZED REFLECTORS

The Commission has frequently emphasized the importance of reducing all photometric results to the international system. To this end it is usually necessary to include measurements of colour in any programme for the determination of magnitudes. Colour measurements of very faint objects near the limiting magnitude of the instrument are, however, impossible at present.

This circumstance, together with the steadily increasing use of aluminized mirrors, presents a situation requiring special attention. The high ultra-violet reflectivity of the aluminium reflector gives rise to a large colour equation in photographic magnitudes determined with such instruments. For a Bo star the gain in limiting magnitude relative to the silvered reflector is 0.32 mag.; for Go it is 0.10 mag.[*] If this colour equation is disregarded, the magnitudes of blue giants in a faint spiral nebula will be in error by about a quarter of a magnitude relative to the average of faint field stars and to the spiral as a whole. The effect on discussions of distribution will be serious. Since colour corrections cannot be determined, some modification of the observing method is desirable. Experiments at Mount Wilson indicate that the difficulty may be avoided by using a clear glass filter of appropriate thickness in front of the plate. The aluminized reflector is thus transformed, statistically at least, into the equivalent of a silvered reflector.

[*] Pettit, *Pub. A.S.P.* **46**, 30, 1934.

The following comments have been received:

I am strongly in favour of the proposed definition of the zero point which formally sanctions the present usage and which meets all practical requirements.

Dr Seares in his memorandum has already outlined the principles of standardization with aluminized reflectors. As to the practical consequences, it should be pointed out that Pettit's computations (*loc. cit.*) are based on black-body radiation, neglecting the Balmer continuum for the A-type stars and the influence of the line absorption for the later types. Both effects diminish considerably the computed amount of the colour equation for types later than B8. The colour equation therefore will be large (of the order of 0·3 mag.) only for stars of normal colour of spectral types B and earlier, whereas it diminishes rapidly to negligible amounts for later types.

It is probable that the colour equation of aluminized mirrors will be of only minor practical importance for most photometric investigations in our own galaxy because the more distant B-type stars show considerable colour excesses.

For individual stars in globular clusters, or nearby extragalactic systems outside the zone of obscuration, the case is different. The difficulties encountered in such cases are illustrated by the experience of the writer in studying the Cepheids in the nearby system I.C. 1613. About half the plates used in this investigation have been obtained with silvered mirrors, the rest with aluminized mirrors. In plotting the final light curves it was found that on plates taken with aluminized mirrors the Cepheids were on the average 0·25 mag. fainter than on those obtained with silvered mirrors. A detailed investigation revealed the following reason for this discordance: since I.C. 1613 is situated in high galactic latitude, practically all the comparison stars are members of the system. A large percentage of the brighter stars of the system are of early type (probably early B's) which gained about 0·25 in magnitude on the aluminium system, whereas the gain for the Cepheids, being of spectral type G and later, was zero. Since the stars in question are too faint for a sufficiently accurate determination of their colour indices with our present optical equipment, the colour equation had to be applied in a statistical way. This procedure is far from satisfactory; since it does not take care of the individual case, it introduces a new source of accidental error. Moreover, for I.C. 1613 the colour correction is a function of the apparent magnitude, which opens the way to systematic errors in the final results. To avoid future troubles of this kind we are using now for all photometric purposes a Schott GG1 filter (1·8 mm. thick) in front of the photographic plate. The absorption of this filter in the ultra-violet is such that it converts, with sufficient accuracy, the colour curve of the aluminized reflector back into that of the silvered reflector. The loss in limiting photographic magnitude due to the filter is negligible (of the order of 0·1 mag.).

Such a radical procedure seems to be fully justified. As pointed out above, only B-type stars of normal colour show an appreciable gain on the aluminium system compared with the silver system. For most photometric problems this gain for a very restricted group of stars has only nuisance value (see above).

<div align="right">W. BAADE</div>

Your circular letter proves to be a difficult one to answer, for it seems that the whole subject is coming to a parting of the ways that could not have been foreseen even a few years ago.

<div align="center">217</div>

I will first comment briefly on the suggestions made in the letter; secondly, I will raise some questions of my own.

The Zero Point of Photographic Magnitude and Colour Index. There seems to be little reason for adhering to the original definition of the zero point of the photographic system (*Astr. Nach.* **186**, 40, 1910), especially because the Harvard Catalogues, as has now been realized, are far from homogeneous in colour equation, and therefore provide a very poor medium for relating the visual system to another; it is very regrettable that the Potsdam Catalogue was not used. Furthermore, the definition was never actually used in practice (and would have been difficult to use).

