USE OF LARGE TELESCOPES IN FAST FOCAL RATIO MODE - APPLICATION TO THE 6m TELESCOPE (BTA)

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ABSTRACT: Large aperture telescopes usually have an unavoidably long focal length so that stellar image diameters are often much larger than the resolution of the detector. The detection of extended sources can take advantage of a faster focal ratio and both stellar and extended monochromatic sources can be detected with great sensitivity by using interference filters and a focal reducer, without much loss in resolution. Extragalactic results obtained with the 6 meter telescope at focal ratio f/1 are given as examples.

With few exceptions, ionized hydrogen regions in a galaxy are extended sources emitting only a few lines of very faint intensity. The use of a narrow interference filter (to select one of the most intense lines) in combination with a focal reducer (to increase illumination at the focal plane) and a large aperture telescope is the best way to obtain deep photographs of these ionized hydrogen features in nearby galaxies (Courtès, 1973). It should be noted that in this optical arrangement the filter is not set in the small f-number beam of the focal reducer, but in the slower aperture ratio beam of the telescope, thus making possible the use of very selective interference filters (which accept a narrow angular field). This method has been extensively used for several years by Courtès and his co-workers at the 1.93m telescope of Haute Provence Observatory, at the Palomar 200 inch telescope, and, more recently, at the 3.6m telescope of ESO and the 6m BTA telescope.

As previously discussed (Courtès, 1965), when an f/1 focal reducer is attached at the focus of a 2m class telescope (for instance the f/5 Newtonian focus of the 1.93m telescope of Haute Provence), the illumination of the photographic emulsion is increased (by a factor of 25 in this example) but the spatial resolution is unavoidably degraded (a pixel size of 20 microns corresponds to 2.1 seconds of arc). On the other hand, when an f/1 focal reducer is used in combination with a 4m class or even larger telescope, the equivalent focal length becomes long enough for the minimum image diameter to be determined mainly by the seeing instead of by the resolving power of the emulsion. In the case

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of the f/8 Cassegrain focus of the ESO 3.6m telescope (a project using such an instrument with the 3.6m ESO telescope has been designed by M. Leluyer) the illumination of the detector is increased by a factor of 64 and the limiting angular resolution is near 1 second of arc for a pixel size of 20 microns (Boulesteix et al., 1974).

One of the most important results that has been obtained when applying these techniques to the study of the ionized gas of nearby spiral galaxies is the discovery of a general, diffuse Hα emission in the spiral arms and, sometimes, over the entire galactic disk (Carranza et al., 1968; Monnet, 1971). In our Galaxy also, the interstellar medium is ionized outside the condensed, classical HII regions. The presence of a general Hα emission background throughout the Milky Way has been revealed by the photographic Hα survey of Sivan (1974), the southern part of which was carried out at La Silla using a 60° field with an interference filter and an f/1 camera (Courtès et al., 1981). These observations are in good agreement with those of Reynolds et al. (1974); in addition, they show clearly that the general Hα emission from the arms of the Galaxy is not only diffuse, but that faint filamentary structures as well as ring-like and arc-shaped features are seen in between the bright, classical HII regions. The most recent studies of the nearest spirals have not revealed such an appearance for the diffuse ionized gas. This is mainly because of the scale used.

One of the galaxies best suited for this kind of investigation is the Triangulum galaxy, M33, due to its large angular extent (more than one degree) and its favourable inclination (close to face-on). It has been observed in Hα through a 25 Å filter, using the f/1 focal reducer at the f/5 focus of the 1.93m telescope of Haute Provence (Boulesteix et al., 1974). A higher angular resolution survey proved necessary in order to investigate small and sharp structures in the Hα emission regions.

This is the reason why we have adapted (simply by changing the field lens) the f/1 focal reducer to the f/4 prime focus of the 6m telescope of the Special Astrophysical Observatory. The new survey of M33 we have conducted with this telescope uses the same 25 Å filter to isolate the Hα line and exclude the unwanted continuum from the stars and the atmosphere. The 15cm diameter of the filter limits a 20 arc minute field, well suited for large-scale studies of extragalactic HII regions.

