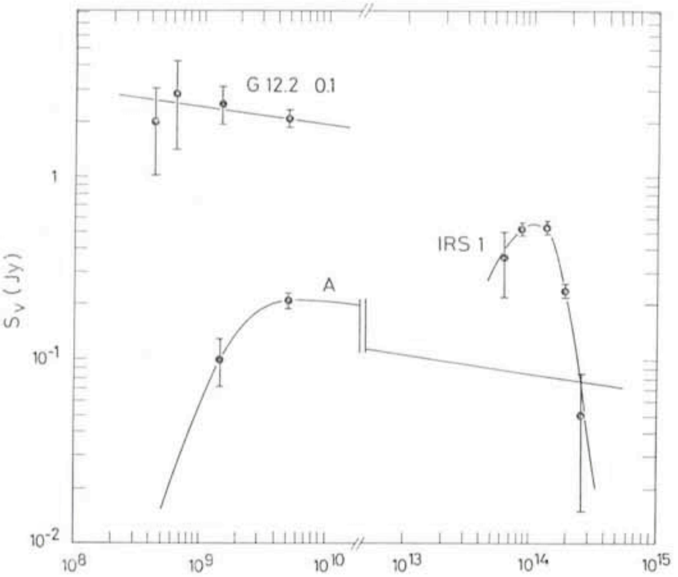

Fig. 2. — *Continuum spectrum of the entire G12.2–0.1 complex (top) and for component A and IRS 1 (bottom).*

sents the total integrated radio flux densities for the entire region. The infrared spectrum of IRS 1 appears to be stellar, an O3–O5 type star with $A_V \approx 23$ mag. However such an early O star would be capable of ionizing an H II region with 100 times the flux of the observed radio source G12.2–0.1. If the star were of spectral type O5 or later then most of the near-infrared emission could arise from a hot circumstellar cocoon (> 1000 K), and even an O7 star would still be capable of powering the radio source. The close H_2O maser association further strengthens our belief that IRS 1 is a cocoon star. Further, longer wavelength infrared observations are planned in the coming season in order to determine the spectral type of IRS 1.

Sources of this nature are often associated with large molecular complexes, and ^{13}CO observations have recently been carried out by Michael Scholtes at McDonald. ^{13}CO emission has been detected, and ^{12}CO observations will be made in the near future.

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A Magic Eye for Astronomical Spectrophotometry

The ability of a telescope to detect faint celestial objects not only depends on the linear size of the telescope, but also upon the efficiency of the light detectors that are used to register the light. For many years, most astronomical spectra were obtained on photographic plates. However, even the best of these rarely achieve detective quantum efficiencies above a few per cent, i. e. they only "catch" two or three out of every one hundred photons hitting the emulsion. During the past decade much effort has therefore been concentrated in astronomy on how to improve the detector efficiency in order to make small telescopes "larger" and large telescopes "very large". For instance, a telescope with a mirror diameter of one metre and a detector efficiency of 50 per cent is (for many astronomical applications) equivalent to a 5 metre telescope with a 2 per cent detector.

In this article, ESO engineer Rudi Zurbuchen from the Geneva group discusses one of the new detectors, the RETICON array.

New Detectors in Astronomy

Times when astronomers forgot their numb fingers, whilst gazing through the eyepiece of a telescope and admiring celestial objects are definitely over. Today's astronomy and the use of its large optical telescopes require less subjective and much more powerful eyes. In many astronomical applications electronic detectors are more and more taking over from the photographic plate. One of them, planned to be used with the instruments of the ESO 3.6 metre telescope, is described here. The actual hardware and software system is presently being developed by a team of ESO's Instrument Development Group and will be the subject of a subsequent article.

A large amount of significant astronomical information such as physical state, material composition and radial velocity of a stellar object is retrieved from the precise measurement of the object's spectrum. The light levels associated with spectrophotometric measurements on a good observing site can be very low and the requirements imposed upon efficient light detectors used in this field are accordingly high.