I am therefore not in favour of attempting to stick to the original definition or even of trying to amend it by excluding certain regions where obscuration may be effective, since our general knowledge of obscuration is at present of the scrappiest kind.

I should like to support the recommendation that the definition be abandoned. I should suggest saying "that the photographic magnitudes now in use (*Trans. I.A.U.* **1**, 71, 1922) be used without alteration in further work, and that attention be drawn to the fact that they do not conform strictly to the original definition of the zero point of a photographic system". People are going to continue to use the standards anyhow, and no change in practice will be introduced. On the other hand they will be reminded (and they cannot be reminded too often) that there are systematic errors and uncertainties, even where accidental error has been reduced to a minimum.

The suggestion of a series of standard spectral types opens up the broad question as to the best ultimate selection of fundamental standards. I should like to suggest that the first requirement would be a selection of stars as nearly as possible identical in colour, and covering as large a range of brightness, and as large a part of the sky, as possible. Main-sequence stars of Group G (F8, G0, and possibly a few of G5) would perhaps be the best selection, since they are of relatively low luminosity, and since their spectra are as little distorted by lines and bands in the photographic region as any that could be chosen. Class A was about the most unfortunate class that could have been selected, from the latter standpoint.

When a reliable fundamental network of stars has been chosen and standardized (possibly with the aid of the photoelectric photometer) a careful selection of stars of other colours with known spectra should also be made. It seems that a network of stars of this sort would be of the utmost use in the unification of results.

It seems to be interesting to raise the question as to the relative precision of spectral classes and colour indices. The latter, measured with care and good methods, may have a probable error of $\pm 0 \cdot 07$, I estimate. What is the probable error of a spectral classification, translated into colour? I estimate that it is from 50 to 100 per cent. larger than that of the colour, and for very faint stars it may be larger still, even without taking into account the systematic errors that affect the spectral classification of faint stars.

Standardization with Aluminized Reflectors. The problem raised by the aluminization of a reflector is no different from that raised in the use of any instrument other than a reflector in work on magnitudes. The aluminization will produce a colour equation that will (presumably) be a function of the colour of the object. In common with all work done with refractors, the work done with aluminized reflectors will require a knowledge of the colour of the objects photographed, if the magnitudes are to be expressed in the international system.

The correction itself is as determinate as the colour equation of any instrument. It is desirable, however, that special attention should be called to the need for determining it, so that several different determinations may be encouraged, and so that current and future work with aluminized mirrors may not be misinterpreted.

The use of a glass filter in modifying the effects of the aluminized mirror would probably be difficult to establish as a standard procedure, unless the precise kind of glass used, and its thickness, were kept constant in different observatories. Even so, it would seem desirable to determine the "colour equation" of the aluminium-glass filter combination directly, and if that has to be done in any case, many will feel, I think, that a direct determination of the colour equation, without any glass filter, would serve the purpose equally well. An additional optical complication would be avoided, and a fainter magnitude probably attained.

It seems likely that some of the fast red-sensitive or yellow-sensitive plates now available, used without a filter or with some slight restraint on the blue, would give a useful clue as to whether the bright stars in a faint spiral nebula were actually very blue or very red stars. In the nebula itself these two kinds should be distinguishable, if they are photographable at all. Such plates would of course be quite useless for determining colour indices, but they should indicate which are the very blue stars, and hence which stars should be corrected for the colour equation of the mirror.

Additional Suggestions. (1) That the Commission pay special attention to photo-electric photometry, especially photoelectric work on standards of magnitude, the relation of photoelectric scales to photographic and visual scales (by encouraging careful study of effective wave-lengths of photoelectric systems), and the unification and direction of photoelectric researches in different places, which are at present in little or ineffective contact. (2) That the Commission feel and take a definite responsibility in the matter of standard magnitudes of comparison stars for variables. The people who use them are not usually photometrically trained, and are not able to produce, themselves, magnitudes that are unimpeachable in scale and colour equation.

<div align="right">CECILIA PAYNE GAPOSCHKIN</div>

In Beantwortung des Rundschreibens an die Mitglieder der Kommission 25 der IAU. teile ich Ihnen mit, dass ich dem Vorschlag, die bisher übliche Definition des Nullpunktes der Farbenindices zu verlassen und statt dessen die photographischen Grössen der Polarsequenz (1922) als Definition des Nullpunktes der internationalen photographischen Skala anzunehmen, zustimme. Ich halte den Vorschlag für den zweckmässigsten, den man machen kann.

