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The Telescope of Geneva Observatory and the Development of Geneva Photometry at La Silla

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When Geneva Observatory set up its observing station at La Silla (Chile), the main objective was to extend its 7-colour photometric system to the southern hemisphere. Indeed, several programmes necessitated the covering of the whole celestial sphere.

Since November 1975, when the 40 cm telescope was put into operation and equipped with a photoelectric photometer for the Geneva 7-colour photometry, the Geneva station has experienced a series of development stages (cf. *Messenger* 6, 1976). This first photometer, simple and strong, was conceived for one optical channel with direct current detection registered by strip chart millivoltmeter. Various precautions were taken in order to stabilize the definition of the pass-bands, in particular by means of careful regulation of the temperature for the photomultiplier as well as for the filters and the main components of the measuring circuit. A differential photometer controlled by a minicomputer HP 2100 is in operation since 1977. This instrument works with a photomultiplier and a performant photon counting system (resolution time 50 ns). Behind a selective set of diaphragms, a quick sampling allows comparison of the flux arriving from both fields, one (A) on the optical axis and the other (B) taken on a chosen polar radius. This second field can be selected by the observer by varying the angular separation (ϱ) of A and B and by choosing the direction (θ) of B relative to A by rotation of the photometer on its own axis.

The sampling of channels A and B takes place behind each of the seven filters of Geneva photometry, arranged on a wheel. Thus, at each revolution of this wheel, we have at our disposal 14 samples summed up on 14 counters. Most of the time beam A takes measures of a star while beam B measures the nearby sky. When the wheel is turning at a speed of 5 revolutions per second each sample is equivalent to an exposure time of about 14 milliseconds. Fourteen averages for each colour on each channel are recorded on magnetic tapes after approximately one minute of total exposure time. This time span allows the collection of 256 samples for each colour. Each mean value is recorded with statistical criteria established in real time. They are based on observed variances as well as on the theoretical variance of the signals. All this information indicates that registration of the measurements proceeds normally; it also allows a subsequent control of the measurement conditions. This photometer has been briefly described by Burnet and Rufener (1979). The nature of the statistical criteria applied, their characteristics and their usefulness have been presented by Burnet (1976). A more detailed analysis by Bartholdi and Rufener will follow shortly. Mr. Burnet, an astronomy engineer who is stationed in Chile since 1977, has brought about several improvements to the controls of the

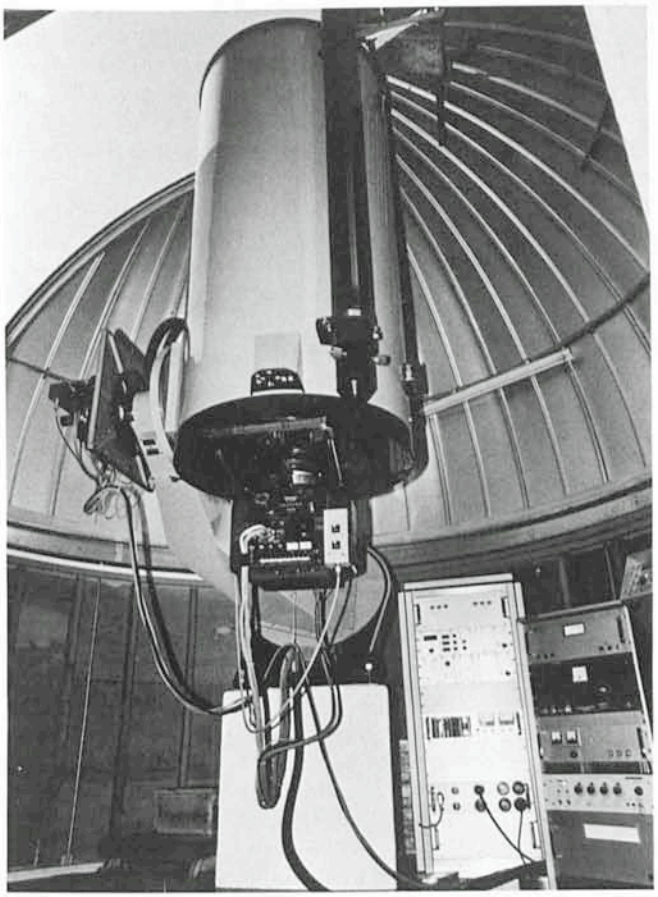

Fig. 1: *The 70 cm telescope installed at La Silla in 1980. We notice on the optical axis the differential photometer which allows rapid sampling and on one of the Nasmyth focuses the photometer for occultations.*

