rates. The derived magnitudes are 19.5 ± 0.5 (No. 3), respectively 20.1 ± 0.5 (No. 2). A comparision of this observed V with the expected value, together with a thorough discussion of error margins, cooling ages of the white dwarfs, and cluster ages led us to the conclusion that 2 of the 3 white dwarfs identified in the direction of NGC 2287 (including No. 2) are most probably cluster members, whereas No. 3 is probably a foreground object. From the turnoff mass of NGC 2287 we thus find that M_{wd} is definitely larger than 3.9 $M_\odot$.

The next step in our project was the extension of RA's photographic search to clusters accessible only from the southern hemisphere. H. E. Schuster (ESO) took excellent Schmidt plates of several clusters in the red and blue spectral regions, which allowed us to find many blue candidates. For NGC 2516 the spectroscopic observations have been completed by D. Reimers in March 1982. Fig. 3 shows 6 white dwarfs identified, three of which lie very close to the cluster centre. An analysis like that for NGC 2287 has not yet been completed; we are quite sure, however, that at least some of them are cluster members. This will bring the lower limit on M_{wd} up to 5 $M_\odot$, without using any statistical considerations.

Conclusions

The 3.6 m ESO telescope and the IDS are an ideal combination to identify extremely faint white dwarfs in open clusters. We have now set by purely observational methods the lower limit of the critical mass M_{wd} that determines the final fate of single stars (white dwarf vs. supernova) at ≈ 5 $M_\odot$. In the case of NGC 2516 one of the original candidates turned out to be probably a QSO. The extragalactic background is obviously not completely obscured even at low galactic latitudes, and spectroscopic observations are necessary to distinguish white dwarfs.

In the future we plan to extend our search to clusters with even higher turnoff masses, and a number of candidates have already been detected on the Schmidt plates.

High Spectral Resolution Observations of [S II] Lines in the Planetary Nebula IC 418 at the CES Spectrograph

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Summary

Preliminary observations of [S II] lines at 6717 and 6731 Å of the planetary nebula IC 418 are presented. Observations are made with the ESO Coudé Echelle Spectrometer (CES) and the Coudé Auxiliary Telescope (CAT); the resolving power is 10^5, corresponding to a dispersion of 1.87 Å mm^{-1} or a spectral resolution of 0.067 Å. Both [S II] lines present two well separated components corresponding to a shell expanding at the velocity of 30.3 km s^{-1}. It is shown that density and thickness of this shell, as observed on the line of sight at two diametrically opposite points, are similar, whereas the S^+ concentration suggests a non-symmetrical ionization structure.

Introduction

The low-excitation planetary nebula IC 418 is a small, nearly round (14 × 11″) ring-shaped nebula. Because of its apparently simple structure it has been carefully studied both observationally and theoretically. Wilson and Aller (1951), Aller (1956) and Reay and Worswick (1979) have published isophotes for several emission lines. Osterbrock (1970) has made high resolution spectral observations at the coudé spectrograph of the 100 inch Mount Wilson telescope: the dispersion was 4.1 Å mm^{-1} in the green spectral region and 6.5 Å mm^{-1} in the red. Whereas the [N II] lines showed double, the [O III] and hydrogen line profiles showed no central dips, in good agreement with Wilson's pioneering work (1950, 1953). This is explained by the fact that O^{++} ions are concentrated near the centre of the nebula, where the expansion is lower, while N^+ is present in the outer layers where the expansion is larger. Simple hydrogen line profiles can be explained partly by the fact that thermal Doppler width is larger and also by the fact that these lines are formed throughout the nebula.

High resolution spectrographic observations of the [S II] doublet at 6717–6731 Å allow the measurement of the expansion velocity of the nebular shell and the determination of the density of this shell (Pradhan, 1978; Cantó et al., 1980; Czyzak and Aller, 1979). On the other hand, from previous observations, it is expected that low-excitation lines, such as the [S II] doublet, will present the most evident splitting effect. These are the reasons why we decided to observe IC 418 at these wavelengths in order to check the feasibility of spectrographic observations of (southern) planetary nebulae with a resolving power of 10^5 with the CES at the coudé focus of the 1.4 m CAT. This first test is quite promising.

The Observations

The integrated magnitude of this planetary nebula is given as 12; we used a slit of 1.3 × 5 arcsec which corresponds, at face value, to a magnitude of nearly 15. The slit was kept aside the central star (m ~ 10.5). Observing conditions (seeing, transparency) were good. The detector was the presently used Reticon Chip cooled to 136°K, the central wavelength 6723 Å and the spectrum length 52 Å. The resolving power was 10^5, corresponding to a spectral resolution of 0.067 Å or a linear dispersion of 1.87 Å mm^{-1}, the channel width being 0.028 Å. The

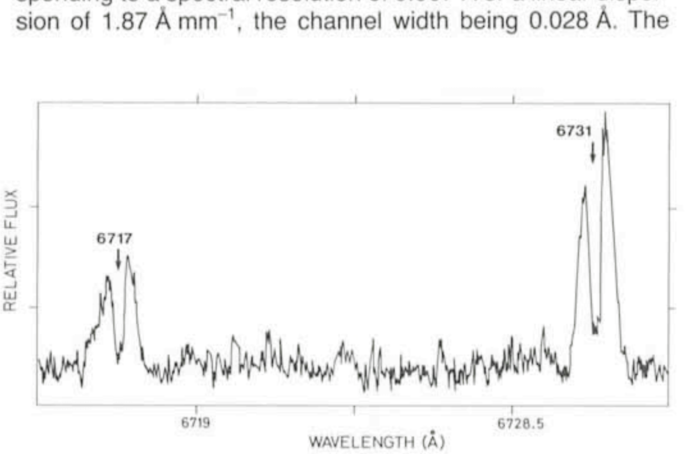

Fig. 1: *Spectrum of IC 418 showing the [S II] emission lines. This spectrum was obtained on 7 December 1981; the exposure time was 5400 s.*

integration time was 1^h30^m. The signal-to-noise ratio, for the continuum is of the order of 20 corresponding to an effective magnitude of the order of 8.5 (see for instance the S/N ratio values as a function of the V magnitude given by D. Enard (1981) essentially due to the emission lines).