<div align="right">P. GUTHNICK</div>

Nullpunkt der photographischen Helligkeitsskala. Ich halte es für dringend erwünscht, die Polsequenz (1922 Werte) als Grundlage der Festlegung des Null-punktes beizubehalten. Eine andere Festlegung ist zur Zeit ohne gewisse Willkür doch nicht möglich, da unsere nur lückenhafte Kenntnis der Absorptionsverhält-nisse im Milchstrassensystem die einwandfreie Auswahl eines absorptionsfreien Gebietes nicht gestattet. Ausserdem würde der Wechsel der Standards später nur zu Irrtümern Anlass geben und unnötige Reduktionsarbeiten erfordern.

Ich möchte aber bei dieser Gelegenheit noch auf einen Punkt hinweisen, der für die Standardisierung nicht unwesentlich ist. Mit der Einführung der Polsequenz

1922 ist ein Helligkeitssystem als Standard genommen, welches mit einem Spiegel (100 bezw. 60 Inch) Reflektor bestimmt ist. Nun besitzt ein Spiegel aber eine sehr grosse Amplitude effektiver Wellenlängen für die Sterne der Typen B bis K (nach Hertzsprung für den MW Spiegel mehrere hundert AE). Das Helligkeitssystem ist also sicher nicht monochromatisch, z.B. der Wellenlänge 4250 entsprechend, die meistens als Äquivalentwellenlänge der photographischen Beobachtungen angesehen wird. Die Helligkeiten werden einem solchen monochromatischen System gegenüber eine Farbgleichung aufweisen. Inwieweit die in üblicher Weise eventuell unter Zuhilfenahme von Registrierphotometern bestimmten effektiven Wellenlängen als Argument für die photometrische Farbgleichung verwendet werden können, lässt sich durch Beobachtungen entscheiden. Unter Benutzung der Russellschen Formeln kann mit den Werten der Temperatur (aus dem Spektraltypus) und den dazugehörigen λ_{eff} für zwei Instrumentarien (Platte und Fernrohr, bezw. Spiegel) der relative Farbindex ihrer Helligkeitssysteme, d.h. die Farbgleichung berechnet werden. Man kann auch versuchen für jedes Instrument die Reduktion auf $\lambda = 4250$ zu berechnen. Ob sich auf diese Weise eine rechnerische Bestimmung der Farbgleichung durchführen lässt, kann zur Zeit nicht geprüft werden, da für die meisten Instrumente, mit denen photometrische Beobachtungen ausgeführt sind, entweder keine λ_{eff} bestimmt sind, oder nicht zu ersehen ist, ob die photometrischen Helligkeiten mit derselben Plattensorte aufgenommen sind, wie die λ_{eff}. Es ist aber für die obige Rechnung erforderlich, dass für Helligkeits- und effektive Wellenlängenbestimmungen Platten derselben Farbempfindlichkeit benutzt sind. Die Verwendung von Objektivgittern gestattet auch für kleine Instrumente die Bestimmung der λ_{eff} der Hauptspektraltypen (z.B. Rosenberg-Bergstrandsche Normalsequenz), ohne Schwierigkeiten. Ich beabsichtige eine derartige Rechnung für die Farbgleichung des Bergedorfer Refraktors auszuführen, kann aber aus den Veröffentlichungen des Mt Wilson Observatoriums nicht ersehen, ob die λ_{eff} von Hertzsprung auf Platten der gleichen Empfindlichkeit wie die photometrischen Beobachtungen aufgenommen worden sind.

