Marsden about 12 hours after the observations and were quite happy to learn that they contributed significantly to the improvement of the orbit and thereby directly to the success of e.g. the radar experiments with the Arecibo and Goldstone antennas.

Late in the evening of 11 May, just after the closest approach to the earth, it was again possible to observe through a hole in the clouds over Munich, and this time Dr. Marsden received the positions only 4 hours later. (It should here be noted that this was only possible because there is no speed limit on the German highways!)

The above story is a nice illustration of how amateur astronomers can contribute significantly to our science. Without the dedication of Mr. Stättmayer, it would not have been possible to obtain these crucial observations and thus to help the professional astronomers pointing their telescopes in the correct direction.

Absolute Photometry of HII Regions

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Today it is possible to observe HII regions not only in the visible part of the spectrum, but also in the radio, millimetre, infrared, and ultraviolet ranges. Combining photometric data from several of these wavelengths helps us to understand the properties of HII regions and of their exciting star clusters. But often, rather surprisingly, the measurements are quite good at these "exotic" wavelengths but only qualitative, or of low accuracy, in the optical region.

A few years ago we decided to try to remedy this lack of accurate absolute surface photometry of emission nebulae by constructing a special photoelectric photometer, which was modified in 1981 by the addition of a scanning Fabry-Perot interferometer. We have since used it at the Observatoire de Haute Provence in France and at the 50 cm and 1.52 m ESO telescopes at La Silla.

Choosing the Instrument

A grating instrument was immediately rejected. This kind of device is good for measuring accurate relative intensities of lines, but it uses an entrance *slit,* which has an inconvenient shape for comparison with radio maps and with photographs; also, total flux measurements are difficult. We chose photoelectric photometry with interference filters (and, later, a Fabry-Perot) because it is sensitive, accurate, can be put on an absolute scale using standard stars, and works with a circular diaphragm of much larger area than a slit. This makes it fairly easy to calibrate photographs, and we can generally arrange to have a diaphragm comparable in diameter to the beam of a radio telescope so as to facilitate radio/optical comparisons.

Nebular photometry requires accurate knowledge of the transmission curves of the filters used. Unfortunately, interference filters are often rather non-uniform in their transmission characteristics, especially near the edges. Therefore we place our filters in a collimated beam, near the image of the entrance pupil, rather than near the focal plane of the telescope as we do for less critical applications. Furthermore, we calibrate our filters *in situ:* we leave them in our instrument and illuminate the entrance aperture with light from a monochromator. Exactly the same part of each filter is used during calibration and during the observations, thanks to a mask placed at the image of the entrance pupil and adjusted at the telescope.

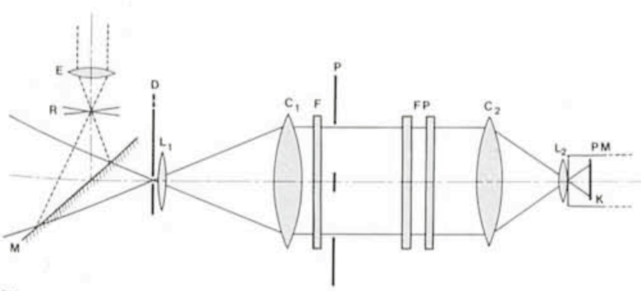

Fig. 1: *Basic optical design of the spectrophotometer, showing principal components. E: eyepiece; R: reticle; M: mirror; D: diaphragm; L_1: field lens; C_1: collimating lens; F: filter; P: mask (image of telescope entrance pupil); FP: scanning Fabry-Perot; C_2: imaging lens; L_2: Fabry lens; PM: RCA C31034 photomultiplier; K: cathode.*

Another requirement is high-accuracy pointing. Unlike stellar photometry, in general not *all* of the light from our emission region falls within the diaphragm. Thus interpretation of the observations requires accurate knowledge of the diaphragm's position. There is not always a star visible at the desired coordinates, so offset pointing is necessary. At the ESO 50 cm telescope, pointing of the telescope itself is sufficiently good for us to offset from a nearby star, but such accuracy is unusual. Hence our spectrophotometer has an x-y offset system which uses micrometer screws to shift the position of the guiding reticle and the eyepiece with respect to the diaphragm. This system was particularly useful at the ESO 1.5 m telescope. At the beginning of our observing run, we measured the relative positions of several stars and (by least-squares) derived the plate scale and a rotation parameter. We were then able to do offset pointing to better than a second of arc.

