IDS Spectroscopy of Faint Emission-Line Objects

I. Lundström and B. Stenholm, Lund Observatory, Sweden

Introduction

During the last decades we have seen the advent of new technology detectors, which no longer contain a photographic emulsion as a last step. These detectors, such as the IDS (Image Dissector Scanner) for spectroscopic work and the CCD (Charge-Coupled Device) for field imaging, produce digitized data, which can easily be stored on a disk or on a magnetic tape.

In this short article we will report some of our experiences of the IDS devices of ESO. The IDS at the 3.6 m telescope was taken into use in 1978 and the one at the 1.52 m telescope followed two years later. Although we have had the opportunity to use both instruments we will concentrate on a programme performed exclusively with the 1.52 m telescope.

The Instrument

The IDS is mounted on a conventional B & C spectrograph. The spectral images fall on an image tube arrangement which ends with an output phosphor. This phosphor, in which an intensified spectral image is formed, is "read" by a scanning device dividing the one-dimensional image into 2,048 pixels. The reading-out procedure goes on continuously during the observation, one cycle being about 1 ms. The building-up of the spectrum can be followed by the observer on a screen, and it can thus immediately be checked that the correct object is observed, provided a rough spectral type is known. This property has been very advantageous in the programme described below.

The IDS actually sees two windows in the decker of the spectrograph simultaneously. One window contains the object and the sky, the other the sky only. In the reduction process these two windows are subtracted from each other, producing, in the ideal case, a clean spectrum of the observed object. The data are stored on disk (and normally copied on tape) ready for reduction with the IHAP (Image Handling and Processing) system, either directly at La Silla or at a later date at ESO Garching or some other astronomical institute in Europe where the IHAP system is available.

The IDS is a very efficient tool for low-resolution spectroscopy of faint emission-line objects. The advantages we particularly appreciate are:

- high sensitivity;
- continuous watching during the observation;
- efficient reduction via the IHAP system.

There are, however, also some disadvantages. The only one that is really important for the present programme is the very low sensitivity of the IDS in the violet and ultraviolet, which effectively hinders the detection of spectral features below $\approx$400 nm.

The Programme

The programme described here concerns low-resolution spectroscopy of faint emission-line objects in the southern Milky Way. Originally, the object list was based on objects found in an objective prism survey near the galactic plane ($-7° < b < 7°$) in the longitude intervals $210° < l < 260°$ and $0° < l < 40°$. We were particularly interested to find new Wolf-Rayet star candidates, but all kinds of emission-line objects were noted. In this way about 130 objects were found, many noted in earlier surveys but normally lacking reliable classification. However, several of the objects were not previously known as emission-line objects. We later decided to include also a number of objects from other discovery lists and catalogues. Many of these objects were near the detection limit of the original surveys, and their nature was in many cases unclear. It is, for example, sometimes impossible to discern on an objective-prism plate between an emission-line object, where only the most intense features show up as a faint spot, from a plate flaw of regular shape. In other cases, the lack of a wavelength calibration makes it difficult to correctly identify the object on a direct plate and can also lead to incorrect line identifications.

The IDS is an ideal instrument for observing emission-line objects with uncertain identifications. One can test without much loss of observing time several objects in the field and in this way make sure that only the correct object is fully exposed. Moreover, faint M stars are sometimes mistaken for emission-line objects. Also in this case the error can be quickly detected, thus saving valuable observing time. The high sensitivity of the IDS also makes it possible to get sufficiently good spectrograms (at least of the line spectrum) with reasonable exposure times even for very faint objects.

