March 18, 1993

Final Report

Grant No. NAGW-319 Basic
1 February 1982 to 14 January 1993

PHOTOABSORPTION AND PHOTODISSOCIATION OF MOLECULES IMPORTANT IN THE INTERSTELLAR MEDIUM

Submitted by:
Long C. Lee and Masako Suto
Department of Electrical and Computer Engineering
San Diego State University
San Diego, California 92182

Prepared for:
NASA Headquarters
Washington, DC 20546
Attention: Dr. Lawrence J. Caroff
Astrophysics Division
Code EZ

# Table of Contents

I. Introduction .................................................... 3  
II. Research Accomplished .............................................. 3  
   A. Photoabsorption and Fluorescence Cross Sections of Interstellar  
      Molecules and Radicals ......................................... 3  
   B. IR Emission from UV Excitation of Aromatic Molecules ........... 4  
III. Publications ........................................................ 5
I. Introduction

The photoabsorption, photodissociation, and fluorescence cross sections of interstellar molecules and radicals have been measured in the vacuum ultraviolet region. These quantitative optical data are useful for the understanding of the formation and destruction processes of molecules under the intense interstellar UV radiation field. IR emissions from UV excitation of aromatic molecules have also been observed in this research program. The research results are useful for studying the sources of the "unidentified" interstellar infrared (UIR) emission bands.

II. Research Accomplished

The research results accomplished in the period from February 1, 1982 to January 14, 1993 are summarized below:

A. Photabsorption and Fluorescence Cross Sections of Interstellar Molecules and Radicals

The photoabsorption and fluorescence cross sections of interstellar molecules, such as Cl₂, HCl, HBr, H₂O, CH₂O, NO₂, SO₂, CS₂, OCS, N₂O, H₂S, CH₄, NH₃, C₂H₂, H₂O₂, CH₃OH, CH₃SH, HONO₂, C₂H₃OH, HCOOH, HCOOCH₃, aromatic hydrocarbons, etc., were measured in the 90-250 nm region using synchrotron radiation as a light source. Optical emissions from excited photofragments produced by UV excitation of these molecules were dispersed, and the emitting species were identified by the fluorescence spectra. The photoabsorption cross sections of the interstellar radicals, such as OH, OD, CN, SO, etc., were measured in the 106-200 nm region. The results have been summarized in the papers that are shown in the publication list.
B. IR Emission from UV Excitation of Aromatic Molecules

IR emissions were observed from UV excitation of aromatic molecules in the gas phase, such as benzene ($C_6H_6$), toluene ($C_6H_5CH_3$), xylenes ($C_6H_4(CH_3)_2$), naphthalene ($C_{10}H_8$), phenanthrene ($C_{14}H_{10}$), anthracene ($C_{14}H_{10}$), pyrene ($C_{16}H_{10}$), methylanthracene ($C_{14}H_9CH_3$), etc. An 3.3 $\mu$m band is commonly observed from all the aromatic molecules studied, and additional bands in the 3.4-3.6 $\mu$m region are observed from the methyl-derivatives of aromatic molecules. The 3.3 $\mu$m band is attributed to the aromatic C-H vibrational mode, and the 3.4-3.6 $\mu$m band to the vibrational modes of the $CH_3$ groups. The results are summarized in the papers as shown in the publication list.

The observed spectra are compared with the IR emissions universally observed in many astronomical objects. The current spectra are very similar to the UIR emission band as shown in the Fig. 5 in the paper published in Astrophysical Journal 383, 459 (1991). IR emissions from UV excitation of many interstellar molecules other than the PAHs are also observed. It is found that the spectra from non-PAH molecules are quite different from the UIR bands; thus, the non-PAHs are not responsible for the UIR bands.
III. Publications

32. "Fluorescence Yields from Photodissociative Excitation of HCOOH, HCOOCH₃