Photometric methods. So far we have described the basic properties of our instrument – as shown in Fig. 1 – except for the Fabry-Perot. Before proceeding further, it is useful to consider how we would use the photometer if we did not have the FP.

First, we must calibrate the photometer-telescope combination, using observations of standard stars through continuum filters for which the transmission curves have been accurately measured. This gives us an *effective collecting area,* which includes the effects of telescope size, reflectivities, photomultiplier quantum efficiency, etc. (but *not* the filter transmission). Now we can observe an H II region using a narrow-band (10 or 15 Å) filter centered on an emission line. Dividing the emission-line signal (in photons per second) by the transmission of this filter and by the effective collecting area gives us the line flux of the region. (Of course, we must correct for atmospheric extinction.)

The main problem is that, even with such filters, there is often a fair amount of continuum radiation which gets through

The article by D. Enard and G. Lund about "Multiple-Object Fiber Spectroscopy" will be published in the next issue of the *Messenger* (September 1983) and not in the present one as was announced in the *Messenger* No. 31.

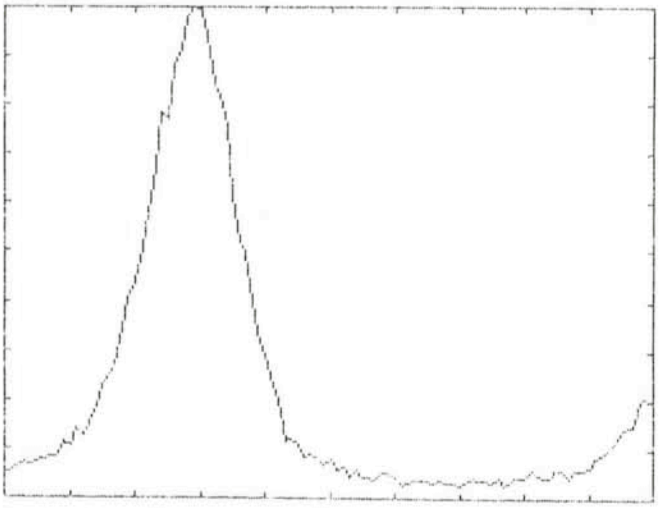

Fig. 2: *An Hα scan of the H II region N 79 in the LMC, obtained at La Silla (ESO 50 cm telescope, integration time 200 s).*

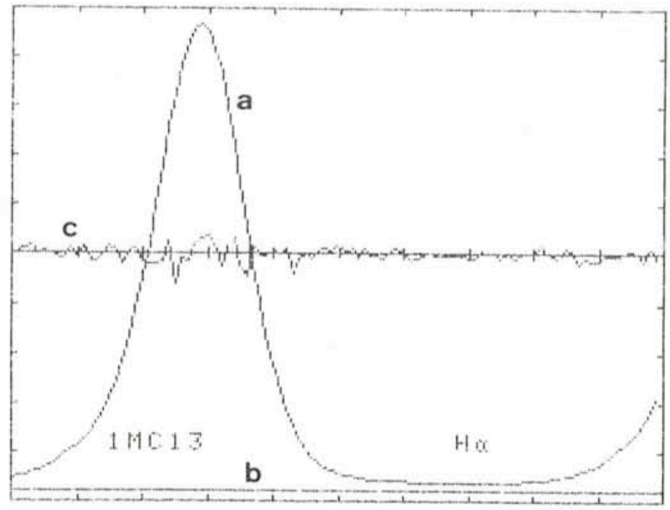

Fig. 3: *Least-squares fit to the scan of Fig. 2. The analytic function (a) representing the convolution of the instrumental profile with a Gaussian, plus a constant (b), is shown on the same scale as in Fig. 2. The residuals (c) are shown also.*

(particularly from OB stars embedded in the nebulosity). To correct for this, we must also measure the continuum radiation adjacent to the line. This is a rather delicate measurement, and a potential source of error.

The Fabry-Perot. The originality of our method comes from the use of a scanning Fabry-Perot interferometer in the photometer itself, so that we have, in the same instrument, rapid filter changes, choice of diaphragm, etc., plus the spectral scanning qualities of a spectrometer. A few years ago it would have been necessary to use compressed gas to scan the interferometer, but we use the extremely stable servo-controlled piezoelectric system developed by Hicks et al. (1974, *J. Phys. E. Sci. Instrum.* **7,** 27) at Imperial College in London.

