

IDENTIFICATION OF THE 3.9 MICRON ABSORPTION BAND IN CARBON STARS

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ABSTRACT

With a 1.7% spectral resolution filter-wheel spectrometer, 1.2–5.2 micron spectra have been obtained of a sample of carbon stars. The previously unidentified 3.9 micron band is attributed to a combination of CS and C₂H₂. We also report the first observation of SiO in a carbon star.

Subject headings: infrared: spectra — stars: carbon

I. INTRODUCTION

The 2–14 micron spectra of carbon stars published by Merrill and Stein (1976) showed molecular absorption bands at 3.1 and 3.9 microns for which they suggested several possible identifications. Ridgway, Carbon, and Hall (1976), using high-resolution spectroscopy, identified the 3.1 micron band as due to HCN and C₂H₂. They also observed CS in some carbon stars (Ridgway, Hall, and Carbon 1977), but none of the stars they observed had the unidentified 3.9 micron band seen by Merrill and Stein. We have studied this band with 1.7% spectral resolution in a sample of carbon stars. Its shape and wavelength of maximum absorption varied among the stars observed. We attribute this feature to a combination of absorption by CS and C₂H₂. The observed changes in shape and wavelength are due to different contributions of the two molecules. We also make the first observation of SiO in a carbon star, 19 Psc.

II. OBSERVATIONS

Spectra were obtained with a liquid-nitrogen-cooled 1.7% resolution filter-wheel spectrometer employing an InSb detector (see Strecker, Erickson, and Witteborn 1978 for a more detailed instrument description). Data were taken with two telescopes, the NASA Mount Lemmon 60 inch (1.5 m) and the Kuiper Airborne Observatory 36 inch (91 cm). The stellar spectra were divided by spectra of standard stars observed each night and multiplied by the intrinsic spectrum of the standard. Differential air-mass corrections to the Mount Lemmon data were made by observing a standard star twice each night to derive an atmospheric transmission spectrum. Standard beam-switching techniques were used for all observations.

A continuum was defined for each star by using high points throughout the entire 1.2–5.2 micron spectrum. A transmission curve was then produced for the 3.9 micron feature by dividing the observed flux at each wavelength by the continuum flux at each wavelength. The results are shown in Figure 1. Indicated on the figure is the band origin and *R*-branch band head of the CS $v = 0-2$ vibration-rotation band, the *Q*-branches of

the $\nu_2 + \nu_5$ combination band of C₂H₂, and the SiO first-overtone vibration-rotation *R*-branch band heads.

III. DISCUSSION

The 3.9 micron absorption in UV Aur and UU Aur can be attributed to the second overtone of CS. The *R*-branch band head and band origin of the $v = 0-2$ band which are marked on Figure 1 align very well with the absorption band in UV Aur (there is less absorption at the band origin than in the *R*- or *P*-branches). CS can also be identified in R Lep, S Cep, and SS Vir by the presence of the CS band origin at 3.95 microns. Since CS cannot absorb shortward of the *R*-branch band head at 3.88 microns, the short-wavelength part of the feature must be due to a second molecule in these three stars. The most likely candidate is the $\nu_2 + \nu_5$ combination band of C₂H₂ which has an absorption centered on the *Q*-branches marked in Figure 1. Goebel *et al.* (1978) previously identified this band in Y CVn. Y CVn is an example of a carbon star with C₂H₂, but no CS observable at our resolution. Further evidence for suggesting C₂H₂ is derived by comparing the central absorption wavelength of the 3.9 micron feature with the absorption at 3.1 microns. The CS absorption is centered at 3.95 microns and the C₂H₂ absorption is centered at 3.75 microns. Since these two contributions are blended at our spectral resolution, as more C₂H₂ is added relative to CS, the central absorption wavelength of the feature will shift to shorter wavelengths. At the same time, the 3.1 micron feature will grow stronger, if the HCN contribution does not decline, as the contribution of C₂H₂ increases. Figure 2 demonstrates this effect, and lends support to the identification of C₂H₂ as part of the 3.9 micron feature. The three stars with an absorption at 3.1 microns of 38% have no visible C₂H₂ at 3.75 microns, so that in these stars the 3.1 micron feature is probably mostly due to HCN.

