

A Laboratory Search for the Carriers of the Diffuse Interstellar Bands

M. H. Stockett, M. P. Wood, and J. E. Lawler*

University of Wisconsin, Department of Physics, Madison, WI 53706, USA

**stockett@wisc.edu*

The identity of the carrier molecules of the Diffuse Interstellar Bands (DIBs) is the most durable mystery of spectroscopic astronomy. The DIBs are persistent absorption features, >300 total, observed along many lines of sight through the Interstellar Medium (ISM). The DIBs are scattered throughout the visible and near infrared, with widths in the 2 - 100 cm^{-1} range. For nearly a century, laboratory spectroscopists have struggled to match astrophysical wavelengths to laboratory wavelengths of known molecules including a variety of stable molecules, radicals, cations, and anions. Many researchers have hypothesized that hydrocarbon molecules are responsible for the DIBs, due to the rich chemistry and high cosmic abundance of carbon and hydrogen. Though large Polycyclic Aromatic Hydrocarbons (PAHs) are now suspected to be the source of the DIBs, no definitive matches have yet been made to laboratory PAH spectra. The Diffuse Interstellar Band Synchrotron Radiation Carrier Hunt (DIBSyRCH) experiment has been built at the Synchrotron Radiation Center (SRC) to test this hypothesis by conducting a spectroscopic survey of a broad range of cold, gas phase PAH molecules.

Using a custom echelle spectrograph and the innovative Cryogenic Circulating Advective Multi-Pass (CCAMP) absorption cell, we have demonstrated a detection sensitivity to molecular densities on the order of 10^7 cm^{-3} with a signal-to-noise ratio of 10,000 in 150 seconds of data collection. The echelle spectrograph draws inspiration from those typically used for astronomical observations, and is similarly equipped with a CCD array. This instrument, coupled with the high spectral radiance of the synchrotron radiation continuum from the SRC's White Light Beamline, permits rapid acquisition of spectra covering broad wavelength regions with resolution appropriate for the DIBs. Only two CCD frames are needed to cover the visible and near IR from 400 to 770 nm with a resolving power of 20,000 to 30,000.

In order to obtain astrophysically relevant spectra of low-temperature, gas-phase PAHs, the molecules are entrained in a flow of cold argon buffer gas inside the CCAMP cell. A multi-pass optical cavity using special high-reflectivity broadband mirrors extends the absorption pathlength to hundreds of meters. The CCAMP cell combined with the broad spectral coverage and high spectral radiance of synchrotron radiation make this experiment uniquely suited to the DIB carrier search.

Preliminary data on small PAHs including naphthalene will be presented. Comparisons of room temperature and cryogenic (77 K) spectra demonstrate the flexibility of the CCAMP absorption cell. Cold gas-phase absorption spectra of many non-volatile compounds can now be recorded using the CCAMP absorption cell, the custom echelle spectrograph, and the synchrotron radiation continuum from the White Light Beamline.