Fig. 2 shows a sample scan obtained with one of the FPs we have used at La Silla. The total scan corresponds to 5.2 Å, which is somewhat greater than the free spectral range (distance between overlapping orders) of 4.4 Å. Profiles such as this allow us to study the Doppler broadening in H II regions, to detect line splitting, etc. From the photometric point of view, one advantage of observing the profile of each line is that we can detect unwanted night-sky emissions. But the principal advantage is that it simplifies the problem of correcting for the underlying continuum. Fig. 3 shows a least-squares fit, to the scan of Fig. 2, of the FP instrumental profile convolved with a gaussian, plus a constant representing the sum of the dark-count signal and the continuum. (This constant is slightly less than the minimum signal because the FP transmission is never quite zero.) This method is quicker than using a separate continuum filter. It is also more reliable, as it does not depend critically on the transmission curves of the filters. And it is a lot more satisfying to really see the continuum!

To find the absolute intensity in a line, we proceed as outlined above, measuring standard stars through wide-band continuum filters and the H II region through narrow-band line filters (but we do not need to measure the underlying continuum). For each filter *we scan the FP.* The stellar continuum measurements give us an effective collecting area which now includes the FP transmission averaged over one free spectral range. Reduction of the emission line scans gives us the line signal averaged over one free spectral range and corrected for the continuum. We simply divide this line signal by the effective collecting area and by the filter transmission to get the absolute flux for each line.

Instrument Control and Data Acquisition

The entire instrument is controlled by a Hewlett-Packard desktop computer which has a parallel I/O interface. A simplified block diagram is given in Fig. 4. A typical observation of an H II region might proceed as follows. The filter wheel rotates to the position of the Hβ filter. A preselected number (typically six) of 100-point FP scans (each lasting 17 seconds) are performed, and the scans are summed in the computer. The filter wheel then moves to the next requested filter, Hα, where the process is repeated (typically two scans). If these are the only two filters requested, the computer beeps, and we can display the observations on the screen. We can then ask for the observations to continue, or tell the computer to stop. The accumulated scans can be stored on data cassettes. The same microcomputer is used for our data reduction.