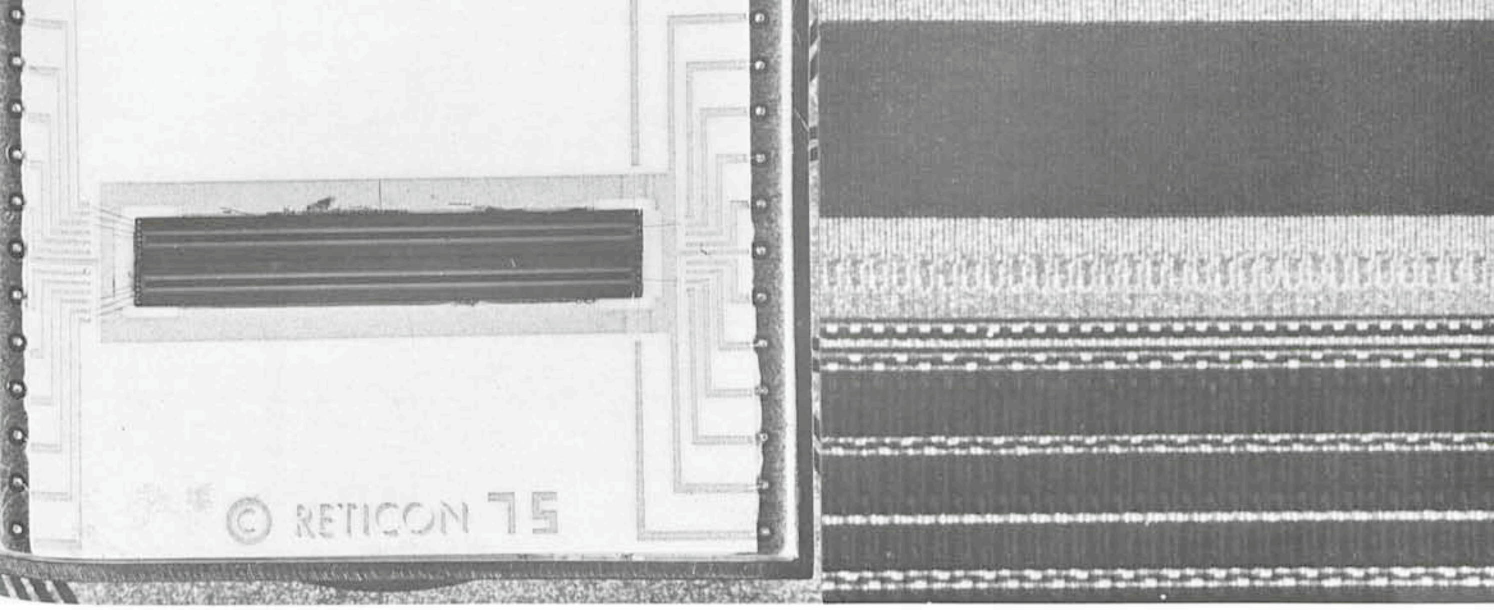
The widely-used singel-channel scanning mode of conventional spectrometers suffers badly from a poor detection efficiency which is partly due to the high light loss inherent to the sampling principle but also to the modest quantum efficiency of even modern photon multiplier tubes. An additional disadvantage of the single-channel scanner is its sensitivity to atmospheric variations.

The RETICON Diode Array

Among the flood of newly-developed electronic photodetectors there is one which is particularly attractive for spectrophotometric applications. It is a self-scanned linear photodiode array manufactured by the RETICON Corporation, Sunnyvale, California. Several other array devices are potentially good competitors but the RETICON seems, at least for the time being, to be the only one which provides as well a diode sufficiently large to cover a typical astronomical spectrum image over its total height, as an adequate linear field and thereby spectral range.

Reticon linear arrays are available with up to 1872 individual photodiodes with centre-to-centre spacings as small as 15 μm. The first RETICON which will be used for the 3.6 m telescope instrumentation programme is a dual 1024-element array with a 25 μm centre-to-centre spacing and an active aperture width of 430 μm. The dual configuration allows simultaneous integration of object and background signals and will be used as a near infrared detector for the low-dispersion spectrograph of the 3.6 m telescope Cassegrain focus. Another similar array is planned to be operated on the coudé échelle high-dispersion spectrometer (see article by D. Enard in *Messenger* No. 11, December 1977).

