PRESENT ASPECT OF ASTRONOMICAL PHOTOGRAPHY

BUNSHIRO TAKASE

Tokyo Astronomical Observatory, Mitaka, Tokyo, Japan

ABSTRACT

Photographic method has long been widely used in astronomical photometry, spectroscopy, and astrometry. There has been a notable progress during the past decade in such respects as photographic emulsions, hypersensitizing techniques, processing methods, and so on.

The present report will outline the current aspect of the astronomical photography together with the practice of photographic work using the Tokyo Observatory 105cm Schmidt telescope.

1. History of Photography in Early Days*

In 1837 Louis Daguerre introduced the first practical photographic method which was called Daguerreotype process. The name of "photography" which means "drawing with light" was given by Sir John Herschel to this technique in 1839. In 1840 John Draper took the first astronomical photograph of the Moon by Daguerreotype, probably using the Harvard 33cm visual refractor, which was not ideally suited for use with blue-sensitive materials.

An early attempt to photograph star images was made at Harvard in 1850 using a Daguerreotype plate and the bright star Vega, but results were reported poor.

De la Rue of England obtained in 1852 the photography of the Moon with the somewhat improved method of the collodion wet-plate process.

The first successful "dry" plates making use of gelatine as the vehicle for the silver halide emulsion were prepared by R.L. Maddox in 1871, and these have become widely used since then.

In 1873 H. Vogel discovered the dye-sensitization phenomenon which extended the sensitivity range of the photographic plate to longer wavelength.

Since these early days more than a century has passed, during which the techniques of photography has steadily developed, although its principle has remained unchanged.

2. Informations Obtained from Astronomical Photography.

a) From *inspection* of astronomical plates, one can make identification of celestial objects; classification, for example, of galaxies from their shape characteristics, and counting, for example, the number of specified type of stars per one square degree of the sky.

b) From *astrometry* of the photographed images, position and proper motion of the objects are measured and further an accurate optical identification of the objects is made which have been found as the sources of radio, infrared, X-ray, and so on.

c) From *photometry* of the plates, informations of magnitude, color, shape, dimension, and variability of stars and galaxies are obtained.

d) From *spectroscopy* of the spectrograms, spectral type and spectral peculiarity of stars and galaxies are acquired, and their radial velocities are also determined.

3. Currently Available Photographic Materials

Fig. 1 shows the differences of the spectral sensitivity between various types of photographic emulsions. Orthochromatic, panchromatic, and infrared emulsions (including IN and IZ types) are

* This section is an extract from an address given by W.C. Miller at the ESO Workshop on "Modern Techniques in Astronomical Photography" held in Geneva, May 16-18, 1978.

all dye-sensitized and have the sensitivity in the regions of longer wave-length.

Fig. 2 is a diagram indicating the spectral sensitivity regions of various Kodak spectroscopic plates which are currently available.

Fig. 3 shows an example of the color band system. This is one now in use at the Kiso Station of the Tokyo Astronomical Observatory, and consists of the combinations of various Kodak plates and Schott color glass filters.

4. Recent Progress in and around Astronomical Photography

A. Millican summarizes the progress of the astronomical photography during the past decade as follows:

a) We have emulsions of finer grain and higher detectivity;

b) Hypersensitization techniques* have developed which make plate sensitivity higher, through the elimination of low intensity reciprocity law failure;

c) We have now several devices of uniform processing procedure which are also effective for larger size photographic plates;