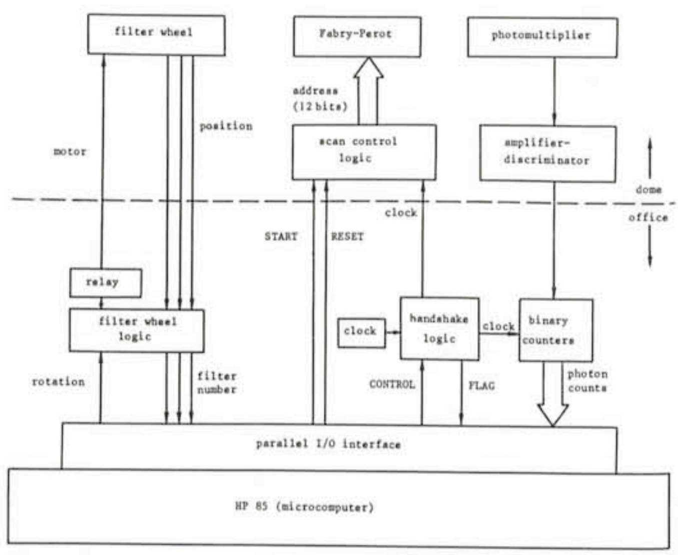

Fig. 4: *Block diagram of the microcomputer control and acquisition system.*

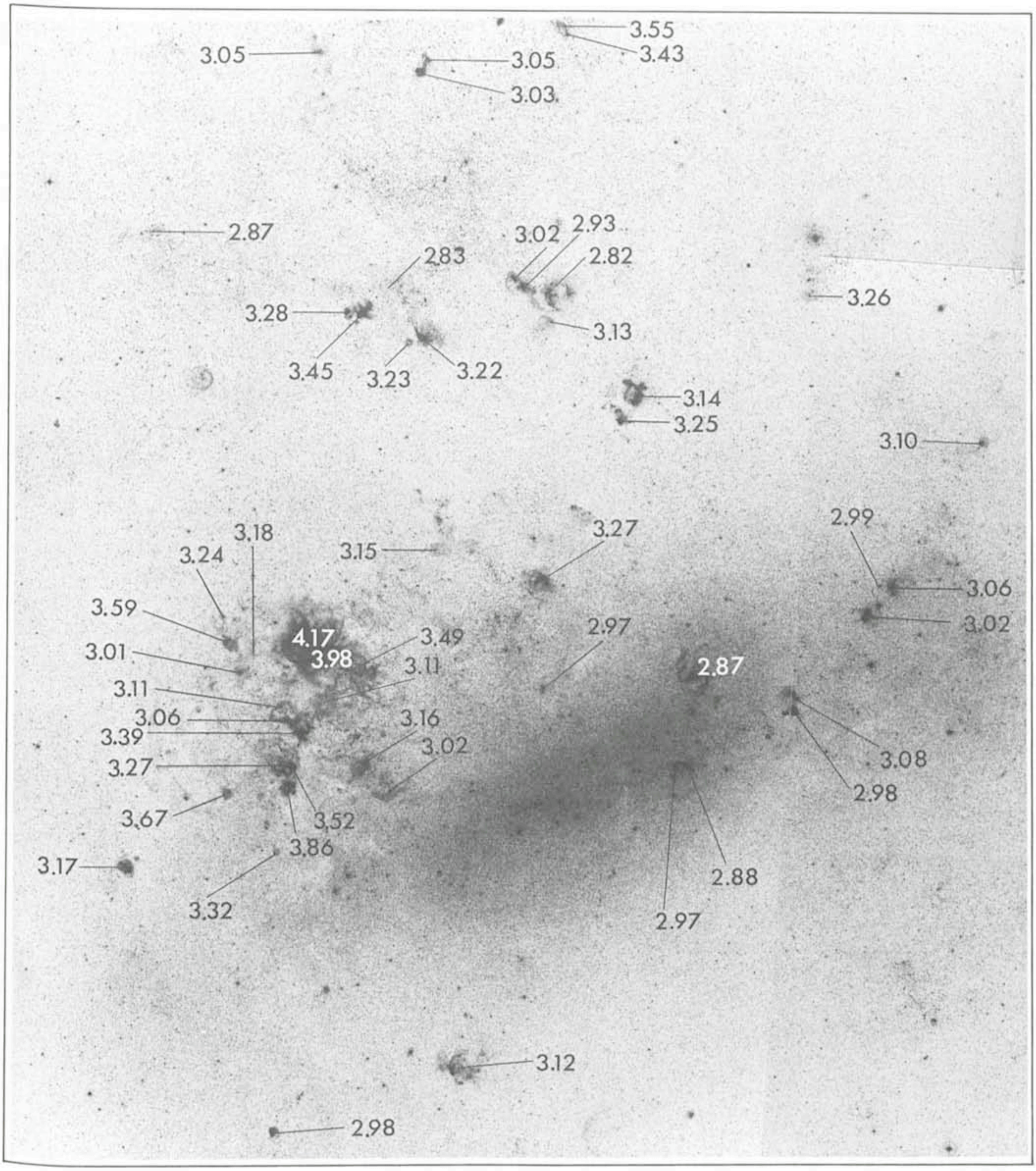

Fig. 5: *Hα/Hβ ratios for H II regions in the LMC, shown on a red ESO Schmidt plate.*

Example: Reddening and Extinction in the Large Magellanic Cloud

Extinction is an important parameter, especially for the interpretation of far UV observations. For example, a colour excess E(B-V) of 0.5 mag in the LMC corresponds to an "absorption" $A_{1600\,Å}$ of about 5 mag. Extinction corrections are thus crucial for determining the intrinsic properties of star clusters.

The extinction in the LMC is generally estimated from stellar photometry. But the far UV observations of Page and Carruthers (1981, *Astrophysical Journal* **248,** 906) show that around 70 % of the detected UV sources are associated with Hα emission (originating in giant H II regions ionized by these hot star clusters). Because of the nebulosity, stellar photometry in the H II regions, even when it exists, is of low reliability. Consequently the extinction is unknown for the majority of the LMC H II regions and associated exciting star clusters.

Extinction in H II regions can be estimated by comparison of the absolute Hα or Hβ fluxes with the radio continuum fluxes (of course, the optical and radio determinations must refer to the same points in the sky and must have comparable angular resolutions). Or we can measure the Balmer decrement – in particular the Hα/Hβ ratio – which provides the total extinction via the reddening law. If the extinction occurs well outside the emission region, and is uniform over the solid angle observed, these two methods are equivalent and give the same results for, say, A_V. In practice this does not always work. For example, Israel and Kennicutt (1980, *Astrophysical Letters* **21,** 1) show that A_v estimated from a comparison of the optical and radio fluxes of giant extragalactic H II regions is almost always greater than that derived from the Balmer decrement. These questions are discussed by Lequeux et al. (1981, *Astronomy and Astrophysics,* **103,** 305). Quite aside from any possible deviations from the standard reddening law, differences between the two determinations are expected if the external extinction is not uniform and/or if the dust is located within the H II region. Further effects arise because of scattering of the nebular light. Thus, comparison of these two determinations of A_v can give information on the characteristics and location of the dust.