We show here (Figure 1) three juxtaposed fields across the surface of M33. By comparing these photographs with the ones previously obtained, one notes the marked gain in resolution for the structure of the HII regions. This is not surprising when one considers that any feature is recorded on the same photographic emulsion on a surface of information 9 times larger. One can see the details of the emission: it is far from being uniform and is rich in abundant filamentary and arc-shaped structures. On the same photograph, at the very end of the optical spiral arms, one sees more clearly the bubble-like HII regions previously observed with the Haute Provence Observatory 1.93m telescope. The sharp

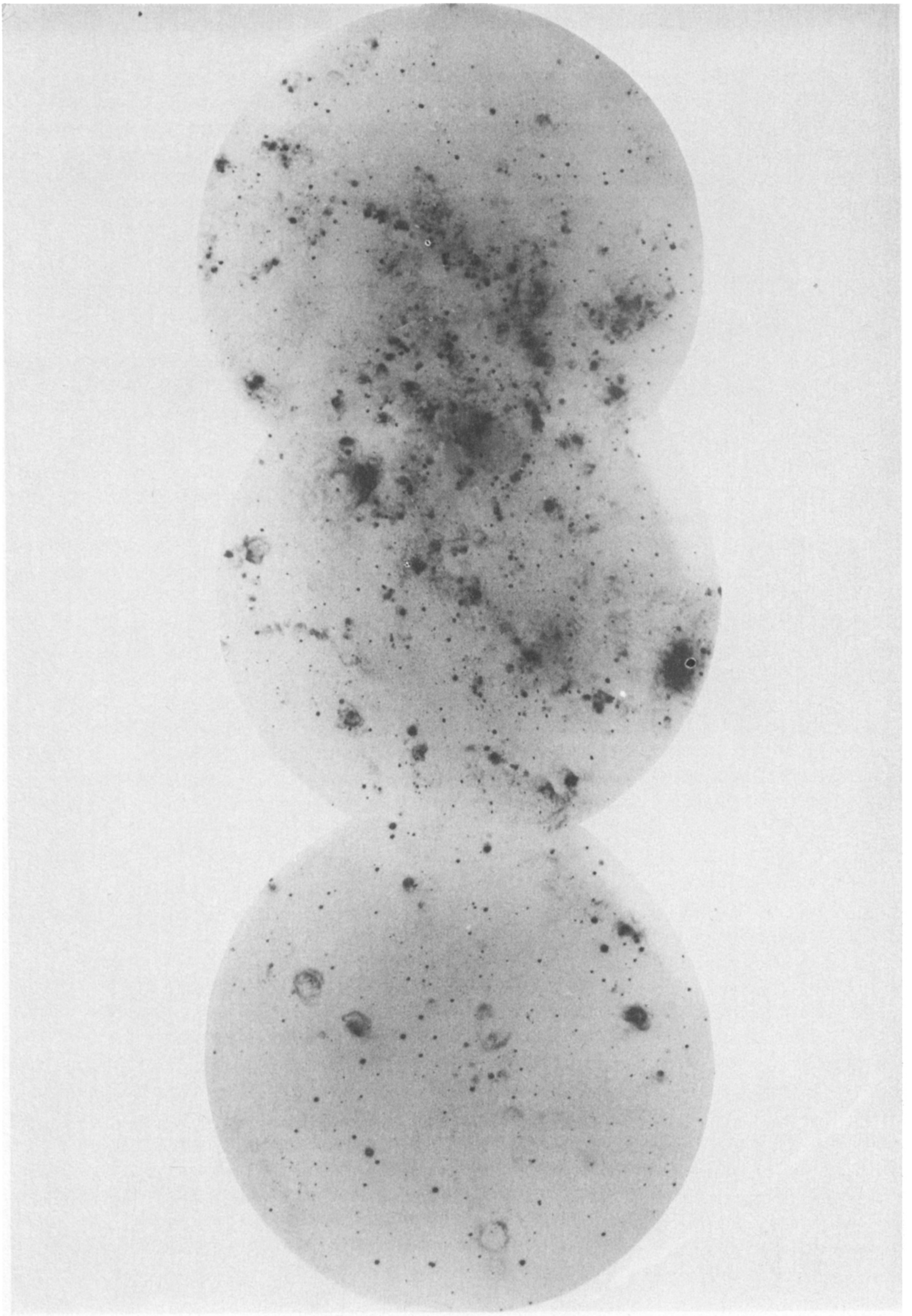

Figure 1. Detection of HII regions and general diffuse hydrogen in M33.