Some Preliminary Results

Our programme has been allotted observing time during three different periods. At the two first occasions, in June 1982 and May 1983, the weather was not good and only a very limited number of objects were observed. Nevertheless, one part of the programme, spectroscopy of faint WR stars, was successfully completed during these two periods (Lundström and Stenholm, 1984). However, during the third period, in April 1984, the weather conditions were excellent and we managed to complete the whole programme. Altogether we have collected spectrograms of about 160 emission-line objects in the wavelength region 400–750 nm with a dispersion of 17 nm/mm. The majority of the objects are planetary nebulae, but there are also numerous symbiotic stars, Be and Bep stars, compact H II regions and a number of objects that cannot easily be put into these categories. Only one new WR star has been found (see below), an unexpectedly low number. The material has still not been entirely reduced and we will give here only a few examples of the various types of objects encountered.

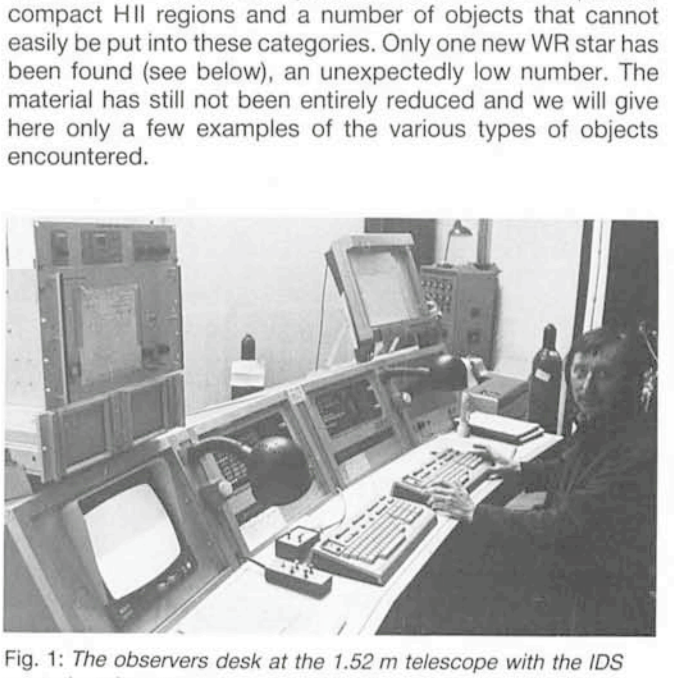

Fig. 1: *The observers desk at the 1.52 m telescope with the IDS control equipment.*

WR Stars

There are two WR stars in our material. One of these, PK 309 −4°1 (= He 2–99) was previously classified as a planetary nebula with a WC9 star as central star (Jones, 1969). Our observations confirm this. The other example is PK 337 +1°1, which appears as No. 67 in the list of misclassified or doubtfully classified planetary nebulae by Sanduleak (1976). The reason for this was the finding by Webster (1969), who from photometric observations concluded that the normally strong [O III] line at 500.7 nm seemed to be absent in PK 337 +1°1. A spectrogram of this object is shown in Fig. 2 (upper). The strongest lines are $H\alpha$ and the [N II] doublet at 654.8 and 658.4 nm. $H\beta$ and [N II] at 575.5 nm are also narrow and relatively strong. The [N II] line is surrounded with broader features, which also can be found near 465 nm and in the red end of the spectrum.

A so-called "high-cut" version of the spectrum (Fig. 2) reveals that these features are due to lines typical for a Wolf-Rayet star of type WC9. In fact the object is very similar to PK 309 −4°1, which also has very weak [O III] lines, a property that is normal for planetary nebulae with late WC type central stars. The most natural interpretation is to regard also PK 337 +1°1 as a planetary nebula with a WC9 type central star.

However, the line widths of the emission lines are normally smaller for planetary nuclei of WR type than for "classical" WR stars of the same type (Smith and Aller, 1971). A comparison with the classical WC9 star, WR 103, which was observed during the same observing run, did not show any significant differences in line widths or line intensities between the two stars. One must therefore also consider the possibility that PK 337 +1°1 might be a normal WC9 star surrounded with a compact H II region. Hopefully, the finally reduced data will permit a more unambiguous interpretation of this object.