Observations and first results. We observed about 50 of the optically brightest H II regions of the LMC with the ESO 50 cm telescope in December 1981. The circular diaphragm had a diameter of 4.9 arcmin, which allows comparison with the 6 cm continuum observations of McGee et al. (1972, *Australian Journal of Physics* **25,** 581) which were made with a 4 arcmin Gaussian beam. In addition, some regions were observed at several positions, with higher resolution. This was the case for N 159, which is formed of several small components and is situated near a region of active star formation.

Both atmospheric extinction and absolute instrumental calibration were determined primarily with the standard star χ Eri (Tüg, 1980, *Astron. Astrophys. Suppl.* **39,** 67). From each observation we have obtained the absolute Hα and Hβ fluxes and thence the Hα/Hβ ratio. Results obtained from repeated measurements, some with different filters and on different nights, indicate errors of a few per cent in the ratio.

Note that FPs are generally coated for a rather narrow range of wavelengths, and therefore cannot be used for *both* Hα and Hβ. Prof. E. Pelletier, of the Ecole Nationale Supérieure de Physique in Marseille, kindly supplied us with the special broadband dielectric coatings which were used for these observations.

Fig. 5 indicates the ratios measured in the LMC. Extinction in the Cloud is generally low. It is very low (or zero) for the regions located along the bar (N 23, N 103, N 105, N 113, N 119, and N 120). It is also low for all the large ring-shaped H II regions such as N 154, N 120, N 11, N 51 D, and N 206. The highest extinction ($H\alpha/H\beta > 4$, corresponding to $E(B-V) > 0.3$ mag), is measured in the 30 Doradus Nebula, and it remains high in the nearby H II regions N 157 B and MC 69. A relatively high extinction is also found in the direction of N 160 and especially of N 159 ($H\alpha/H\beta \sim 3.9$, corresponding to $E(B-V) \sim 0.28$ mag), H II regions situated at the edge of the LMC's largest H I molecular complex, an area of active star formation (as shown by the presence of OH and H_2O masers and of the only compact IR source yet observed in the LMC). The regions N 48, N 79, N 81, N 83, N 59, and N 164 also exhibit a relatively high extinction for LMC H II regions.

These ratios are generally consistent with those obtained for a few objects by Peimbert and Torres-Peimbert (1974, *Astrophysical Journal* **193,** 327) and Dufour (1975, *Astrophysical Journal* **195,** 315), with slit spectrographs. Comparison of the absolute fluxes with the radio measurements is underway. The results will be submitted to *Astronomy and Astrophysics.*

Concluding Remarks

Our spectrophotometer may soon become obsolete. A new generation of Fabry-Perot instruments, including the English TAURUS (see Atherton et al., 1982, *The Messenger* **28,** 9) as well as CIGALE, which we have developed at the Observatoire de Marseille, uses two-dimensional photon-counting detectors. The result is a wavelength scan for *each pixel.* So far, the emphasis with such instruments has been on kinematic work, but thanks to recent progress in detectors, there is no reason why they cannot be used for accurate two-dimensional photometry.

CN Orionis, Cooperative Observations for 24 Hours per Day Monitoring

R. Schoembs, Universitäts-Sternwarte, Munich

Introduction

When modern technologies open the possibility of astronomical measurements in wavelength regions from γ rays to the ultraviolet and from the infrared to the radio band, the visual range shrinks to a very small interval in the flux diagrams. However, the time of use of the necessarily complex and expensive instruments is very limited. Observing runs of an hour or so are of little use for the investigation of astronomical events like stellar outbursts which evolve with timescales of days. So even optical telescopes with apertures below 1 m still have a relevance for long-time observational programmes.

An interesting group of objects which is known to show variations in the time scale mentioned is the class of cataclysmic variables (CV). The general model for all members consists of a Roche lobe filling secondary (near the main sequence) which transfers matter via the Lagrangian point L_1 to the highly evolved primary, a white dwarf or neutron star. Due to its angular momentum the mass stream does not impact but rather surrounds the small primary, building a more or less circular accretion disk. A hot bright spot is produced where the initial stream collides with the already circulating material of the disk. By angular momentum exchange part of the disk material finally reaches the primary.

The increasing amount of information from all kind of observations has made clear that the class of CVs comprises many kinds of interesting objects like X-ray sources, oblique magnetic rotators with synchronized rotation or with rotation with