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Optical and Infrared Observations of Diffuse Clouds

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Abstract. In the past several years, great progress has been made on the spectroscopy of polyatomic molecules in diffuse interstellar clouds. In this talk, I will review recent developments involving H_3^+, C_3, and the Diffuse Interstellar Bands (DIBs).

The simplest polyatomic molecular ion, H_3^+, has long been recognized as the cornerstone of ion-neutral chemistry in dense molecular clouds (Herbst & Klemperer 1973, Watson 1973). However, in diffuse clouds (where electrons are abundantly produced from photoionization of atomic carbon) the H_3^+ number density was expected to be considerably lower than in dense clouds, owing to the efficiency of electron recombination. It was, therefore, a surprise when a large column density of H_3^+ was detected (McCall et al. 1998) in the diffuse line of sight towards Cygnus OB2 12, and subsequently in a sample of heavily reddened diffuse sightlines (McCall et al. 2002). Recently, we have detected H_3^+ even in the classical diffuse cloud sightline towards ζ Persei; together with a new measurement of the electron recombination rate coefficient, this result suggests that the cosmic-ray ionization rate is much higher in diffuse clouds than in dense clouds (McCall et al. 2003)!

In 2001, interstellar C_3 was first detected by J. P. Maier and colleagues (Maier et al. 2001) in three diffuse cloud sightlines. This was quickly followed up by another detection (Roueff et al. 2002) and a survey conducted at low-resolution (Oka et al. 2003). This was followed by a high-resolution survey (Ádámkovics, Blake, & McCall 2003) that yielded rotationally resolved spectra of C_3 in 10 sightlines. Much like C_2, C_3 has no permanent dipole moment, and therefore its rotational distribution serves as a sensitive diagnostic of both temperature and density.

The existence of larger polyatomic molecules in diffuse clouds is clear from the presence of the DIBs, which have remained an enigma since their discovery some eight decades ago. A recent survey of the DIBs at the Apache Point Observatory has resulted in a uniform sample of DIB spectra with much higher signal-to-noise ratios than previously available. Some early results from the analysis of the survey data include the identification of a set of DIBs that are related to C_2 (Thorburn et al. 2003) as well as some well-correlated pairs of DIBs. I will discuss our recent results.

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