The absorption in 19 Psc, which is centered at 4.05 microns, is identified with the first overtone of SiO. The SiO band heads are indicated in Figure 1. SiO is predicted to be more abundant than CS in warm carbon stars if the C/O ratio is not much larger than 1.00 (Scalo 1973). Kilston (1975) lists C/O = 1.085 for 19 Psc, which is consistent with the presence of SiO and

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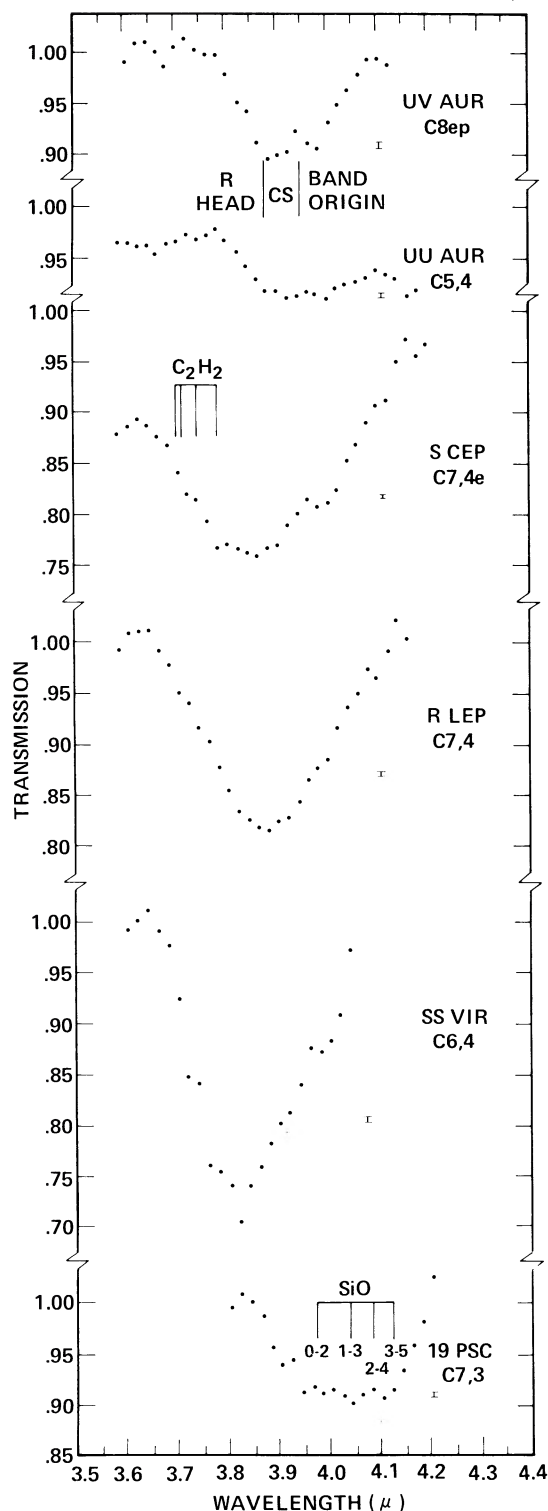


FIG. 1.—The transmission spectra are plotted at the wavelengths of interest for the carbon stars. Error bars indicated for each star are ± 1 standard deviation. The R -branch band head and band origin for the $v = 0-2$ CS band, the $\nu_2 + \nu_5$ C_2H_2 Q -branches, and the $SiO \Delta v = 2$ R -branch band heads are indicated. The CS P -branch absorption accounts for the dip at $4.0 \mu m$.

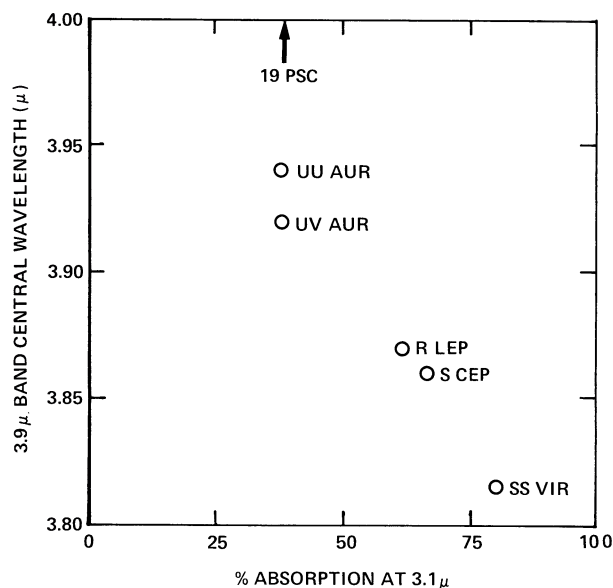


FIG. 2.—The central wavelength of the $3.9 \mu m$ absorption is plotted against the percent absorption in the $3.1 \mu m$ absorption feature. The star 19 Pcs is indicated by an arrow, since it lacks the $3.9 \mu m$ absorption but has a $3.1 \mu m$ absorption feature.

Scalo's calculations. High-resolution observations of these features should be obtained to confirm the identifications.

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