TWO DIMENSIONAL INTERFEROMETRIC PHOTON COUNTING OBSERVATIONS WITH THE 6m TELESCOPE

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I. DESCRIPTION OF MARSEILLES IPCS "COLIBRI"

This detector has been in use since 1977. Following Labeyrie (1977), it consists of a microchannel plate electrostatically focussed intensifier (TH 9304) coupled by fiber optics to an SIT camera (TH 9655), these parts being manufactured by THOMSON-CSF (FRANCE). The diameter of the S20 photocathode is 25mm but the silicon target is only 18mm wide. The scanning electronics are conventional. The detector is cooled to -5^{o}C, the photocathode being in a dry nitrogen chamber. The system has been described by Boulesteix (1978).

The electronics were derived from earlier versions developed by the LAS (Laboratoire d'Astronomie Spatiale) at Marseilles (Cenalmor, 1976; Lamy et al., 1976; Cenalmor et al., 1978). They consist of the following units:

1) a centroiding system in a 512 x 512 grid. The size of each pixel is 26μ, slightly less than the intrinsic resolution of the tube (15 1p/mm) with large aperture optics.

2) acquisition of the addresses of the centered events with real time integration and color display allowing the astronomer to see the image building up and to control the acquisition.

3) a magnetic tape recorder where the events are recorded frame by frame, thus preserving temporal information (with a time resolution of 1/50 s). Each tape contains about 8.10^{6} events. Such data storage is required for time dependent observations and for cleaning up the images to remove persistence and other tube defects.

Data pre-treatment software, first developed on a mini-computer, allows the final images to be obtained without persistence (important in silicon targets) and flashes (with the photocathode operated at -10kV). The increase in S/N is about 2.5. Such complex image processing is extremely time consuming and needs a more powerful computer.

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II. WORKING CHARACTERISTICS

The IPCS used here is well adapted to low flux observations (<5000 $ev.px^{-1}.h^{-1}$). For low fluxes, photon counting provides the best signal to noise ratio (Boulesteix and Marcelin, 1979) and observations of higher fluxes are well covered by other forms of detector (photographic plates, electronographic cameras, analog TV or CCDs).

The basis characteristics have been discussed in a previous paper (Boulesteix, 1978) and are:

- the linearity of the system, which is excellent for typical low fluxes observed with this device.
- the dark noise, which is of the order of a few $ev.px^{-1}.h^{-1}$ when cooled and after pre-treatment of the image. The noise characteristics are close to Poissonian.
- the response to uniform illumination is acceptable, even before any treatment.
- the relative sensitivity computed as the gain in exposure time on the same object for a given S/N ratio is 4 to 5 with respect to a 2 stage electromagnetically focussed image tube (RCA 33063) and about 40 with respect to a 103aE photographic plate (for an integration time of 1 hour).
- the detection limit of an extended source with a focal reducer at f/1.6 at the prime focus of the 6m telescope is 10^{-7} $erg.cm^{-2}.s^{-1}.sterad^{-1}$.

III. OBSERVATIONS AT THE 6m TELESCOPE

Observations with a focal reducer at the prime focus of the 6m telescope were followed by observations with the IPCS. They permitted direct comparison of the receivers, with the same optics and for the same objects, and confirmed the high sensitivity of the IPCS.

The first observing run with our IPCS at the 6m telescope was held in October 1980. We obtained an interesting result with a Perot-Fabry interferometer: the diffuse general emission of the ionized gas in [NII] light in the disk of M33 was detected for the first time in a 2 hour exposure (with rather poor sky conditions, the exposure being equivalent to about 1 hour with good conditions). This diffuse [NII] emission at 6584A appears as complete interference rings in the southern part of the galactic disk. The image is displayed in Fig. 1 where one can see another emission line of the sky background (OH 6577A). This second system of rings is easily recognized because of its faintness, the rings produced by the [NII] emission of the galaxy being strongly reinforced where they are crossed by the southern arm.

Up to now such a general emission of the ionized disk of nearby galaxies has been detected by interferometric means only in Hα light (Carranza et al., 1968; Deharveng and Pellet, 1970; Monnet, 1971). Such measurements necessitate the use of modern detectors (although, in the unique case of M33, complete interference rings in Hα light could have been detected on direct photographic plates with very long exposure times).

