

THE INTERSTELLAR C-H STRETCHING BAND NEAR 3.4 μm : CONSTRAINTS ON THE COMPOSITION OF ORGANIC MATERIAL IN THE DIFFUSE ISM

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ABSTRACT. The spectra of objects suffering extinction by diffuse interstellar dust contain a broad feature centered at $\sim 3300\text{ cm}^{-1}$ ($\sim 3.0\ \mu\text{m}$), attributed to O-H stretching vibrations, and/or a feature near 2950 cm^{-1} ($3.4\ \mu\text{m}$) attributed to C-H stretching vibrations. The 2950 cm^{-1} feature can be attributed to C-H stretching vibrations in the $-\text{CH}_2-$ and $-\text{CH}_3$ groups of a fairly complex carbonaceous material containing aliphatic functional groups.

1. The Observations and Data

To constrain and quantify the composition of material in the diffuse interstellar medium (ISM), we took $3600\text{--}2700\text{ cm}^{-1}$ ($2.8\text{--}3.7\ \mu\text{m}$) absorption spectra of objects which have widely varying amounts of visual extinction due to diffuse medium dust along different lines-of-sight. The data were obtained using NASA's Infrared Telescope Facility (IRTF) on Mauna Kea. The spectra of these objects contain a feature centered near 3300 cm^{-1} ($\sim 3.0\ \mu\text{m}$), attributed to O-H stretching vibrations, and/or a feature near 2950 cm^{-1} ($3.4\ \mu\text{m}$) attributed to C-H stretching vibrations. The lack of correlation between the strengths of these two bands indicates that they do not arise from the same molecular carrier.

2. Discussion

We attribute the feature near 2950 cm^{-1} ($3.4\ \mu\text{m}$) to material in the diffuse ISM on the basis of the similarity between the band profiles along the very different lines-of-sight to Galactic Center source IRS7 and VI Cygni #12 (Figure 1). Similar features were also found in the spectra of Galactic Center source IRS3, Ve 2-45, and AFGL 2179.

The interstellar C-H stretching feature for Galactic Center source IRS7 has sub-peaks near 2955 , 2925 , and 2870 cm^{-1} ($\pm 5\text{ cm}^{-1}$), which we attribute to C-H stretching vibrations in the $-\text{CH}_2-$ and $-\text{CH}_3$ groups of aliphatic hydrocarbons. These band positions fall within 5 cm^{-1} of the values normal for saturated aliphatics. The absence of a distinct band near 2855 cm^{-1} suggests that the material contains small amounts of electronegative groups like O-H or $-\text{C}\equiv\text{N}$. The relative strengths and profiles of the 2955 and 2925 cm^{-1} features

towards five objects suggests an average diffuse ISM line-of-sight $-\text{CH}_2/-\text{CH}_3$ ratio of about 2.5, indicating the presence of relatively complex organic materials. The strengths of the subpeaks at 2925 and 2955 cm^{-1} , due to $-\text{CH}_2-$ and $-\text{CH}_3$ groups, respectively, correlate with visual extinction, strongly suggesting that the C-H stretching band is a general feature of the material along different lines-of-sight in the diffuse ISM. We find average ratios of $A_V/\tau(2925\text{ cm}^{-1}) = 240 \pm 40$ and $A_V/\tau(2955\text{ cm}^{-1}) = 310 \pm 90$ for the objects we have observed. We deduce that 2.6-35% of the cosmic carbon in the ISM is tied up in the carrier of this band with the most likely value falling near 10%.

The interstellar C-H band is remarkably similar to the feature in lab residues produced by irradiating analogs of dense molecular cloud ices. This is consistent with a model in which the hydrocarbon component in the diffuse interstellar medium consists of complex hydrocarbons containing aliphatic side chains and bridges which are produced in dense molecular clouds and subsequently modified in the diffuse medium. A more complete discussion of these results can be found elsewhere (Sandford et al. 1991).

3. References

Sandford, S.A., Allamandola, L.J., Tielens, A.G.G.M., Sellgren, K., Tapia, M., and Pendleton, Y. (1991) 'The interstellar C-H stretching band near 3.4 microns: Constraints on the composition of organic material in the diffuse interstellar medium', *Astrophys. J.* 371, 607-620.

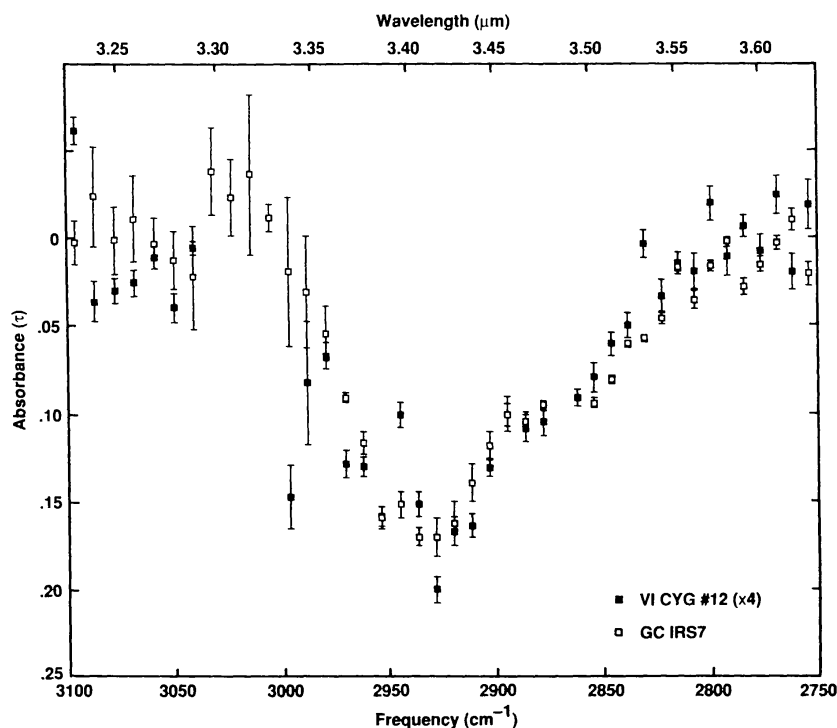


Figure 1 - Comparison between the C-H stretch feature (in absorbance) of Galactic Center source IRS7 and VI Cygni #12. The VI Cygni #12 absorbance spectrum has been scaled up by a factor of 4.