Rothelligkeiten. Ferner möchte ich darauf hinweisen, dass auch für die Rothelligkeiten die Festlegung einer Skala im engsten Anschluss an die Polsequenz 1922 wünschenswert ist. Hierdurch wird die unnötige Einführung mehrerer Referenzskalen vermieden. Schon heute bestehen mehrere Kataloge von Rot- bezw. Infrarothelligkeiten, und es wird früher oder später der Zustand eintreten, dass eine grössere Zahl von Beobachtungsreihen mit verschiedenen Bezugsskalen vorliegt, deren gegenseitige Reduktion zeitraubend und nur durch neuen Aufwand an Beobachtungsmaterial möglich ist. Durch den Vorschlag einer Rotskala wären Beobachter von Rothelligkeiten verpflichtet, ihre Beobachtung an diese Skala hinsichtlich des Nullpunktes anzuschliessen, und durch Aufnahme der Skala einen Vergleich zu ermöglichen, wie es sich bei den photographischen Helligkeiten und bei den Beobachtungen der effektiven Wellenlängen bewährt hat. Bei der Festlegung der Standardsequenz für Rothelligkeiten muss noch der Umstand berücksichtigt werden, dass die Benutzung der eigentlichen Polsequenz (schwächere Sterne) zu grossen Belichtungszeiten führt, die helleren Sterne aber für Instrumente mit einem kleineren oder mässig grossen Gesichtsfeld wegen ihrer Verteilung über ein grösseres Areal des Himmels nicht sehr geeignet sind, und deshalb vielleicht eine Hilfssequenz hellerer Sterne im Bereich 8–12ter Grösse in Erwägung zu ziehen wäre. Ich selbst habe für die Bergedorfer Rotaufnahmen eine Gruppe von Sternen dieses Helligkeitsbereiches in der Umgebung der Sterne 8 und 9 der Polsequenz verwendet.

Farbenindices. Es ist empfehlenswert, wenn die Kommission eine oder mehrere Gegenden, die nach dem augenblicklichen Stand unserer Kenntnisse als frei von Absorption anzusehen sind, in Vorschlag bringen würde zur Bestimmung absorptionsfreier Farbindices. Hierzu würde sich z.B. die Gegend des galaktischen Pols (eines der in der Nähe gelegenen Kapteynschen Eichfelder) oder z. B. die nach Harvard Angaben freie Gegend nahe dem Eichfeld 26 $(6^h 36^m + 45°)$ eignen. In diesem Gebiete wären dann auch die absorptionsfreien Standardspektraltypen B, A, u.s.w. festzulegen. Eine in dieser Richtung gehende Untersuchung ist am Anfang des letzten Jahres am 60-cm. Refraktor der Hamburger Sternwarte (siehe Bericht) begonnen worden.

<div align="right">J. Hellerich</div>

In reply to your letter to the members of the Commission on Stellar Photometry I wish to say first that I endorse entirely your proposition regarding the zero point of the photographic magnitudes. It has long been recognized by us here and at Upsala in the course of our spectrophotometric researches that the heterogeneity in absolute magnitude and colour of the Ao stars makes it difficult to adhere to the old definition, especially because there might easily be a systematic change with the galactic latitude. As you remark, the difference of intensity in the ultraviolet due to a different width of the hydrogen lines and a resulting variation in the depression of the average intensity curve will make the old definition sensitive to the kind of instrument used. The effect of the absolute magnitude will also vary with the ultra-violet extension of the spectral region and thus with the instrument. Space absorption, of course, enters also as a disturbing element.

Regarding the proposition to use a glass filter in the case of an aluminized reflector, I have not sufficient experience to venture a definite opinion. It seems in a way a pity to cut down the efficiency of the aluminized mirror. Perhaps photometry with and without a glass filter may be worth while to be carried out parallel to one another, as the difference may tell us something regarding the character of the white stars. I may refer here to the properties of an ultra-violet colour index studied by Dr Öhman with a special method mentioned below.

<div align="right">Bertil Lindblad</div>

I see no necessity for any change in the zero point of colour indices. It might be argued that the metre should be changed, since it no longer satisfies its original definition. The confusion resulting would be similar in the two cases. Should a change be adopted now, subsequent research would undoubtedly lead to further correction. This is more than likely, since our present knowledge of the distribution of absorbing matter is somewhat sketchy.

<div align="right">F. E. Ross</div>

(After some correspondence concerning the memorandum)
I have your letter of December 13 and I am completely reassured with respect to the proposals in your report.

<div align="right">Jan Schilt</div>

I agree with you that we should not tamper at present with the zero point at the North Pole. If adjustments are to be made, now is not the time.

I think we must face aluminum magnitudes bravely. The job before us will include calibrations and standardizations, with the photographic sequence at the

North Pole a base of reference. I do not believe that we at Harvard, at least in practice, will want to introduce the use of a neutral filter that will compensate for the contribution of aluminum surfaces.

HARLOW SHAPLEY

Je suis d'accord avec les projets du point de zéro et de la standardisation des indices de couleur.

B. ŠTERNBERK

I do not quite agree with your proposal that "the photographic magnitudes of the Polar Sequence be accepted as a definition of the zero point of the international photographic scale".

