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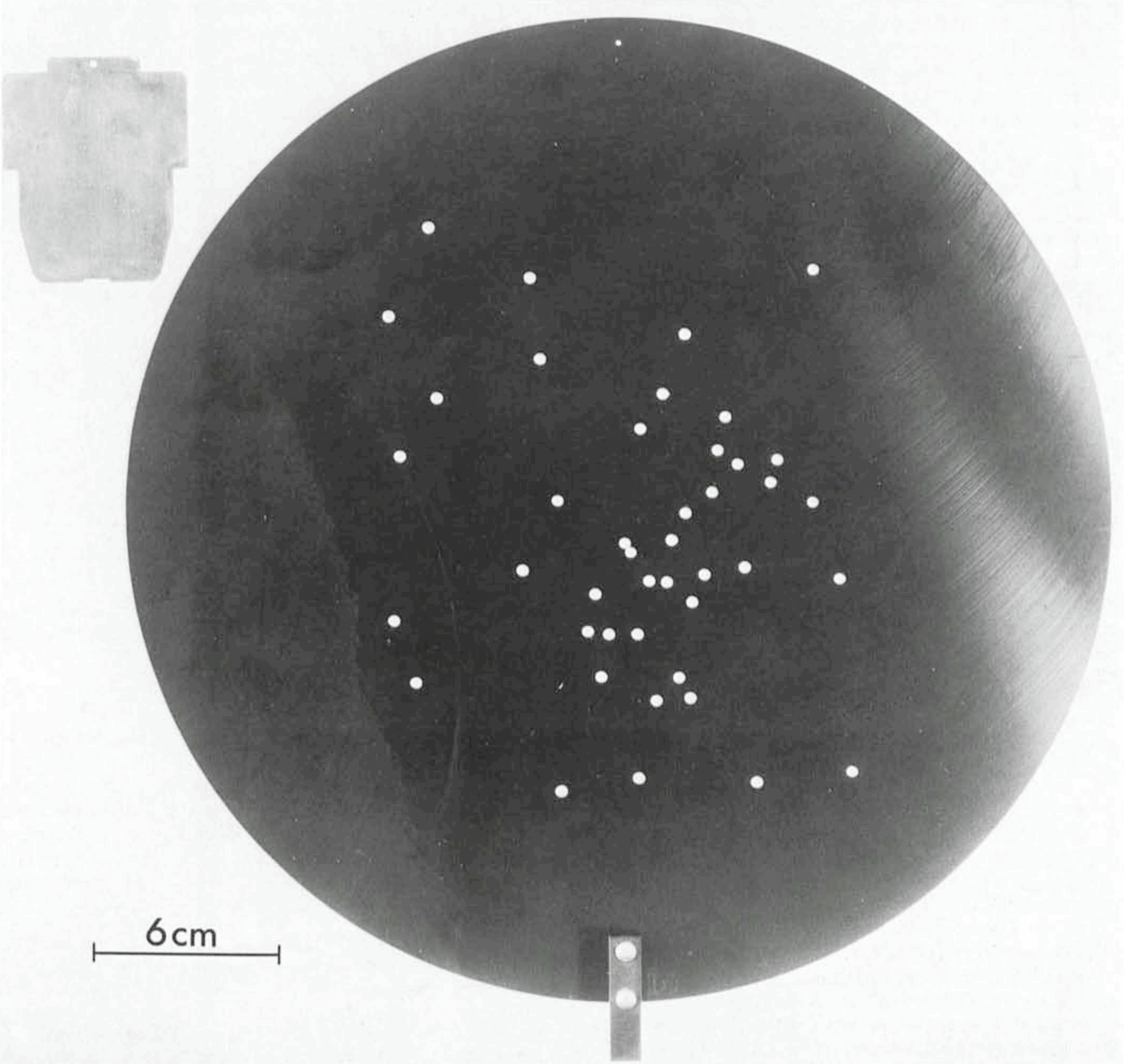
Two Multi-Object Spectroscopic Options at the ESO 3.6 m Telescope

In March, two instruments to obtain the spectra of several objects in a field in a single exposure were successfully tested at La Silla.

An improved version of OPTOPUS (see the *Messenger* No. 33 for a description of the prototype) has been used at the Cassegrain focus of the 3.6 m telescope. With this instrument, the light of up to 54 objects in a field of 33′ diameter is guided by fibers to the slit of a modified B&C spectrograph. A CCD is used as a detector. In the three test nights, the instrument operated smoothly on 8 fields and more than 300 objects were successfully observed.

OPTOPUS will be offered to the users as of October 1, 1985.



The giant and the midget: both attractive in their own way. In this picture, taken in the ESO Photolab, an OPTOPUS plate with holes to fit the optical fibers is shown close to a much smaller plate to be mounted on the EFOSC aperture wheel. Both combinations sample targets for multi-object spectroscopy at the Cassegrain focus of the 3.6 m telescope.

EFOSC, the ESO Faint Object Spectrograph and Camera, has also a multi-object spectroscopic mode (see the *Messenger* No. 38 for a description of the instrument).

A file containing the coordinates needed to punch an aperture plate can be created by identifying the targets on a CCD frame (5 × 3 arcminutes in size) obtained with the same instrument. Up to 11 plates can be mounted at one time on the EFOSC aperture wheel. In the March test, a plate with holes corresponding to positions of peculiar H II regions in M 83 was prepared in the La Silla workshop and used successfully in the following night.