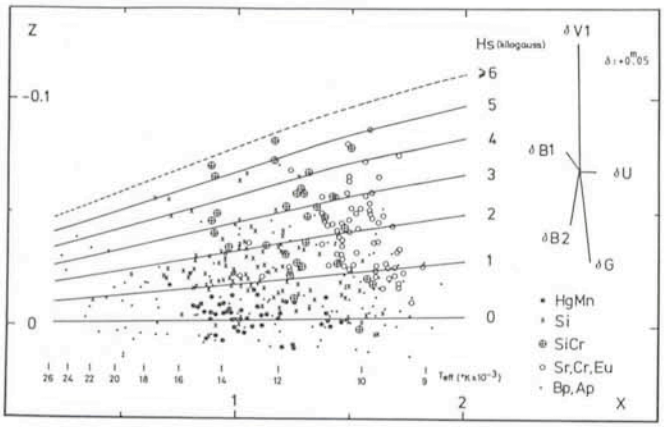

Fig. 2: *On this plan of the photometric parameters X and Z one can identify several star categories showing spectral peculiarities recognized spectroscopically. The set of curves indicates the correlation of the parameter Z with the magnetic field Hs (Cramer and Maeder, 1980).*

telescope and the dome. Both can now be positioned automatically on the basis of coordinates previously prepared by the operator. Two micro-processors determine and control the necessary displacements. Photometric measurements are recorded with all information on coordinates displayed by the telescope console during observation as well as the detailed state of the photometer. Over the years the steering programme of the photometer has been improved continually in order to obtain more complete information on the observations performed. This constant evolution has considerably improved the output and reliability of the observations.

In 1980 the 40 cm telescope was replaced by a 70 cm optical telescope on the equatorial table. Thus, an increase of 1.2 magnitude on the limiting magnitude could be obtained. The new telescope tube allows the Cassegrain focus on two Nasmyth positions to be moved. One of these focuses is equipped with a photometer specialized in recording star occultations by the moon. The diffraction fringes are registered simultaneously by two detectors. The signal transmitted by a dichroic beamsplitter is fed onto a photomultiplier with a pass-band centered on 450 nm. The reflected beam is fed onto a refrigerated diode with a pass-band centered on 900 nm. This equipment developed by P. Bartholdi can be put into operation very quickly. An interesting occultation can be registered in only 15 minutes. The controls of the telescope make it possible to observe not only the star eclipse behind the first quarter of the moon but also its appearance after the passage of the third quarter. These optical phenomena with a total time-span of several hundred milliseconds are registered in two colours, simultaneously with a 10 kHz frequency and time signals. Several unknown double stars have been discovered and some contributions to stellar diameter measurements have also been made possible.

However, the principal activity of this station remains photometric observation in the Geneva observing system. In 1980 the third edition of the Geneva photometric catalogue was compiled and published (Rufener, 1981). Over 14,600 entries reflect the main interests of the Swiss photometrists. The observers take turns in order to cooperate in a general programme resulting from the blending of individual research programmes. The observations and their reduction are dealt with in a single system centralized in Geneva. This contributes to maintaining intercomparison and homogeneity as systematic as possible. Two distinct procedures of processing and weighing are carried out for the reduction of the "colours" (colour index relevant to colour B) and for obtaining the V magnitude whose pass-band is equivalent to the UBV system of Johnson-Morgan. The following is a brief description of programmes already started. Some of them are near completion, others are followed up closely and much effort is put into them. In the beginning, particular interest was taken in the study of the left part of the H-R diagram only, whereas today our effort is oriented towards the entire diagram.

– The observation of bright stars (Catalogue of Bright Stars) allows compilation of a large number of calibrations and comparisons with spectroscopic information as well as with other photometric systems. Many gaps in the knowledge about these stars have been filled.