It seems to me that we ought to make a restriction as to which stars of the Sequence should be used for the definition of the zero point. If e.g. the photographic magnitudes determined at some observatory have a colour equation relative to the international system, the zero point of these magnitudes may be determined by equating either the magnitudes of the white stars in both systems or of the red stars.

We have to make a choice and it seems to me that it is better that all astronomers make the same choice. Similar difficulties will occur if the magnitudes show a scale difference relative to the international photographic scale. Would it not be better to have the zero point fixed by means of the stars 2, 4 and 5 of the Polar Sequence which are all of about the same magnitude and colour?

P. J. VAN RHIJN

INVESTIGATIONS IN PROGRESS

The following material has been submitted for publication in the Report:

1. The reduction of forty thousand stars in various visual catalogues to a homogeneous system has been completed.

2. A number of photographic catalogues, notably the Yale and Columbia Catalogues and the original *Göttingen Aktinometrie* have been combined with the reduced visual magnitudes (having been themselves reduced to the International Photographic system where necessary) to form a catalogue of colour indices of comparatively bright stars.

3. The stars in the catalogue of colour indices, together with the available information on parallaxes and proper motions, are yielding a discussion of the colours of stars, as a function of spectral class and apparent magnitude. This discussion has for its object the formation of definite standards of colour, in relation to which reddening can be measured. In the absence of such definite standards, all conclusions as to reddening must be very tentative.

4. Three sets of photo-red standards have been established.

(a) The red magnitudes (12-inch Metcalf refractor, Eastman I-C spectral plate, Ciné red filter) have been established at the North Pole.

(b) Red magnitudes have been established in all the Harvard Standard Regions at +15°.

(c) Red magnitudes have been established in all the Selected Areas at and south of the declination −30°. All three determinations go somewhat fainter than the

twelfth (photo-red) magnitude. All are being published in Vol. **89** of the *Harvard Annals,* and will be in print in a few weeks.

5. The determination of photographic and photo-red magnitudes for all stars of known spectra in the Kapteyn "Eichfelder" in the southern sky has progressed. Photographic magnitudes have been determined and published (*Harvard Mimeograms,* Series II, Nos. 1, 2, 3) at $-15°$ (Selected Areas only), $-45°$ and $-60°$. Photo-red magnitudes have been determined in eight of these Selected Areas, and will shortly be published. A preliminary discussion of the red indices appears in *Harvard Annals,* **105**. The remaining photographic and photo-red magnitudes are now in process of measurement.

<div align="right">CECILIA PAYNE GAPOSCHKIN</div>

Sternphotometrie. Im Jahre 1938 werden rund 350 Felder für veränderliche Sterne und mehr als 200 Felder in der Umgebung von hellen Nebeln abgeschlossen sein. Grenzen der ersten Reihe 8^m bis $14^{m}·5$, der zweiten $7^{m}·5$ bis 12^m. Die Messungen erfolgten an den grossen Refraktoren der Sternwarten Bergedorf und Wien mit Vergleichsphotometern eigener Bauart unter strengem Anschluss an die Harvard-Skala. Beobachter: K. Graff.

Sternkolorimetrie. Ausser dem Farbenkatalog aller Sterne bis 5^m zwischen dem Nordpol und 40° südlicher Deklination sind Zonen der Sterne bis $6^{m}·5$ in Bearbeitung, die folgende Gebiete umfassen:

A. Zonen: $-40°$ bis $-10°$ (erschienen 1936)
$\qquad\quad -10°$ bis $+20°$ (1937 bis auf 3 Stunden abgeschlossen)
$\qquad\quad +20°$ bis $+40°$ (1937 begonnen)

B. Milchstrassenfelder: Cepheus (erschienen 1937)
$\qquad\qquad\qquad\quad$ Cassiopeia (erschienen 1937)
$\qquad\qquad\qquad\quad$ Perseus (1937 fast abgeschlossen)
$\qquad\qquad\qquad\quad$ Camelopardalis (1937 begonnen)

Beobachter : K. Graff. Instrument : Visuelles Kolorimeter eigener Konstruktion an einem 11-cm. Refraktor. Beobachtungsort : Insel Mallorca (Spanien) und Insel Solta (Dalmatien). Seit Ende 1932 rund 21 000 Messungen.