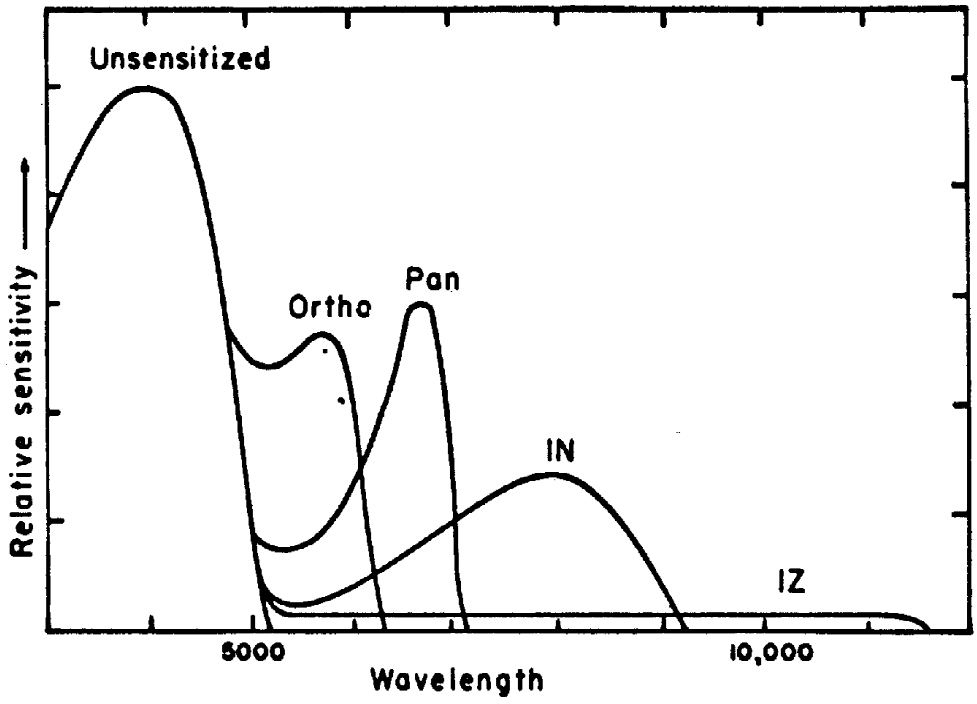

Fig. 1: Relative spectral sensitivities of various type emulsions (quoted from J. Stock & A.D. Williams, Astronomical Techniques of Stars and Stellar Systems, p. 374, 1962).

* Hypersenstization techniques include preflash, evacuation, cooling, baking, soaking, bathing, and so on.

d) High-speed measuring instruments are now available to permit computer manipulation of the photographic data; and

e) Large aperture and low focal-ratio telescopes have appeared which make the deeper sky observation with photography possible.

Millikan further mentions on the complementary characteristics of astronomical photography and photoelectronic observation methods, the latter of which have also largely progressed during the past decade.

According to him, electronic detectors are superior to the photographic plate in such respects as:

a) Sensitivity and quantum efficiency;

b) Real-time output in computer-usable form; and

c) Linearity between input and output.

On the other hand photographic method excels the photoelectronic one in the following respects:

a) Coverage of the larger sky area;

b) Spectral sensitivity in wider wave-length range; and

c) Relative simplicity and low cost, suitable for various kinds of tasks.

The conclusion is that, consequently, the importance of the photographic method for the astronomical observation will never decline.

5. Practical Photographic Work at the Telescope — Example Case of the 105cm Schmidt Telescope at the Kiso Station of the Tokyo Astronomical Observatory