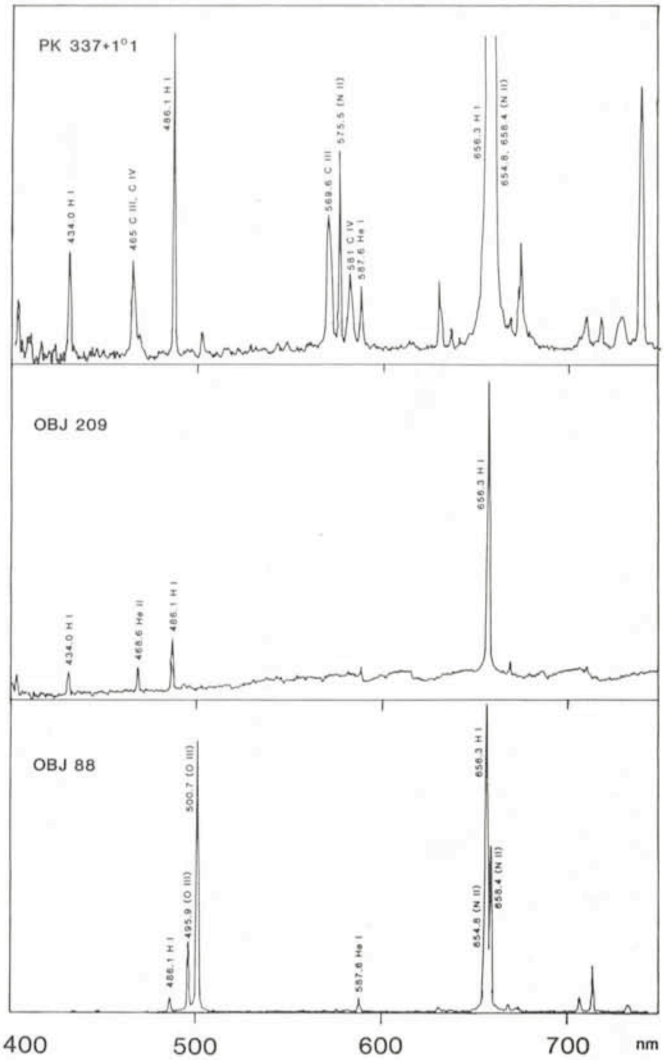

Fig. 2: *Spectral signatures of three objects mentioned in the text. Not finally reduced, no calibration of the ordinate is done.*

Symbiotic Stars

Fig. 2 (middle) shows a spectrum of our object 209, also known as No. 324 in the list of $H\alpha$ emission objects by Stephenson and Sanduleak (1977). The true nature of this object was previously unknown, but our spectrogram clearly shows a symbiotic object, with a high excitation line spectrum superposed on a late-type stellar spectrum.

Planetary Nebulae

Our final example is a spectrogram of our object 88 ($\alpha = 18^h46^m.11$, $\delta = -5°59'.8$). This object does not, as far as we know, appear in any other list of emission line objects. The spectrum (Fig. 2, lower) is typical of a planetary nebula of medium excitation.

There are of course several other interesting objects in our material, but since almost no reductions have yet been made, we feel that a discussion of these must be postponed to a later occasion. Let us only once more emphasize that the IDS is an excellent tool for studying faint emission-line objects and that we certainly intend to make use of this fine equipment for future investigations of similar kind. For example, with the experience hitherto gained, we are now designing a programme for ESO in which we will investigate all known or suspected planetary nebulae in the southern sky. This project, which will not require very much telescope time, will go into a planned catalogue of planetary nebulae as proposed by Agnès Acker at the Strasbourg Observatory.

References

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Colour Gradients in Elliptical Galaxies – Some Results from CCD Photometry

E. Sadler, ESO

The use of charge-coupled device (CCD) cameras in galaxy photometry offers a number of significant advantages over traditional photoelectric and photographic techniques. CCDs have a high quantum efficiency compared to photographic