<div align="right">K. GRAFF</div>

Weiter teile ich Ihnen mit, dass hier ein Katalog lichtelektrisch gemessener Helligkeiten in zwei Spektralgebieten von allen mit unseren instrumentellen Mitteln bequem erreichbaren Sternen nördlich des Aequators geplant ist. Ein erheblicher Teil der notwendigen Vorarbeiten ist bereits erledigt und die Beobachtungen sollen noch im Laufe dieses Jahres beginnen. Die Beobachtungen sollen auf zwei Instrumente verteilt werden, von denen das lichtstärkere für die Messungen mit einer Rubidiumzelle und Gelbfilter, das andere für die Messungen mit einer Kaliumzelle und Blaufilter, oder eventuell mit einer Natriumzelle, bestimmt ist. Vorerst sollen die hellen Sterne bis herab zur Grösse 4 oder $4\frac{1}{2}$ erledigt werden, dann im Anschluss daran die schwächeren bis zur erreichbaren Grenze. Die Messungen der einzelnen Sterne sollen an den beiden Instrumenten möglichst gleichzeitig erfolgen.

<div align="right">P. GUTHNICK</div>

60-cm. Refraktor der Sternwarte Hamburg-Bergedorf. Die Helligkeiten von Sternen des Bereiches $8^m–13^m$ Grösse in mehreren Feldern in der Koma sowie den Kapteyn Eichfeldern 40, 41, 64, 87, 98 sind bestimmt worden. Die Helligkeiten

<div align="center">223</div>

dienen als Standardsequenzen für das laufende Programm der Bestimmung der Helligkeiten in 20 galaktischen Sternhaufen. Für diese Sterne werden auch die Rothelligkeiten im Anschluss an eine in der Nähe des Nordpols gelegene Standardsequenz mit dem Verkleinerungssystem bestimmt. Die Aufnahmen der galaktischen Sternhaufen und der Standardsequenzen sind abgeschlossen. Für die helleren Sterne der Spektraltypen B-F sind in der Umgebung des galaktischen Poles sowie des Kapteyn Eichfeldes 26 am Refraktor in Verbindung mit dem Einprismenspektrographen die Spektraltypen dieser Sterne bestimmt.

J. HELLERICH

Dr Malmquist has written to you recently concerning his work here. In the course of a spectrophotometric investigation of the Hyades region to phot. mag. 13·5, Dr J. Ramberg determines also the photographic magnitudes of the stars down to this limit in a way similar to that employed by Malmquist in his work on the 4500 stars near the galactic pole. Dr Ramberg makes a spectrophotometric study of the Hyades and Praesepe in order to study the spectrophotometric criteria for these groups.

An application of the spectrophotometric criteria of absolute magnitude to the Selected Areas with special slitless spectrographs on the 40-inch reflector is planned by me. I hope to reach about magnitude 14·0. The dispersion is low but the focus is very good from ultra-violet to red.

The spectrophotometric work of course belongs to another Commission, but I have mentioned it here because it may have consequences of some interest for the photometry and colorimetry of the stars in question.

In the following statement Dr Öhman describes some further colorimetric results with his rotatory spectrograph:

This instrument has been described by me in *Observatory*, **69**, 335, 1936 and in *Stockholms Observatorium Meddelande*, Nos. 28, 31, 32, 1936–37. A lecture dealing with this matter, given at the Paris meeting of astrophysicists in July 1937, will soon be printed.

The new method has been tested in several different respects. In order to investigate the nature of the colour index obtained with the rotatory spectrograph I have observed selected bright stars, as well as some stellar clusters and Selected Areas. The mean error in a determination of the relative colour index of a star from one exposure (4 images) has proved to be slightly less than 0·03 mag. when a field of stars is observed. The double cluster h and χ Persei has been observed on a number of plates. Some preliminary measurements show a very good agreement with Oosterhoff's effective wave-lengths. For about 50 bright stars a good agreement with W. Becker's photoelectric colour indices has been found.

The best way of standardizing the plates has proved to be the grating method. With a grating in front of the telescope twelve images are obtained of every star. These images can be used not only for deriving the plate characteristics but also for studying the effective wave-lengths of the two kinds of images.

BERTIL LINDBLAD

The photometric work mentioned in the report to the Paris meeting has been published as " Investigations on the Stars in High Galactic Latitudes II, Photographic Magnitudes and Colour Indices of about 4500 Stars near the North Galactic Pole" in *Stockholms Observatoriums Annaler*, Band **12**, No. 7, 1936.

