Optical Haloes Around Galaxies

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There are many reasons why massive haloes are expected to surround galaxies. Flat rotation curves are observed in spiral galaxies out to the largest observable distance from the nucleus. Studies of galaxies in pairs, groups and clusters also suggest mass at large distances from the galaxy centre. From these considerations the "missing mass" was postulated and various authors came with spectacular suggestions to explain this: small black holes, heavy leptons, neutrinos with rest mass, ordinary matter in particles of any size between gravel and Jupiter. Could the missing mass be "hidden" as late type dwarf stars? Is there any indication for weakly luminous matter surrounding galaxies? Do we see reflection from dust in outer reaches of galaxies? How big are galaxies?

Answering all these questions is not easy. The light of a galaxy usually falls off very rapidly from the nucleus so that in the outer reaches of galaxies the light is usually well below the night sky level. Airglow variations (and the cirrus clouds) disturb the photometric measurements at distances from the

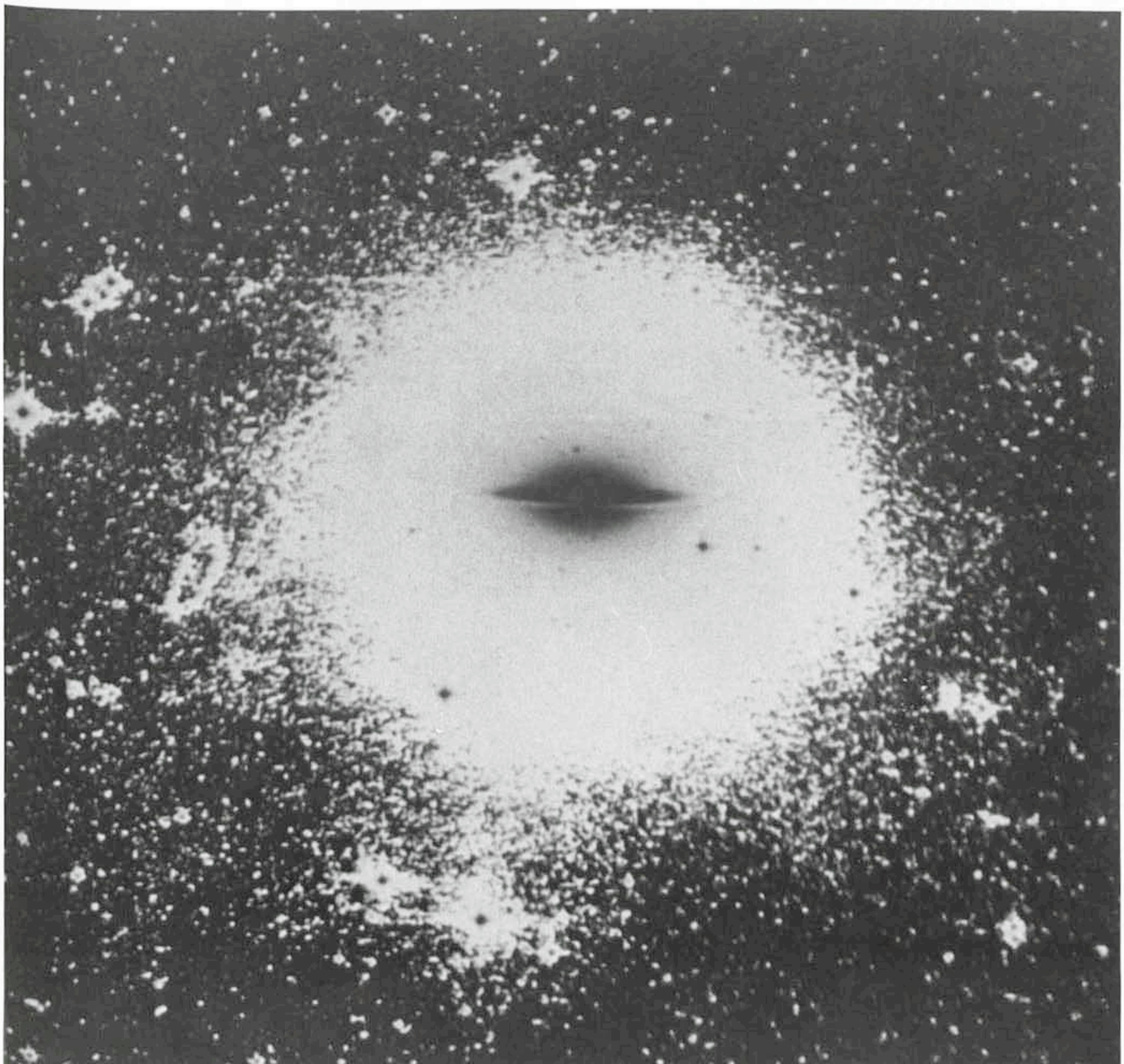

Fig. 1: *The digitized image of M104 – the well-known Sombrero galaxy – from a deep IIIa-F plate of the ESO Schmidt telescope. North is at top, east to the left and the field shown is ~ 34′ on a side. The grey scale representation produces a pseudo-contour at a surface brightness of $\mu_R \cong 25$ mag/□″.*

nucleus which are necessary to start to answer the many questions. However some pioneering work on selected edge-on galaxies (see review by Kormendy (1980)) showed that with modern techniques such studies are possible.