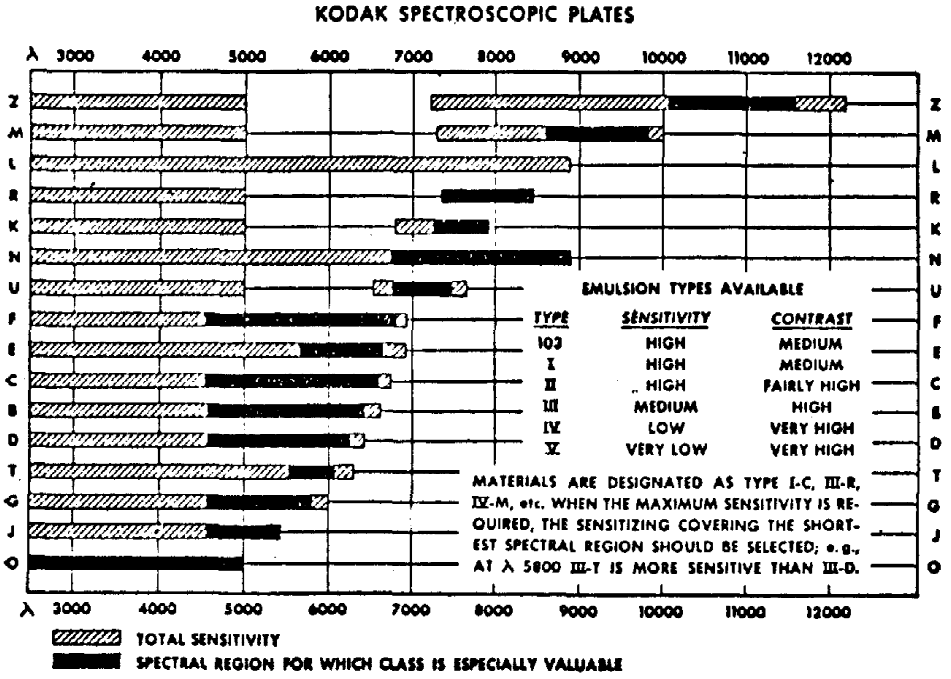

fig. 2: Spectral sensitivity of Kodak spectroscopic plates (Eastman Kodak Company),

Basic data of the 105cm Schmidt Telescope and its objective prisms are following. A detailed description of the elescope is given in Takase et al[3].

Aperture of the corrector plate and that of the spherical mirror are 105cm and 150cm, respectively. Focal length of the system being 330cm, its focal ratio is F/3.1, plate scale 62".5/mm, and therefore 14 inch (35.5cm) square plate which is usually used covers about 5°.5 square field.

Two objective prisms of which vertex angles are 2°and 4°are available. The dispersions at Hγ and A band of the former one are 800 and 3800 A/mm, and those of the latter 170 and 1000 A/mm, respectively.

The observation programs now under operation will be described below, classifying them into four items given in section 2.

a) Survey Programs Where the Inspection of the Plates is the Main task

(i) Detection of galaxies in the zone of avoidance

A systemetic survey of obscured galaxies near the galactic equator is being carried out in I color band. Quite a lot of galaxies which are embedded in HII regions and difficult to discern on Palomar sky survey atlases in H α and B color bands, have been picked up from our I color plates.

(ii) Detection of UV excess objects with UGR three image method

Our Schmidt telescope has a mechanism to apply each of three alternative filters simply by pushing the selection button on the operational panel, keeping the telescope direction unchanged. So it is quite convenient to make use of the so called three image method.[4] We have adopted UGR color system which has longer separation between color bands than UBV system. Exposure times are set so that the three images have equal densities for AO to A5 stars.

Many UV excess objects have been detected on these plates. For example on a plate centered at $\alpha = 8^h\ 48^m$ and $\delta = +40°$ are two white dwarfs which have already found by Giclas et al[5], GD 98 (B-V = -0.13, U-B = -0.94) and GD 94 (B-V = +0.29, U-B = -0.60). With careful inspection of this plate, 7 extremely UV bright stars which are further bluer than GD 98, 22 stars of which U brightness is in between GD 98 and GD 94, and 14 bluish stars have been detected. Quasars and compact galaxies might be among these objects. Several calibration trials are now in progress.

On the same plate is a Markarian galaxy Mkn 391. There exist quite a number of galaxies having the same order or stronger UV excess