A spectrophotometric analysis of about 2800 of these stars down to photographic magnitude 13·5 has now been finished and will be published as soon as the statistical discussion of the material has been brought to an end. For the later spectral types a separation between giants and dwarfs has been made by the aid of the cyanogen equivalent. The differences in mean colour indices between giants and dwarfs of the same spectral type are very marked, as is seen from the following table:

Spectrum:	G0	G5	G8	K0	K2	K4	K6	K8
Giants:	0·69	0·88	0·97	1·06	1·26	1·41	1·43	?
Dwarfs:	0·55	0·62	0·74	0·82	0·89	1·02	—	1·20

A differential method of determining colour indices with reflectors, consisting of a combined use of half colour filter and grating has been examined from some plates of the Praesepe cluster. The method was proved to work very satisfactorily; no traces of systematic errors were found over an interval of seven magnitudes, covered by the preliminary tests. The mean error of a colour index, derived from *one* pair of images, was found to be 0·05 mag. in a scale 25 per cent. wider than that of the international system of colour indices. This investigation, which will soon appear in print, contains colour indices of 220 stars in the cluster.

<div align="right">K. G. MALMQUIST</div>

1. Vol. **6**, part 2, of the publications of the Observatory contains visual magnitudes and co-ordinates of 6284 comparison stars in 350 regions of long-period variable stars. The zero point and scale are on the Harvard visual system. It is planned to reduce these magnitudes to the I.A.U. system by reobserving a number of regions photovisually in connection with the derivation of proper motions of the variables.

2. Vol. **7** of the publications contains the photovisual magnitudes of 18,000 stars from 8th to 13th magnitude in 341 regions fairly uniformly distributed over the sky north of −30° Decl. The probable error of one magnitude is ±0·12. Much care was taken to have the system of magnitudes coincide with the I.A.U. system. The colour correction was found to be satisfactorily small.

3. In connection with this work, an investigation of the zero point and scale of the Durchmusterung (B.D., S.D. and Co.D.) magnitudes reduced to the Harvard visual system indicated that they may be reduced to the I.A.U. system by the formula

$$IPv = (\text{Durchm})_{\text{H.V.}} + 0·15 − 0·2\ C.$$

4. In fifty-two of the Selected Areas the observation of the photovisual magnitudes down to the 13th magnitude with the 10- and 26-inch refractors is now in progress. Only galactic Selected Areas (with latitude ±20°) and north of −30° Decl. are included in the programme. The zero point and scale are to be on the I.A.U. system.

5. Magnitude sequences down to the 10th magnitude are being observed with the 10-inch Cooke telescope in 340 regions distributed uniformly between −25° and +75° Decl. at intervals of 36^m sec δ in R.A. and 10° Decl. One comparison with the N.P.S. is made for each sequence. It is proposed to use the sequences as standards in connection with the various proper motion programmes of the Observatory.

<div align="right">S. A. MITCHELL</div>

The systematic programme of photographic magnitudes for AG stars has been continued. Plates are taken with the 3-inch Ross lens of 21-inch focal length at

the Yale Observatory. Since my previous report the magnitudes in the zone $+55°$ to $+60°$ have been published in *Contributions from the Rutherfurd Observatory of Columbia University*, No. 30, together with a detailed description of the method used. The resulting magnitudes appear to have a mean error of ± 0.094 mag. They are related to WPg (Seares, Ross, and Joyner, *Magnitudes and Colours of Stars North of $+80°$*, 1935) by the equation

$$0.995 \ WPg \quad -0.088 \ \text{C.I.} \quad +0.042 = m_{pg}$$
$$\pm 0.006 \ \text{(m.e.)} \quad \pm 0.016 \quad \pm 0.047$$

and to A. de Sitter's magnitudes (*Bulletin of the Astronomical Institutes of the Netherlands*, Vol. **6**, No. 210, 1930) by

$$1.012 \ m_{dS} \quad +0.032 \ \text{C.I.} \quad -0.060 = m_{pg}$$
$$\pm 0.015 \ \text{(m.e.)} \quad \pm 0.026 \quad \pm 0.100$$

The magnitudes for the zone $+50°$ to $+55°$ have been completed in manuscript. The equations giving the relations to WPg and to A. de Sitter are substantially the same as above. The method has now been sufficiently standardized and we do not expect to make important changes in the procedure for the remaining four zones between $+30°$ and $+50°$. The work on these zones is well in hand.