The spectrum is shown in Fig. 1. Profiles of both [S II] lines at 6717 and 6731 Å appear double; the separation of the two peaks corresponds to an expansion velocity of the shell of 30.3 km s^{-1}. This value is in good agreement with the result obtained from [N II] line observation by Osterbrock (1970).

Let us call I_{1B} and I_{1R} the blue and red shifted components of the [S II] line at λ = 6717 Å, I_{2B} and I_{2R} the corresponding components of the [S II] line at λ = 6731 Å. A cursory examination of the line profiles permits the following comments:

(1) The ratios $I_{1B}/I_{2B} = 0.58$ and $I_{1R}/I_{2R} = 0.56$ show that both recessing and approaching parts of the expanding shell have similar electron density.

(2) The widths at half-maximum of I_{2B} and I_{2R} have the same order of magnitude ($\Delta\lambda \sim 0.45$ Å); therefore, it may be expected that the corresponding parts of the expanding shell have similar thickness.

(3) The ratios $I_{1B}/I_{1R} = 0.84$ and $I_{2B}/I_{2R} = 0.80$ are also quite similar. Taking into account the previous comments, this indicates that the abundance ratio of S^+ ions in the recessing (R) and approaching (B) parts of the expanding shell is of the order of 0.8. This may be due to a non-symmetrical ionization structure of the nebula as suggested by Osterbrock (1970) from other considerations.

Conclusion

So far, it is the first time that the planetary nebula IC 418 is observed with a spectral resolving power as high as 10^5. Both [S II] lines at 6717 and 6731 Å show well separated components corresponding to a "classical" expanding shell. Density and thickness of both parts of the nebula observed on the central line-of-sight are quite similar. However, the S^+ concentration seems larger in the farther (recessing) part of the shell than in the nearer (approaching) part. This is certainly due to a non-symmetrical ionization structure of the shell.

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The Fate of Dust Grains in a Shock Wave Originated by a SN Explosion

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Observations of SNR at 10 μm can be compared with the theoretical prediction of IR emission of shock-heated dust.

1. The Role of Dust in Supernova Remnants

Several theoreticians have investigated the behaviour of dust grains in the surroundings of a supernova explosion. It has been suggested by the computations (Silk and Burke, 1974, *Astrophysical Journal* **190**, 11) that thermal energy from the gas heated by the passage of the SN blast wave should be deposited in the dust grains by ion-grain and electron-grain collisions and subsequently radiated by the dust in the infrared. The efficiency of this cooling mechanism depends mainly on the interstellar medium pre-shock density and the shock velocity. Other important parameters are the assumed composition and size distribution of the grains and the rate of collisional heating and destruction for the grains in a hot plasma.

The more recent computations have dealt with a variety of physical cases. Shull (1980, *Ap. J.* **237**, 769) and Wheeler et al. (1980, *Ap. J.* **237**, 781) studied the emission of dust for the case of a SN exploding in the vicinity of a dense molecular cloud. In this case the main heating mechanism for the grains is absorption of UV and X-ray photons from the hot interior of the SNR, and the larger fraction of the infrared emission comes from the grains exterior to the shock. According to the theoretical computations, this type of remnants could be discovered in a survey of nearby galaxies at infrared and X-ray wavelengths but it is unlikely that it can be detected in the optical because of the heavy extinction in the dense material which surrounds the SN.

Draine (1981, *Ap. J.* **245**, 880) and Dwek (1981, *Ap. J.* **247**, 614) concentrated on the infrared fluxes expected from the dust heated by collisions in the hot interior of a SNR. This dust, originally associated with the interstellar gas, is only partially destroyed by the passage of the shock wave. Dwek and Werner (1981, *Ap. J.* **248**, 138) considered the emission from grains formed in the SN itself, which are to be found in the fast moving ejecta observed in the remnant or in the "evaporated" gas which surround them.

However detailed the calculations, there is as yet no direct observational evidence for the presence of grains in a SNR. For this reason, any observational results, being it a detection or a significant upper limit, is useful to understand the fate of dust in a SN vicinity. So far a systematic search for infrared emission (80–350 μm) has been made only in three young galactic SNR (Wright et al., 1980, *Ap. J.* **240**, L157).

Preliminary Results for the 10 μm Emission from SNR in the LMC

Systematic observations of three remnants in the LMC were carried on one night last November at 10 and 12 μm, using the ESO bolometer attached to the 3.6-m telescope with a diaphragm of 7.5 arcsec diameter (see the article by Moorwood in this issue for details on the instrument).

The choice of our targets in the Large Magellanic Clouds has various motivations. For a given diaphragm, the fraction of a remnant surface seen at the distance of the LMC is much larger than for a galactic case thus making a systematic exploration much easier. On the other hand, if the dust is distributed