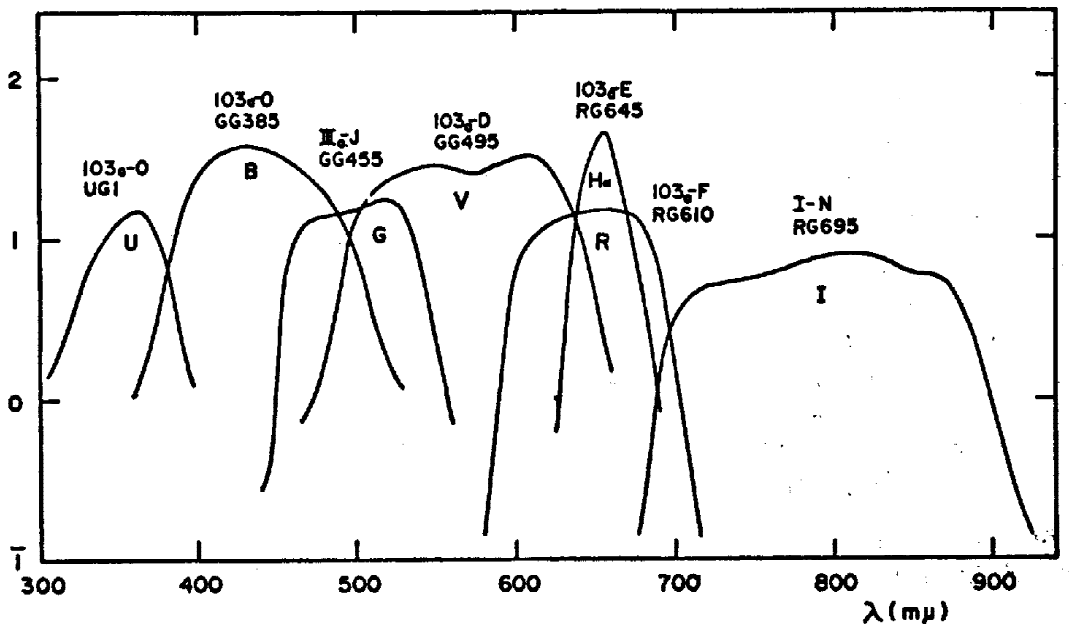

Fig. 3 The color band system now in use at the Kiso Station of the Tokyo Astronomical Observatory

compared to Mkn 391. Three image plates like this seem to be promising for a systematic detection of such galaxies as Markarian, Seyfert, and N types.

b) Survey Work Accompanied by the Astrometric Measurement

(i) Hunting of asteroids and comets

A pair of B color plates taken with 20 minutes exposures which are separated by 1 hour so is used to detect asteroids and other moving objects using the blinkcomparator. For example, from the plates centered at $\alpha = 1^h 40^m$ and $\delta = +10°$, about 200 candidates of asteroid are found out. Among them 4 are the already numbered asteroids and 10 are uncertain objects with given orbital elements. These identifications are made by the astrometry with the comparator measurement and its reduction. The rest of the objects are unknown but suspected asteroids or the like.

c) Photometric Works

(i) Distance determination of red giants

Red giants survey in the low galactic latitude region has been conducted to study the galactic structure based on the distribution of these stars. We take the photographs in V and I color bands, together with the spectral plates which will be mentioned later in paragraph d). From these direct plates the V and I magnitude and V-I color of the candidate stars are determined with the irisphotometer to give their distances. Our survey is expected to reach as far as 10 kpc.

(ii) Surface photometry of galaxies

The plates taken in several color bands are measured with the micro-photometer or the isophotometer to obtain the isophote and isochrone curves of galaxies in the fields. Analyses of these give basic informations on various characteristics of galaxies.

d) Spectroscopic Programs

(i) Survey of red giants

Late M giants and carbon stars are very easily detected on the spectral plate taken with 4° objective prism using IN emulsion and Schott RG 645 filter. The classification is being progressed according to the Case system developed by Nassau and his collaborators.

(ii) Survey of emission-line objects

A survey of emission-line galaxies and quasars with large redshift has been in progress using 2° objective prism and hypersensitized IIIaJ emulsions. Presently planned survey area is about 2000 square degree region of $b > +50°$. We intend to be a northern counterpart of CT10 survey group for the same kinds of object.

On the other hand a survey of such emission-line stars as Wolf-Rayet, Be, and Mira type has also started, mainly in the low galactic latitude region. For this purpose 4° prism plates of F emulsion with Schott GG 455 filter is appropriate.

(iii) Radial velocity measurement

Inspecting the spectra taken with 4° prism on I color plate, we can see that the atmospheric A band (7594A) appears as quite a sharp line. Radial velocity measurement referring to this band is among our programs. At present we plan first to detect high velocity stars in the regions of high galactic latitude and of brighter than 12 or 13 magnitude.

REFERENCES

1) West, R.M. & Heudier, J.L. *ed.* Proceedings of the ESO Workshop on "Modern Techniques in Astronomical Photography," ESO/Geneva, 1978, p.1.
2) *ibid*, p. 15.
3) Takase, B. Ishida, K. Shimizu, M. Maehara, H. Hamajima, K. Noguchi, T, & Ohashi, M. Ann. Tokyo Astron. Obs. 2nd ser. 16, 74, 1977.
4) Haro, G. & Luyten, W.J. Bol. Obs. Tonantzintla y Tacubaya, 3 (No. 22), 37, 1962.
5) Giclas, H.L, Burnham, R. Jr. & Thomas, N.G. Lowell Obs. Bull. 6, 155, 1965; 7, 49, 1967.
6) Smith, M.G., Aguirre, C, & Zemelman, M. Astrophys. J. Suppl. *32*, 217, 1976.