The RETICON is a monolithic integrated circuit and as such exhibits excellent geometric accuracy and stability. Besides the photodiodes, the circuit has integrated into the same silicon chip the analog switching circuitry needed for reading out the diode



The left photograph shows a dual 1024 photodiode (RETICON) array. The two array chips, each with an active area 25 mm long and 0.43 mm high are the dark, rectangular elements mounted in the centre of their common ceramic substrate. The right picture shows an enlargement of part of an array on which the individual photodiodes (each 0.025 mm wide) may be discerned together with part of the read-out electronics on the chip.

signals sequentially by commutating one after the other to a common video line. The dual array package is shown in the figure.

Associated with each photodiode is a small capacitance upon which an electric charge can be stored by reverse biasing the diode and then allowing it to float. Electronhole (e–h) pairs generated in the diodes due to incident photons (the signal) and to thermal effects (dark current) will slowly discharge the diode capacitance until some specified integration time has elapsed, at which point each diode in its turn is again reverse biased. The amount of charge required to re-bias each individual diode is then a measure of signal plus dark current.

In contrast to the scanner principle, where the signal of only one single spectral element is integrated over a given sampling time, the entire spectrum is projected onto the RETICON surface and the total photon flux is simultaneously detected and integrated as charge, in the case of the diode array. This results in a tremendous increase in efficiency and elimination of atmospheric noise.

The useful response of silicon photodiodes ranges from 0.3 μm to 1.1 μm and within the 4000 Å to 10000 Å region it surpasses the performance of any conventional photocathode. A maximum responsive quantum efficiency (RQE) of 80 per cent is reached (!) in the 7000 Å to 9000 Å region and contributes to the overall performance of the detector.

The Noise

Several sources of noise must be considered. Various noise components associated with reading and processing the charge signals imply that extreme care must be given to the design of the analog electronic circuitry. The total readout noise of a single readout can be minimized to a noise equivalent charge (NEC) of about 800 e–h pairs and sets the absolute low limit of the dynamic signal range. The high limit is determined by the saturation charge of the diode or any other saturation effect in the signal processing. A typical dynamic range of four decades (10,000) can be reached, within which the detector can be considered as linear.

In principle a single measurement may consist of one long exposure or of a series of short coadded ones. But since the noise per readout is constant, it can readily be seen that the detective quantum efficiency (DQE) for low light levels is increasing with exposure time and therefore a single integration and reading gives by far the best result.

As already mentioned, diode capacitance discharge is not only resulting from the incident photons, but also from thermal e–h pair recombination. As a result the RETICON has to be cooled to a temperature as low as –150° C in order to make the dark noise nearly negligible. Unfortunately cooling results in a rapid drop of the RQE at the IR end of the spectral range. Consequently, higher sensitivity at higher temperatures has to be paid for with increased dark noise in this particularly interesting spectral region. Or, in other words, above 8000 Å the limiting magnitude of the RETICON decreases markedly. Incidentally, another limiting factor at the IR end is an increase in crosstalk between adjacent diodes and loss in effective spectral resolution. This effect is attributed to the increasing transparency of silicon at longer wavelengths, which in turn leads to a deeper penetration of red photons and a bigger lateral charge diffusion covering more than one diode width.

Summing up, the RETICON self-scanned linear photodiode array has, by virtue of its high sensitivity over a wide range of wavelengths, its high dynamic and linear signal range and its relative operational simplicity, an excellent application in astronomical spectrophotometry.

Garden Party at ESO Guesthouse

The Director-General invited the participants of the IAU meeting, held in Santiago from January 16 to 19, to a garden party in the ESO Guesthouse.

About 120 guests came: Chileans and people from other Latin American countries, USA and Europe, partly with wives and children.

Apart from a lovely garden in full bloom, ESO was able to offer a candle-lighted summer night, a full moon in the sky, folkloristic dancing and music, and last but not least, nice cool drinks and an appetizing cold buffet.

The guests seemed pleased and so were the hosts: Prof. Woltjer, ESO astronomers and the ESO/Chile administration.

NEWS and NOTES

Move to Munich Delayed

The Max Planck Society has informed ESO that there will be some delay in the construction of the ESO Headquarters Building in Garching. This is mainly due to new legal provisions in Germany imposing stricter regulations on the thermal insulation of buildings. As a consequence, it has been necessary to review the technical specifications of the ESO building.

It is now estimated that the construction will be terminated in the early summer of 1980 and that the move into the new Headquarters may take place soon after.