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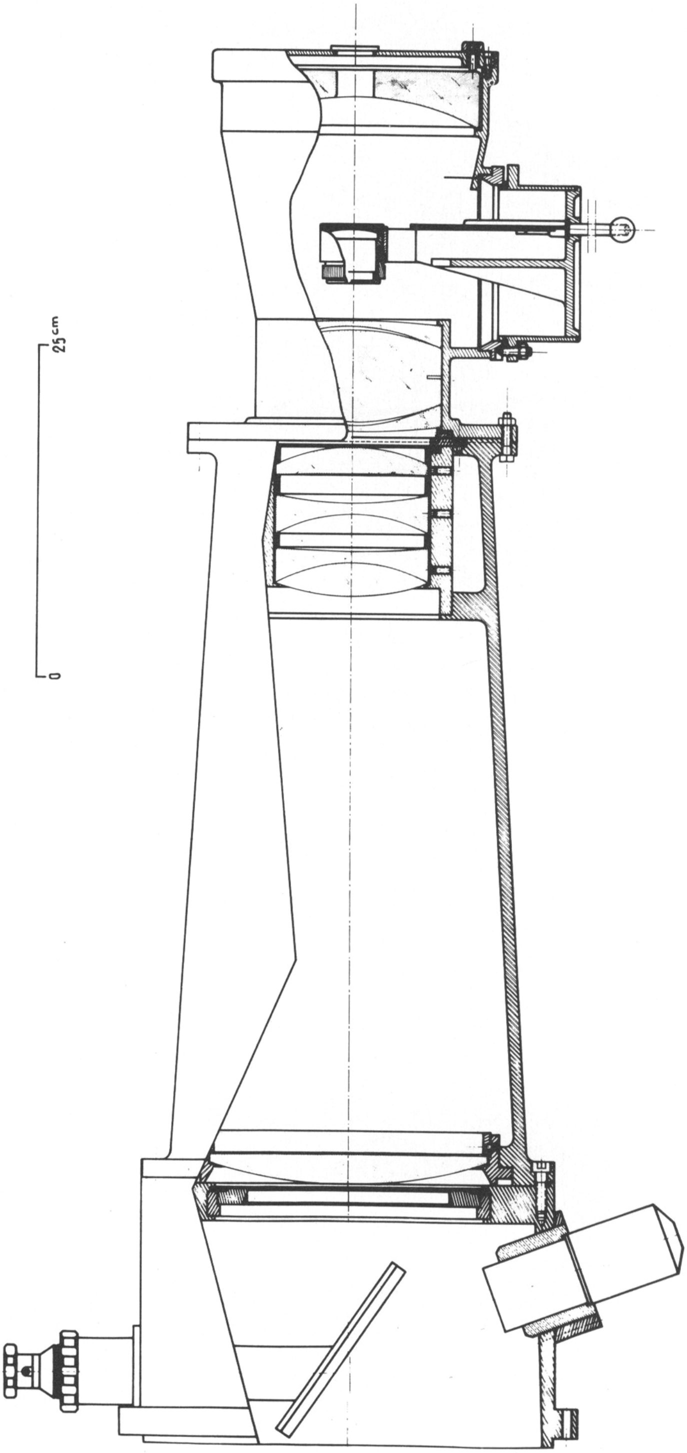

Figure 2. The focal reducer showing retractable mirror, Foucault equipment, field recognition eyepiece, interference filter, field lens, anastigmatic collimator and f/1 pseudo-Schmidt camera and film casette.

structure suggests a strong similarity to many features of the ionized hydrogen in the Milky Way, like the Barnard and Cetus Loops and the Gum Nebula (Sivan, 1974), and with the giant Hα shells observed in the Large Magellanic Cloud (Davies et al., 1976). Further investigations (in particular spectroscopic observations) are required to understand the origin of the isolated ring-like structures shown in Figure 1 as well as that of those observed in the spiral arms. The energy released in the interstellar medium by supernovae explosions and stellar winds may play an important role in this context.

The optical concept of the focal reducer is very flexible and can be used with various dispersive elements, prisms, gratings, interferometers, situated in the parallel beam portion (Figure 2; Courtès, 1973). Interference filters are put near the focal plane of the telescope in order to have over the whole field an approximately constant angle of incidence for the incoming beams. Furthermore, the correction by the focal reducer of the off-axis aberrations of the parabolic mirror of the telescope leads to an exceptional large field which would be always impossible to collect directly by any electronographic detector.

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