COMPLEX CARBON CHEMISTRY AND THE DIFFUSE INTERSTELLAR BANDS IN THE MAGELLANIC CLOUDS

N. Cox(1), P. Ehrenfreund(2), J. Cami(3), J. Jiménez-Vicente(4), B.H. Foing(5), L. Kaper(1), A. Van der Meer(1), L. D’Hendecourt(6), J. Maier(7), F. Salama(8), P. Sarre(8), T. Snow(9), P. Sonnentrucker(10)

(1) Astronomical Institute, Univ. of Amsterdam, Kruislaan 403, 1098 SJ A’dam, NL (ncox@science.uva.nl)
(2) Leiden Observatory, PO Box 9513, 2300 RA Leiden, NL
(3) NASA Ames Research Center, CA 94035–1000, Moffett Field, Ca, USA
(4) Kapteyn Institute, Groningen, NL
(5) ESA ESTEC, Keplerlaan 1, Postbus 299, 2200 AG Noordwijk, NL
(6) Institut d’Astrophysique Spatiale, Orsay, France
(7) Institute for Physical Chemistry, Univ. Of Basel, Switzerland
(8) School of Chemistry, Univ. Of Nottingham, Nottingham, UK
(9) Center for Astrophysics and Space Astronomy, Univ. Of Colorado, Boulder, USA
(10) Department of Physics and Astronomy, John Hopkins Univ., Baltimore, USA

ABSTRACT

Our research is directed at identifying the carriers of the diffuse interstellar bands (DIBs), observed in spectra of bright reddened stars shining through interstellar clouds. These absorption features, believed to arise from complex carbon molecules, are important to understand interstellar carbon chemistry. Pending their identification, DIBs will be important diagnostic tools to probe the chemistry of the interstellar medium (ISM). In order to study a wide range of environmental effects (such as metal content, irradiation conditions) we have initiated a search for DIBs outside our own Galaxy, in our nearby neighbours the Large and Small Magellanic Cloud (LMC & SMC), which are at 50 and 60 kpc resp. These galaxies have a much lower metallicity (factor 2.5 and 10 smaller) than our galaxy and different star formation fields. The extreme sensitivity of the Very Large Telescope in Chile has been exploited to detect small narrow DIBs in the SMC (for the first time) and LMC. From measurements of the strengths of DIBs in our spectra we conclude that although metallicity is an important factor, other properties like the UV irradiation field and star formation activity may play an important role as well.

1. INTRODUCTION

Investigating the distribution and physical nature of diffuse interstellar bands (DIBs) is important for our understanding of the properties of the interstellar medium (ISM). More than 75 year after their first discovery, the carriers of DIBs are still unknown, although a variety of possible candidates exists, from small grains to large polycyclic aromatic hydrocarbons (for a review see [1]). Very likely, DIBs are caused by complex carbonaceous molecules and one possible identification is that of C₆₀⁺ with 2 correlated DIBs at 9577 and 9632 Å [2]. Linking DIB observations with other ISM properties in various galaxies, like the Magellanic Clouds, enables us to trace and understand the distribution of complex molecules in interstellar clouds, the building blocks of stars and planets.

2. DIBS IN THE SMC & LMC

With the Very Large Telescope we obtained very high resolution spectra toward reddened hot stars in the LMC and SMC (Figures 2 and 3). For the first time strong narrow DIBs have been identified in a SMC target (Sk 143) [3]. Contrary to other SMC sources only this target shows the presence of the 2200Å bump, which is commonly associated with carbonaceous material.

Figure 1. Star location skymap of the Large Magellanic Cloud. Targets shown correspond with LMC spectra in Figures 2 & 3.
DIB equivalent width measurements, normalized to the reddening \( E(B-V) \), show a large variety in depletion in LMC stars (Figure 3), suggesting a multitude of environmental parameters determining the physical properties of the ISM toward the Magellanic Clouds. Their strengths are much weaker than in galactic sources, indicative of a correlation with metallicity, and the UV irradiation field.

3. FUTURE RESEARCH

A more detailed study of the obtained SMC and LMC spectra is in progress. We are expanding the existing DIB database and will correlate (new) measurements with environmental parameters, like the electron and H densities, UV irradiation field, local star formation activity, etc. Identification of the carriers is the second major objective, which is intertwined with the first.

Figure 2. Spectra of the 5789+5797Å DIBs. Target plus unreddened reference spectra in the SMC (top) and LMC (middle) are shown. The galactic target HD 163472 is shown (bottom) for reference and is scaled to match the reddening of the other sources. The measured positions of DIBs (vertical lines) in our Galaxy, the SMC and LMC are shifted from each other due to their different space velocity. One can also see that, due to this velocity difference, the galactic foreground does not significantly contribute to DIBs in the Magellanic Cloud itself.

Figure 3. DIBs at 6270 and 6284Å are shown for three sources, after correction for the \( \text{O}_2 \) telluric lines. At the bottom a galactic reference target HD 183143 with high reddening is displayed for comparison. On top we display spectra of one SMC source with no detectable DIB, and four LMC sources with similar reddening but different DIB strengths. It is unknown why the relative depletion of DIB carriers varies from DIB to DIB and in different environments.

4. REFERENCES