The rapid development of observing techniques has aided this type of work. The use of fine grain sensitized astronomical plates with subsequent diffuse light enhancement (e.g. Malin, 1978, 1981; Beck et al., 1982) allowed the study of the large nearby edge-on or nearly edge-on galaxies. Also the use of digitizing microdensitometers with subsequent data processing enables us to search for weak light. The CCD cameras now available are ideally suited for similar studies of smaller edge-on galaxies.

We have so far concentrated our attention on the large southern galaxies NGC 55, NGC 253, NGC 4594 (M104) and

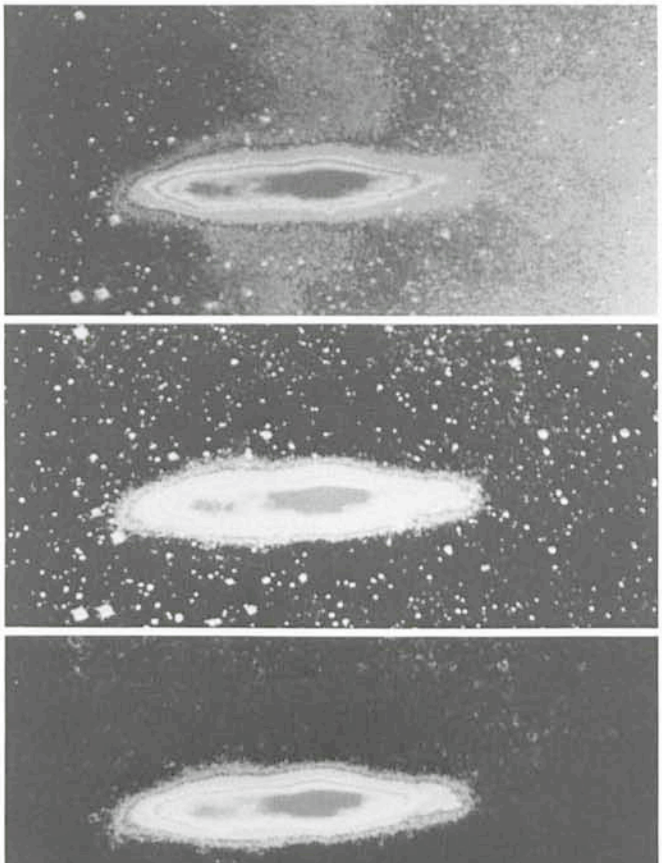

Fig. 2: *The steps of reduction are demonstrated for NGC 55 which is a Magellanic type irregular galaxy of the Sculptor group seen edge-on. A large gradient in the background is visible in the field scanned from a standard SRC-J survey film. This gradient is corrected in the first step. In the second step foreground stars are removed. In the final step some smoothing shows a thick disk of weak light surrounding the galaxy.*

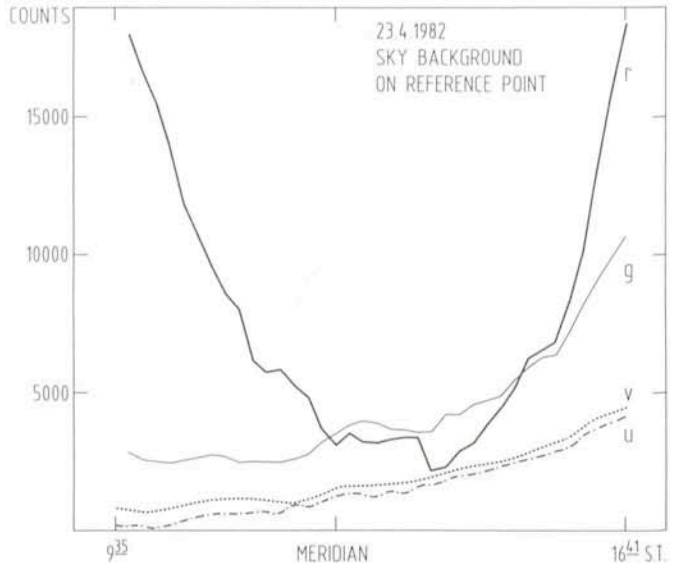

Fig. 3: *Night sky variations during a 'good' night measured continuously at a reference point by the monitor telescope. The general trend is due to extinction but the spurious variations are comparable to the signal expected from a weak light surrounding a galaxy.*

NGC 4945. Similar studies of a number of large northern edge-ons are planned. In addition to using the Schmidt plates we made photoelectric photometry measurements on selected points in the galaxy disk and in the halo. Also a number of surrounding stars were measured, so that the scanned plates can be "tied-in" to stellar images.

