N92-13591

MEASUREMENT OF THE SPECTRAL SIGNATURE OF SMALL CARBON CLUSTERS AT NEAR AND FAR INFRARED WAVELENGTHS

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A significant percentage of the Carbon inventory of the circumstellar and interstellar media may be in the form of large refractory molecules (or small grains) referred to as carbon clusters. At the small end, uneven numbers of carbon atoms seem to be preferred, whereas above 12 atoms, clusters containing an even number of carbon atoms appear to be preferred in laboratory chemistry. In the lab, the cluster C_{60} appears to be a particularly stable form and has been nicknamed "Bucky Balls" because of its resemblance to a soccer ball and to geodesic domes designed by Buckminster Fuller.

In order to investigate the prevalence of these clusters, and their relationship to the polycyclic aromatic hydrocarbons (PAHs) that have become the newest focus of IR astronomy, it is necessary to determine the spectroscopic characteristics of these clusters at near and far infrared wavelengths. This paper describes the construction of a near to far IR laser magnetic resonance spectrometer that has been built at the University of California Berkeley in order to detect and characterize these spectra. The equipment produces carbon clusters by laser evaporation of a graphitic target. The clusters are then cooled in a supersonic expansion beam in order to simulate conditions in the ISM. The expansion beam feeds into the spectrometer chamber and permits concentrations of clusters sufficiently high as to permit ultra-high resolution spectroscopy at near and far IR wavelengths.

The first successful demonstration of this apparatus occurred last year when the laboratory studies permitted the observational detection of C_5 in the stellar outflow surrounding IRC+10216 in the near-IR. Current efforts focus on reducing the temperature of the supersonic expansion beam that transports the C clusters evaporated from a graphite target into the spectrometer down to temperatures as low as 1°K. If this can be achieved, then the spectral characteristics that are measured in the spectrometer will correctly reflect the physical conditions in the ISM. The first results on the far-IR spectra of C_3 are encouraging. The signal-to-noise ratio is so high that it should be possible to measure the spectral characteristics of much heavier clusters in the near future.

When the lab studies have provided sufficiently precise identifications for these heavier C clusters, an attempt will be made to detect them in circumstellar and interstellar regions using spectrometers flown on the Kuiper Airborne Observatory. The equipment used in these laboratory studies is extremely complicated and difficult to operate, but its advantage lies in the precision with which the various rotational and vibrational transition frequencies can be specified. There can be little or no doubt about subsequent observational identification of astrophysical species.