– For B and A stars, three linear colour combinations determine three optimized and calibrated parameters. X for the effective temperature, Y for the absolute luminosity and Z for the estimation of the spectral peculiarity of these stars. Z represents a quantitative evaluation of the peculiarity. This evaluation is affected by the depression of the continuum at 5300 Å. Z is in close correlation to the existence of a strong magnetic field. Important samples of B and A stars are measured which have been selected from the catalogue by N. Houck; priority is given to all stars represented in the TD1 catalogue. These measurements are expected to yield an improved description of the galactic distribution of these stars

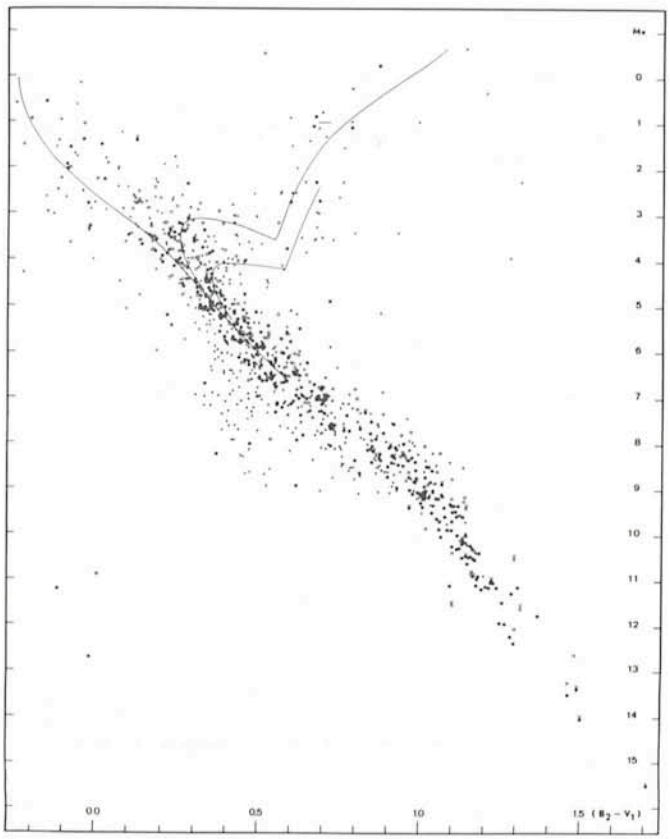

Fig. 3: *Hertzsprung-Russell diagram obtained for 1077 stars in the Gliese catalogue. The photometric data of the Geneva catalogue have been associated with revised trigonometric parallaxes. Symbol explanation: ○,● : Stars with a probable error $\Delta M_v \leq 0.30$ mag.; X, + : $\Delta M_v > 0.30$; O, X: multiple stars. Complementary sign V shows the variability. Solid lines: sequences of the galactic clusters Pleiades and M67, and the probable limiting isochrone of the old disk population (Grenon and Rufener, 1981).*