The Schmidt plates were taken in four colour ranges: U, B, R und I. The plates were all sensitized and exposed to the sky limit. It was the fine work of the Schmidt telescope staff that gave us the uniform plates. And a lot of this was done during the bad-weather period at La Silla! The plates were scanned with the PDS machines at ESO, Munich, and Münster University. The image processing was done on the VAX of the Astronomical Institutes of Bonn University. We used both the Starlink ASPIC and the MPI NOD software systems to present the data. One result, shown in Fig. 1, is the giant halo surrounding M104 which is seen after digitizing and computer processing. The photographic laboratory of the MPIfR also produced diffuse light pictures from the plates. The results were very similar, but the treatment of the digitized image with various filtering and convolving functions seems to offer the possibility of seeing more of the halo. Another example of a sequence of manipulations is shown in Fig. 2. Here we see the original plate, the plate with the large-scale gradient removed, the galaxy after filtering out of point-like objects (stars) and a weak-light enhanced version. This manipulation was made from a normal survey plate where the galaxy NGC 55 is taken nearly at the edge of a standard field.

The photoelectric photometry measurements were made on our galaxies with the 1 m and 50 cm ESO telescopes used simultaneously. We used the Thuan and Gunn (1974) uvgr filter system, because the passbands of this system avoid the strongest night sky lines. The two telescopes together allow us to monitor the night sky variations and achieve further reduction of these spurious signals. The most sensitive observations reached $\mu_B \cong 27$ mag arcsec^{-2}. To make the observations, one astronomer from Bonn was joined by a partner from the Instituto Argentino de Radioastronomía, Villa Elisa, and the simultaneous observing was done via the telephone between the domes. Measurements of the sky brightness during a

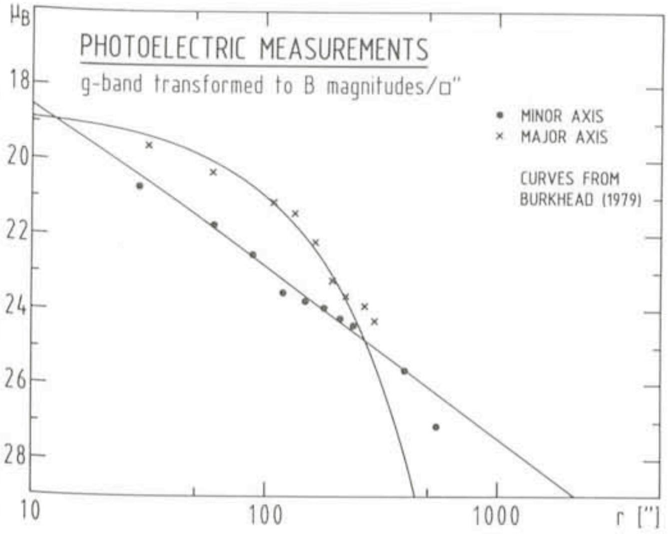

Fig. 4: *The monitoring telescope technique allows photoelectric photometry down to a surface brightness of $\mu_v \sim 27$ mag/□". Our photometry of M104 is compared with photographic photometry by Burkhead (1979). The g-band was transformed to B magnitudes assuming a colour of B-V = 1.0.*

"good" night on La Silla are shown in Fig. 3. A bad night (70% of the nights in this project were bad) shows constant jumps of counts and cannot be used for the determination of the colour.

The galaxy NGC 4594 (M104) is the prime "standard" (Fig. 1) since it was known to possess an extended halo (Burkhead, 1979) and it can also be observed from northern sites. In Fig. 4 we show the results of our observations superimposed on the profiles derived by Burkhead (1979). The colour of the halo emission is red with B-V ≅ 1.0. We found no significant variations of this colour out to the limits of detection in the halo of M104.

In studies of NGC 4565, Jensen and Thuan (1982) also find no definite colour gradient in the halo and B-V = 0.9. On the other hand, the colour of the halo surrounding NGC 253 is bluer.

The present sensitivity is such that we can study weak light in outer reaches of galaxies. The question of the origin of this light is still unclear. Lack of reliable colour information at the faint end of a galaxy makes it difficult to make any interpretations. Also the sample of galaxies that has so far been investigated is too small. Further studies using CCD detectors with colour and polarization filters are needed to bring us nearer to an interpretation of this very interesting phenomenon.

Acknowledgements

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ALGUNOS RESUMENES

El Servicio de Coordinación Europea para el Telescopio Espacial comienza sus actividades

P. Benvenuti, ST-ECF

El día 23 de febrero de 1983 los Directores Generales del Observatorio Europeo y de la Agencia Espacial Europea firmaron un Convenio para crear el Servicio de Coordinación Europea para el Telescopio Espacial (ST-ECF). Un año más tarde, el día 1° de marzo de 1984, el ST-ECF inició sus actividades en el edificio de la ESO en Garching.