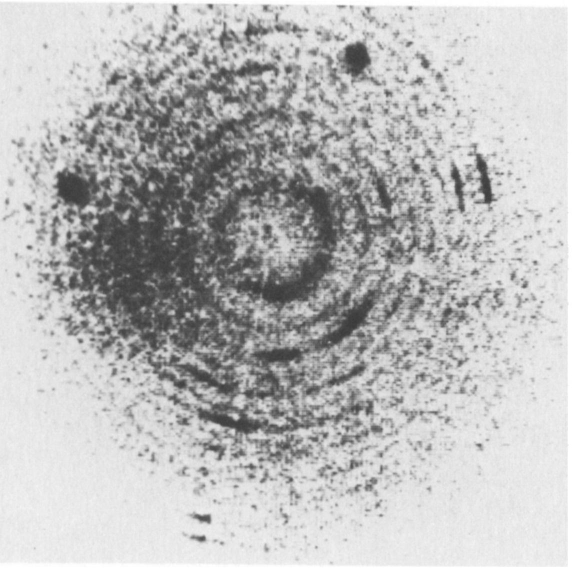

Figure 1. Interferogram of M33 in NII light. 2^h exposure time. Southern part of the galaxy (inverse image).

The faintness of the [NII] emission of the disk of M33 leads us to think that the Hα/[NII] ratio is closer to 5 than to unity as previously estimated by Deharveng and Pellet (1970) who suggested a Hα /[NII] ratio of 1.3 in the disk (from monochromatic plates) and a Hα /[NII] ratio of 7.2 in the bright HII regions of the galaxy. We thus conclude that the Hα/[NII] must be about the same in the galactic disk as in the bright regions.

The second observing run with our IPCS at the 6m telescope was held in January 1981. Interferometry with the Perot-Fabry equipment permitted us to complete the study of the velocity field of the barred spiral galaxy NGC 925, begun with image tube observations in 1979 at the 6m telescope (to be published in Astron. and Astrophys.) Five interferograms of the spiral galaxy NGC 2903, showing complete interference rings in the central parts of the galaxy, will permit the study of its velocity field. An example of the interferograms from this object is given in Fig. 2. Systems of rings due to OH emission of the night sky are also seen on this picture. The Hα signal was obtained not only from HII regions but also from general disk emission in the central parts. The velocity field seems very perturbed near the center as one can see distinctly the distortion of the two first Hα rings. Such a galaxy cannot be observed by interferometry with smaller telescopes. Previous observations with the 2m telescope of Haute Provence Observatory and an image tube were not conclusive because of the very small size of the HII regions. With the increased aperture of the 6m telescope and the greater sensitivity of photon counting, we obtained here an excellent result.

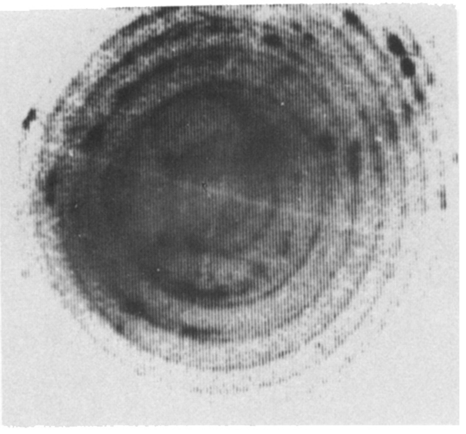

Figure 2. Interferogram of NGC 2903 in Hα light (inverse image): 1^h30 exposure time.

Our main astrophysical interest in these barred galaxies was to observe the velocity field with respect to the location of the bar, in order to confirm or refute the first observations made on NGC 1313 (Marcelin, 1979a, 1979b) showing that the center of rotation is outside the bar, far from the nucleus.

Interferometric observations of the central jet in the galaxy NGC 4258 were also obtained. For the first time, the jet appeared on the Hα interferograms with the 6m telescope.

Important data have been obtained from two-dimensional imaging studies performed at f/1.5, f/4 or f/10. These include:

- NGC 925, in which two bubble-like HII regions were discovered.
- a Hα study of the interactive galaxy VV551.
- Hα exposures in the center part of M33, showing clearly the string of HII regions in the near center with excellent spatial resolution.
- exposures in the Galactic interarm region, which were taken to investigate the structure of the diffuse Hα emission of the disk (filaments or homogeneous diffuse structure). It seems now that bubbles and filaments of gas are not only found in the spiral arms of galaxies but

that there are also filaments in the disk.

IV. SCANNING PEROT-FABRY INTERFEROMETER

A scanning Perot-Fabry interferometer controlled by piezo-electric elements has now been built at Marseilles for the 3.6m CFH telescope. Large field interferometric studies of small galaxies as far as 20 Mpc will be possible with large telescopes. About 20 images corresponding to 20 channels of different interference orders will permit direct acquisition of the complete two-dimensional velocity map of the objects. Each channel will be scanned every 15 min and the total exposure will be several hours. A special electronic servo-system acting on the piezo-electric transducers corrects automatically the parallelism and the separation of the silica plates. The appropriate detector for such a powerful system is of course a photon counting camera and the "Colibri" camera has indeed been developed for such an interferometer. First observations with the two complementary instruments were conducted in 1980 and 1981 on small telescopes and proved to be successful.

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