This observing mode will be offered to the users as of April 1, 1986.

A detailed description of the results of the tests and the operating manuals of OPTOPUS and EFOSC will be available by next fall.

S. D'Odorico

Submillimetre Spectroscopy on La Silla

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1. Of Pearls and Swine

Who would play a Stradivari violin at a country dance? Or who would mix very old Scotch with Coca-Cola? Not us. But we do things that look equally improper in the eyes of many astronomers. We employ fine optical telescopes to observe at submillimetre wavelengths, although for our purposes the surface accuracy of the mirror could be 1,000 times worse. One excuse which we (and the ESO Observing Programmes Committee) can offer is that at present there are no submillimetre telescopes that we could use instead of the optical ones. We believe that one can get information about star-forming regions through submillimetre observations that cannot be obtained by other means. This article is an attempt to convince you that this is the case.

2. The Value of Submillimetre Spectroscopy

There is a gap in observational astronomy between 20 μm and 1 mm that is only gradually beginning to be filled. This has two major causes. Firstly, the atmosphere is generally opaque because of water vapour and only in a few windows are observations possible from dry, high-altitude sites. La Silla is such a place. Secondly, up till a few years ago receiver technology at these wavelengths was not very advanced. However, all cold objects with temperatures below, say 50 K, emit predominantly at far infrared or submillimetre wavelengths. Molecular clouds are an example. H_2, CO and more complicated species can form, if they are shielded by a few magnitudes of visual extinction from the energetic UV photons of the interstellar radiation field, which would otherwise dissociate the molecules. This shield is supplied by dust grains. Many of the astrophysically relevant atomic and molecular transitions lie in the submillimetre region. The whole problem of the early stages of star formation depends observationally on infrared and submillimetre astronomy, because protostellar clouds are completely opaque in the optical. While far infrared and submillimetre continuum measurements can determine the luminosity of a protostellar object, spectroscopic observations yield information on the kinematics of the gas, necessary to understand the collapse, and on the temperature and density structure as well.

CO is a key molecule in the study of the interstellar medium. It is abundant, easily excited and readily observed in its ground rotational transitions. They are labelled by their quantum number J of the upper and lower level. The lowest transition J = 1−0 occurs at 2.6 mm wavelength. It is always optically thick in the line centre. However, due to velocity shifts of the gas through turbulent and systematic motion one can also look into the cloud and detect the warmer and dense regions around embedded stars. The radiation of these young or even pre-main-sequence stars is absorbed by the dust. The dust is at densities of more than 10^5 atoms per cm^3 thermally coupled to the gas and heats it. Such regions show an enhanced CO line temperature and are therefore called hot spots.

The J-th rotational level of CO lies 2.8 J (J + 1) degrees Kelvin above the ground level. A comparable gas temperature is needed for its excitation. So in the CO ground transitions one mainly sees the cool gas away from the heating sources. For the study of star formation one wishes to penetrate as closely as possible to the protostar. The J = 4−3 line at 0.65 mm wavelength already needs an excitation of 55 K. Gas at such a temperature is found only in the vicinity of an embedded star. It is part of the protostellar cloud and its dynamics is dominated by the gravitational pull of the central object. The kinematics strongly influence the shape of the lines. Systematic motions which encompass the whole protostellar cloud, such as accretion, rotation or outflow, may be present together with chaotic or turbulent motions. Other effects, which are also

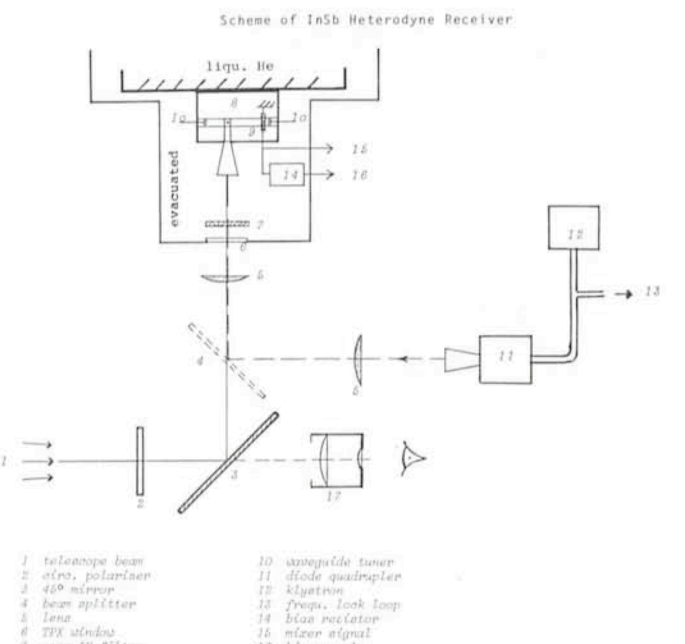

Fig. 1: *Schematic drawing of the Indium Antimonide heterodyne mixer receiver (0.65 mm wavelength). The crystal sits within a front-end block with a horn antenna and a tunable waveguide circuit; its dimensions are 0.04 × 0.04 × 0.2 mm. The local oscillator is a microwave klystron plus a Schottky diode quadrupler. Matching of the telescope beam to the beam shape of the horn antenna is done with lenses. The 45° mirror can be quickly exchanged by an eyepiece for optical pointing.*