SYMBIOTIC STAR AS 201: A PLANETARY NEBULA

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ABSTRACT. Optical spectrum of AS 201 is presented: this object shows emission lines of moderate excitation (exc.class 5) and absorption spectrum of a G2III star. For the interstellar extinction and distance the values c=0.45 and d=1.5 kpc were estimated. The hot components of AS 201, Cn 1-1 and M 1-2 are located on the Harman-Seaton sequence in the region of evolved central stars of PN. It is suggested that the hot components of some SS are evolved nuclei of PN; high el.density of their nebulae may be explained due to mass loss from the respective cool stars of the binaries.

1. INTRODUCTION

AS 201 was discovered by Merrill and Burwell (1950) in the Mount Wilson objective-prism survey as a star having H_α in emission. Allen (1979) was the first who included this object in the list of symbiotic stars (SS); its spectrum (Allen, 1984) shows absorption features of a G-type star together with moderate-excited emission lines. Sanduleak and Stephenson (1972) observed an exceptionally strong [O III] λ4363 emission line; they suggested this object to be similar in nature to IC 4997 and to several other strong λ4363 objects suspected of being proto-planetary nebulae (PN), so that Kohoutek (1977) listed it as a possible proto-PN.

2. OBSERVATIONS AND ANALYSIS

The spectrum of AS 201 (ESO La Silla, 1.5m-tel. + IDS, resolution 6 Å) in the range 3700-7715.5 Å was taken in Dec. 1983 (Fig.1). It shows H_α [O III] $\lambda\lambda$5007,4959 lines, very strong [Ne III] λ3869 and extremely strong [O III] λ4363. Also [N II] $\lambda\lambda$6584,6548 are present. Besides those em.lines which are visible in practically all kinds of emission-line objects, all faint emission lines seen in the spectrum of AS 201 can be found in nova-like stars, in SS, gaseous nebulae, PN and novae.

It was possible to classify more accurately the late-type star according to the criteria given by Seitter (1970). The underlying con-

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tinuum belongs to a star of the sp.type G1 - G4, its luminosity class was estimated to be III or IV. The resulting sp.type G2III is believed good to ± one subclass.

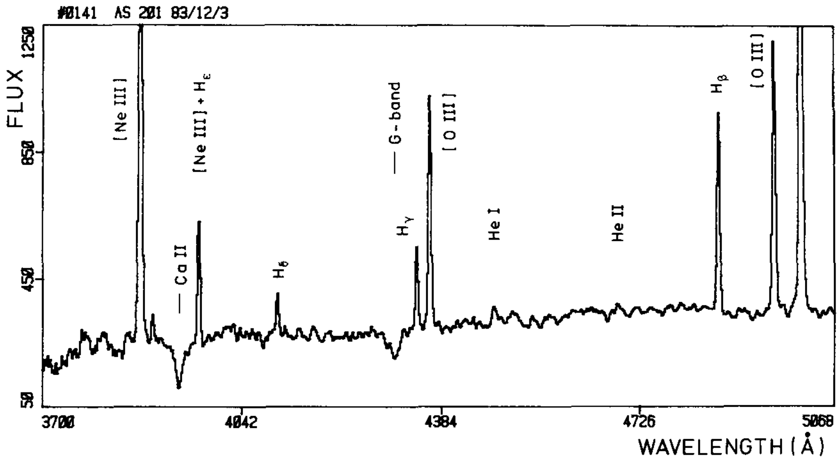

Fig.1. Intensity tracing of the spectrum of AS 201 in the blue region

The relative intensities of the lines [I(Hβ) = 100] were corrected for the interstellar extinction. The reddening constant follows from the observed hydrogen lines: c = 0.54 (H_α:H_β), c = 0.47 (H_γ:H_β), c = 0.60, (H_δ:H_β); nevertheless, as the Balmer lines of the cool component are in absorption, they diminish the hydrogen nebular emissions. We estimated this effect to be 2-10 % and adopted c = 0.45.

The excitation class of AS 201 was determined according to the criteria given by Aller and Liller (1968) as follows; exc. class 4 from I(λ5007 + λ4959)/I(Hβ) and exc. class 6 from I(λ4686)/I(Hβ).

The density of the object was estimated from the usual diagnostic line ratios. The absence of the line [O II] λ3727 (Sanduleak, Stephenson, 1972) and of [S II] λ6717 in our spectrum yield $N_e \gtrsim 10^6$ cm^{-3}. From [OIII] (λ5007 + λ4959)/λ4363 and assuming $T_e \sim 1.5 \times 10^4$ K, we derived $N_e = 6 \times 10^6$ cm^{-3} (see Seaton, 1975); however, from [N II] (λ6584 + λ6548)/λ5755 follows only $N_e = 6 \times 10^5$ cm^{-3}.

