ULTRAVIOLET OBSERVATIONS OF NORMAL GALAXIES

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ABSTRACT

The UV spectrum of galaxies provide us with the unique chance to detect those hot stellar components, which normally do not appear in the visible spectrum. Such components, interpreted as possibly due to horizontal-branch stars, have been found in spectra of early-type galaxies. All these spectra exhibit an UV excess shortward of 3000 A with respect to the energy distribution of a K-type star. UV excess is present in different amount also in spectra of late-type galaxies, but the data are fragmentary.

There is hope to define a standard UV spectrum of nearby elliptical galaxies to compare with that observed in the visible region in distant galaxies. This would allow the determination of the evolutionary effect.

The emission lines in elliptical galaxies are found much stronger than one would expect if the physical conditions are similar to those of HII regions.

Direct images of galaxies allow to trace the spiral structure defined by hot stars and to study the UV luminosity profile in the nuclear region.

1. INTRODUCTION

The last few years mark a great achievement in our knowledge of the UV radiation from galaxies. On the spectroscopic side, in addition to the outcoming of the observations made during the last decade, a new powerful tool,

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the International Ultraviolet Explorer, has been recently put into operation and continuously provides us with completely new spectroscopic data. The rapid development of suitable UV detectors has allowed to obtain the first direct images of galaxies from balloon and rocket borne experiments. All this information sets up the background for the future use of the Space Telescope.

2. UV IMAGERY

The first set of UV photographs of galaxies was obtained from the lunar surface with an electrographic Schmidt camera during the Apollo 16 mission (Carruthers and Page, 1972; Page and Carruthers, 1977). Particularly interesting is the image of the Large Magellanic Cloud, showing the distribution of hot stars, which is remarkably different from the visible image.

Images of M 31 with about 40" resolution have been obtained with an electrographic Schmidt camera during a sounding rocket flight (Carruthers et al., 1978) in the region 1230-2000 A. Two conspicuous features have been detected : one coincident with the nucleus of the galaxy and the other with the bright stellar associations NGC 206. Since the isophotes of the nuclear region appear to be flatter in UV than in visible light, the authors interpret the UV radiation as due to stars lying close to the equatorial plane on the galaxy and consequently assign it to young early-type stars.

A more recent image of M 31 obtained by Deharveng et al. (1979) during a balloon borne experiment shows, in addition to the nuclear region, the general spiral structure as a ring,which appears to be in good coincidence with OB associations and HII regions.

UV photographs of M 51 and M 101 with a resolution of 10" have been recently obtained by R. Bohlin and T.Stecher (1979, private communication) with a 13-inch telescope on Astrobee rocket. In both cases the spiral pattern marked by hot stars is very well developed.

3. PHOTOMETRY AND SPECTROPHOTOMETRY

Before IUE, satellites carrying UV experiments on galaxies were OAO-2 and ANS. Both produced information on the UV spectrum in the form of broad band photometry, with a quite large field of view (10' and 2!5 respectively). IUE is a new generation instrument since it provides a continuous calibrated spectrophotometry from 3300 A down to Lα and a much higher spatial resolution (the entrance slot and the resolution normally used for galaxy work are 10" x 20" and 6 A respectively).Clearly, due to its limited collecting power, IUE is more suitable for the study of emission line spectra. However, when the exposures are pushed to the limit, it is able to provide reliable information on the energy distribution at least of the central parts.

3.1. Early-type galaxies

Recent data obtained with IUE for the giant ellipticals M 87 (Bertola et al., 1979a) and NGC 1052 (Fosbury et al., 1979), for the dwarf M 32 and the bulge of M 31 (Johnson, 1979), as well as the ANS observations of M 31 and M 81 (Wu et al., 1979) confirm a phenomenon which was firstly noticed in the early OAO-2 observations (Code and Welch, 1979). In fact, the UV energy distribution of the elliptical galaxies and of the bulges of spirals does not match anymore, as it does in the visible,that of a K-type star. While ANS observations of M 31 and M 81 show that F_λ is almost constant from 2500 A down to 1500 A, the energy distribution derived for M 87, M 31 and M 32 with IUE has an increase shortward after a minimum has been reached at about 2000 A, in agreement with OAO-2 observations.

A detailed analysis of the UV luminosity profile of M 87 (Bertola et al., 1979a), obtained with scans normal to the dispersion, shows that it follows the same law as the visual one. Therefore it is concluded that the UV excess in the nucleus should be due to the nuclear stellar content and not to the point-like source present in it.

The UV excess can be interpreted either as due to the presence of upper main sequence stars or produced by horizontal-branch stars. However, several pieces of evidence seem to favor the second case (Bertola et al., 1979a; Wu et al., 1979).

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Several absorption lines similar to those of the Sun have been identified in M 31 and M 32 (Johnson, 1979). An attempt to identify absorption lines in the UV spectrum of M 87 has failed because of the low signal to noise ratio. Emission lines have been identified in all the early-type galaxies observed with IUE. Their strength is not easily understood if mechanisms similar to those present in HII regions are considered. In the case of NGC 1052 (Fosbury et al., 1979) the emission lines are interpreted by means of a shock heating model, the same already used by the authors to match the optical emission lines spectrum.

Due to the small number of galaxies observed so far, it is not yet well established whether the UV spectrum of ellipticals repeats exactly from galaxy to galaxy. IUE spectra of M 87 and NGC 3379 (Bertola et al., 1979a, 1979b) in the long wavelength range (2000-3300 A) look similar. This fact gives some hope to define a standard UV spectrum of nearby elliptical galaxies to be compared with ground based spectra of distant galaxies ($z \sim 0.5$). In this way, it will be possible to investigate the presence of the evolutionary effect, which is extremely relevant in cosmology.

3.2. Late-type galaxies

Only very few late-type normal galaxies have been observed in UV, so that a comprehensive discussion of their properties is still premature. In the peculiar Sc NGC 3310, observed with ANS (van der Kruit and de Bruyn, 1976) and in the Magellanic system NGC 4449 (Code et al.,1972) F_λ is increasing shortward of 3500 A. On the contrary the clumpy irregular Ma 297 (Benvenuti et al., 1979) shows a flat energy distribution. It is possible that the effect of differential absorption within the system in these dust rich galaxies is quite prominent and different from one galaxy to another, causing different trends of F_λ.

In Ma 297 absorption features typical of stars from late O to AO are identified, indicating the contribution of hot main sequence stars. No emission lines are present in the UV spectrum, while they are abundant in the visible. Line intensity calculations show that this is the expected behaviour, if the physical conditions of the gas in this galaxy are the same as in HII regions.

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DISCUSSION

H. Gursky: What corrections have been made for reddening in the observed galaxy?

F. Bertola: No correction is probably needed for early-type galaxies not affected by interstellar dust. The problem of reddening is much more serious for late-type galaxies and requires careful consideration.

W. Bidelman: Do you have observations of NGC 205, which has a number of rather bright hot stars as noted long ago by Baade?

F. Bertola: No, we have no observations for that particularly galaxy, but we plan to observe dwarf ellipticals in order to ascertain whether the stellar population is the same as in the giant systems.

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