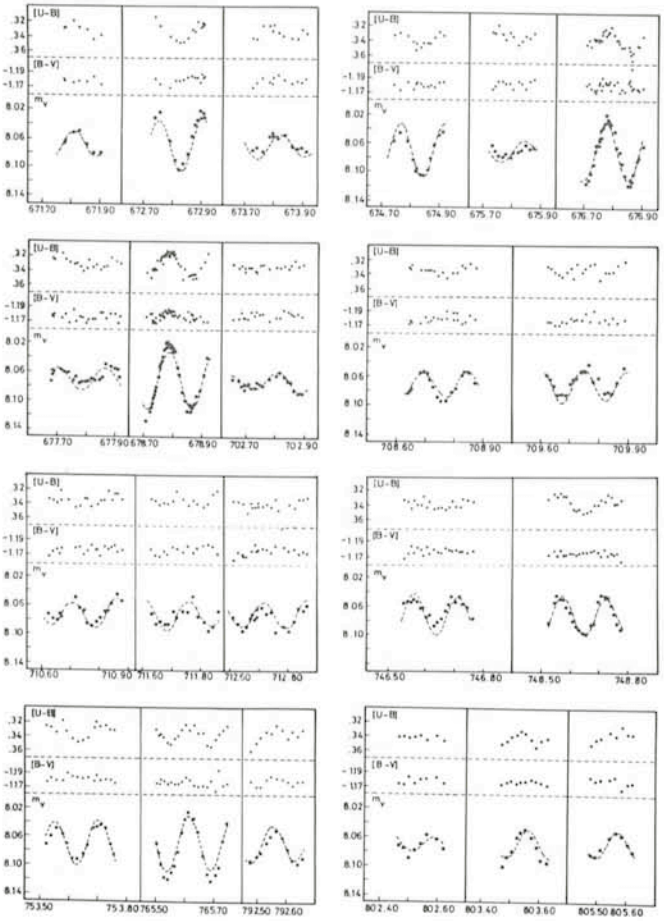

Fig. 4: *Parts of the light curve of HD 129929, a star found to belong to βCep category (2,444,000 days have been deducted from the Julian period). The harmonic analysis has yielded the three following periods and amplitudes:*

PERIOD (days)	AMPLITUDE (Vmagn.)
$P_1 = 0.154776$	0.0176
$P_2 = 0.143268$	0.0119
$P_3 = 0.155062$	0.0101

The presence of non-linear phenomena appears through the increase of the amplitudes observed during maxima and their decrease during minima (Waelkens and Rufener, 1983).

and of the interstellar matter together with a large list of unknown peculiar stars.

– Systematic measuring of O stars should contribute to a better description of the galactic structure on a large scale and to interstellar extinction laws.

– The instabilities observed in supergiant stars of all types, in βCMa type stars and in certain Ap stars are the subject of extensive observations in order to accumulate facts about the nature and recurrence of these phenomena. Several unusual stars have been discovered in this way. Some of them show three clearly distinguishable frequencies.

– A large number of galactic clusters have been observed with great care in order to get experimental sequences in the H-R diagram with a view to confrontations with theoretical models on star evolution.

– Studies of the fine structure components of the H-R diagram in the Teff $\leq$ 6500° K region are elaborated with stars from the Gliese catalogue, cold stars in the Hyades and Praesepe, binary systems with important proper motions as well as stars in globular clusters. Applied to cold stars, Geneva photometry is an original means of determining some effects of temperature, luminosity, various chemical compositions, interstellar reddening or the simulating effects of binarity. These abilities have guided several programmes, such as:

– Analysis of the local population by means of critical tests on the membership and the search for cold stars belonging to spheres 10, 20 and 25 pc centered around the sun. Any suspected bias should be eliminated. The selection of new candidates is guided by kinematical criteria, spectral types and photometric classification.

– The study of old halo stars on the basis of local measurements of intermediate and population II stars within a sphere 50 to 100 pc; also by deep probing into regions close to the galactic poles. For this study the photometry of a large number of cold stars and often measurements of radial velocities are necessary.

– The development of an extensive programme covering all stars with large proper motion and a $m_V \leq 11.50$ detected in the Luyten's survey (NLTT). This project of long duration is on schedule for future observations with the satellite Hipparcos, the spectrovelocimeter CORAVEL and naturally with Geneva photometry.

– The concept of "photometric boxes", developed by M. Golay, makes it possible to select stellar samples with complete photometric similarity. The examination of possible divergences of their spectroscopic properties is always a source for improvement and refinement of stellar classification. The assumption of identical absolute magnitudes inside a photometric box has proven to be, for several fields of the H-R diagram, an original means for evaluating photometric parallaxes when a star with a known parallax is a member of the considered box. In application of this procedure, distances have been evaluated for 43 galactic clusters.

At the present time, the various programmes of Geneva photometry comprise a total of of 31,500 stars. In the two hemispheres combined, close to 20,000 stars already have one or several measurements. Of the roughly 115,000 measurements in 7 colours gathered during the 23 years of Geneva photometric elaboration, more than two thirds will have been registered at La Silla.

I do not want to close this presentation without taking the opportunity to express my best thanks for the kind welcome at La Silla and to thank everyone who made a contribution to facilitate progress of this programme by his continuous help.

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