<div style="text-align: right">JAN SCHILT</div>

The extension of the Polar Sequence undertaken at Mount Wilson with the co-operation of Dr Ross of the Yerkes Observatory has been described in earlier reports and in various publications, and the final photographic magnitudes were presented to the Commission at the Paris meeting of 1935. Owing to difficulties arising from abnormal plate corrections, the photovisual results are still unfinished. To strengthen the connection between the photographs at 87° Decl. and those at 83°, an additional series centered at 85° has been included in the programme. Unless additional delay is encountered, the investigation should be finished sometime during 1938.

<div style="text-align: right">F. H. SEARES</div>

In our work on galaxies we have during the past three years established more than two hundred magnitude sequences by the star-count method (for use in the determination of the magnitudes of external galaxies and of faint variable stars in the higher latitudes), and extending from the 12th magnitude to magnitude 18 and fainter. Wherever we have checked the star-count sequences in the northern sky with Selected Area sequences, we have found surprisingly good agreement. The star-count sequences are of course useful and dependable only in latitudes higher than $\pm 20°$. We are troubled about faint-star sequences in general in the southern sky, but for the time being we must use the standards at present available.

We shall get under way within a few months a special study of the magnitude sequences to the 17th photographic magnitude for Selected Areas south of $-15°$ Decl. The extension of these carefully revised sequences to fainter magnitudes must await an opportunity of including such work in the heavy programme of the southern 60-inch reflector. To the 17th magnitude the work can be done we believe (with as high accuracy as obtained in the northern hemisphere) with the use of the

<div style="text-align: center">226</div>

Bruce refractor at the Boyden station. An objective grating, a thorough inter-comparison with equatorial Selected Area sequences, and a thorough examination of the colour equation of the Bruce telescope will all be involved in this research that is now getting under way.

We continue to set up sequences in the Magellanic clouds in blue and in red, referring the sequences always to the International Standards for the blue, and to the Harvard Standards in the Standard Region or Selected Areas for the red.

With the Metcalf refractor at Oak Ridge we are continuing to accumulate material for the determination of photovisual-magnitude sequences for northern long-period variable stars.

<div align="right">HARLOW SHAPLEY</div>

As stated in the last report, the photographic magnitudes of stars brighter than 13 in the northern Selected Areas 1 to 115 are being determined at the Kapteyn Laboratory with a Schilt microphotometer on plates taken with the 8-inch Draper lens of the Harvard Observatory ($1' = 0.367$ mm.). The spectral classes of the stars are being determined at the Hamburger Sternwarte by Prof. Schwassmann. The field of each Selected Area is $3°.5 \times 3°.5$. The standard magnitudes of each area have been found by means of 5 to 7 polar comparison plates, using as a basis the international magnitudes of the polar stars. It appears that the colour equation of the magnitudes relative to the International System is zero. The spectral classes and photographic magnitudes of Areas 1 to 19 have been published in Band I of the *Bergedorfer Spektral-Durchmusterung*. The magnitudes agree with the *Mount Wilson Catalogue of Photographic Magnitudes in Selected Areas 1 to 139*. The second volume of the *Bergedorfer Spektral-Durchmusterung* containing Areas 20 to 43 will be published before the end of 1937. The mean differences Δm between the magnitudes of the Mount Wilson catalogue quoted above and the Groningen magnitudes are:

m	Δm
9·1	+0·26
10·5	+0·04
11·5	−0·01
12·6	−0·05

The Groningen scale therefore differs from the Mount Wilson scale, especially for the bright stars.

The following experience we have had in connecting the magnitudes of the polar sequence with the magnitudes of the stars in the Selected Areas may be of import-ance. This connection has been made for Areas 1 to 19 by taking exposures of the Polar Sequence and of the Selected Area of equal length on the same plate. It appears that the magnitudes of the stars in the Selected Area on the plates taken in the order Pole–Area are systematically fainter than the magnitudes derived from the plates taken in the reverse order. Dr Bok found this effect on plates measured at the Harvard Observatory and it certainly is equally present on the plates measured here. The difference varies from plate to plate and in some cases amounts to 0·8 mag. The effect is probably due to a decrease of the sensitivity of the plate during the first exposure caused by the moisture in the atmosphere.

In order to avoid this effect, the magnitudes of Areas 20 to 43 have been standardized by taking the exposure on the Polar Sequence and the Selected Area

on different plates taken from the same box and developed together. The error introduced by this effect in the magnitudes of Areas 1 to 19 is not large because half of the polar comparison plates of these Areas have been taken in the order Pole–Area, the other half in the order Area–Pole.

P. J. VAN RHIJN

F. H. SEARES
President of the Commission

March 12, 1938