The distance of AS 201 can at present be estimated only roughly. Using the diagram colour excess versus distance (FitzGerald, 1968) we estimated d ≃ 2.0 kpc; nearly the same distance was found using the reddening-distance method (Gathier et al., 1986 and the fields of the nebulae NGC 2452 and NGC 2792). If we assume that the continuum belongs mainly to a giant of the sp. class G2 ($M_V \simeq +1.0$ mag and V ≃ 12.5 mag adopted) the corresponding distance would be 1260 pc. We adopt d=1.5 kpc.

The object is unresolved. Assuming its angular diameter to be 1" or less, its linear diameter would be 7×10^{-3} pc or less and the upper limit of the luminous material would be 0.03 $\mathfrak{M}_\odot$.

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The brightness of AS 201 has been found constant between 1963 and 1973 on plates of the Bamberg Observatory archives.

3. SYMBIOTIC STARS AND PLANETARY NEBULAE

According to the emission-line spectrum and the derived el.density it would be possible to describe AS 201 as a dense PN of moderate exc.class (similar to IC 4997) having a binary central star. This object is not unique. Recently Lutz (1984) classified another SS, Cn 1-1, as a dense PN. Another symbiotic object, M 1-2 (= VV 8), was described as a young, high-density PN according to the ultraviolet spectrum (Feibelman, 1983). Feibelman discussed the ratio $R = F(CIII]\lambda 1909)/F(SiIII]\lambda 1982)$ as a possible discriminant between SS, proto-PN and PN. For AS 201 a value $\log R = 1.44$ - being typical for PN - was obtained from very recent observations (Feibelman, 1986).

Several astronomers suggested a connection between PN and SS in the sense that some SS develop into PN or that some SS are proto-PN (there are 46 PN included in the list of SS given by Allen, 1979). These conceptions are based mainly on two observational results which are common for SS and for proto-PN: the nebulae have high el.densities ($\sim 10^{6-8} cm^{-3}$), and very small angular as well as linear dimensions (both kinds of objects are unresolved). The main problem of such a connection is the high-excitation emission spectrum of most SS (resulting from the central source with a temperature of the order of 10^5 K), whereas the proto-PN should be of low excitation.

The position of the hot component of AS 201 in the HR-diagram was derived from the relative line intensities of $H\beta$, HeII 4686 and HeI 4471 lines using the well-known procedure of Harman and Seaton (1966). This nebula is optically thick in the HI Lyman continuum, as the [O I]λ6300 line is present; $T_z = 78000$ K, $\log (L/L_\odot) = 0.94$, $R = 0.016\ R_\odot$ were derived (assuming blackbody radiation of the star).

From the data given by Lutz (1984) the position of the hot component of Cn 1-1 was derived: $T_z = 72000$ K, $\log (L/L_\odot) = 0.84$, $R = 0.02\ R_\odot$. For M 1-2 it follows from Kohoutek and Martin (1981, Fig.3a): $T_z = 85000$ K, $\log (L/L_\odot) = 1.92$, $R = 0.04\ R_\odot$. Both Cn 1-1 and M 1-2 are optically thick in the HI Lyman continuum. The location of the hot components of some SS in the same region of the HR-diagram as the central star of PN is known. Let us mention that Boyarchuk (1969, 1985) published some positions and that he pointed out, that the nonstability of these objects has perhaps a common nature.

The hot components of AS 201, Cn 1-1 and M 1-2 are located exactly on the Harman-Seaton sequence in the region of evolved central stars of PN. These components seem really to be evolved, because their (blackbody) radii are $0.02 - 0.04\ R_\odot$. In this area of the HR-diagram we are used to find also evolved PN ($R_{neb} \sim 0.2$ pc, $N_e \sim 10^{2-3}\ cm^{-3}$). Why don't we observe such nebulae in SS? The dwarf central stars of PN are able to ionize large nebulae but having small el.density - such nebulae are density bounded. The nebulae of the above symbiotic objects are on the contrary very dense, therefore they are radiation bounded.

It is interesting to note that AS 201, Cn 1-1 and M 1-2 are binaries having cool components of F-G sp.type (yellow symbiotic stars - Glass, Webster, 1973). These three objects are of infrared type D' (Allen, 1984) with a considerable amount of dust.

The main problem of above conception is just the high el.density of the nebulae. Without going into more details, let us speculate, that the high el.density of SS nebulae is due to the binary nature of their central stars (in comparison with the low density of PN which probably have single central stars) due to mass loss from the cool star. We suggest that the hot components of some SS (not the "classical" SS, but perhaps belonging to "PN symbiotics" (Plavec, 1982), to BQ[ ] stars (Ciatti et al., 1974), to Type II SS (Paczyński, Rudak, 1980) or to the Allen's infrared D-type stars) are in principle evolved central stars of PN. The visible nebulae are so dense that they absorb all ultraviolet photons of their subdwarf central stars.

The present study on AS 201 is only preliminary; the detailed investigation of this object including the IUE spectra is in progress.

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