OBSERVATIONS OF ISOTOPE FRACTIONATION IN PRESTELLAR CORES: INTERSTELLAR ORIGIN OF METEORITIC HOT SPOTS? S. N. Milam[1] and S. B. Charnley[1], [1]NASA Goddard Space Flight Center, Astrochemistry Laboratory, Code 691.0, 8800 Greenbelt Rd., Greenbelt, MD 20771, USA (email: stefanie.n.milam@nasa.gov).

Introduction: Isotopically fractionated material is found in many solar system objects, including meteorites and comets [1]. It is thought, in some cases, to trace interstellar material that was incorporated into the solar system without undergoing significant processing. Here, we show the results of models and observations of the nitrogen and carbon fractionation in proto-stellar cores.

In interstellar molecular clouds, ion-molecule chemistry continually cycles nitrogen between the two main reservoirs - N and N_2 - leading to only minor ^{15}N fractionation effects [2]. Charnley and Rodgers (2002) originally showed that depletion of CO removes oxygen from the gas and weakens this coupling such that significant ^{15}N enhancements can occur for N_2 and ammonia in N-rich CO-depletion cores [3].

Observations following the outburst of comet 19P/Holmes indicate that the low $^{14}CN/C^{15}N$ ratios commonly measured in all comets derive from low $H^{14}CN/HC^{15}N$ values [4], and not from some organic polymer synthesized from ammonia (cf. Ref. 3). Furthermore, the recent detections of CN, HCN, C_4H and C_6H in well-studied depletion cores like L1544 and L183 [5, 6] demonstrate that sources of organic carbon

remain present even as CO is lost. These C-bearing molecules can therefore participate in the associated fractionation chemistry. Figure 1 shows that both nitrile and amide functional groups can become highly fractionated as the depletion chemistry evolves.

Observations: Observations are being conducted at millimeter and submillimeter wavelengths employing various facilities in order to both spatially and spectrally, resolve emission from these cores. The preliminary data was collected at the Arizona Radio Observatory's 12m telescope on Kitt Peak, AZ. Spectra were obtained at high resolution (0.08 km/s) in order to resolve dynamic properties of each source as well as to resolve hyperfine structure present in certain isotopologues. Most of the previous work on nitrogen and carbon isotopes in dense cores have applied a double isotope method to their analysis to overcome large opacity effects, requiring assumptions for one of the isotopes as either a measurement of a different species known to trace different regions (i.e. ^{12}CO and ^{13}CO) or using the local ISM values. These methodologies may provide false abundances for various species and can introduce errors to further analysis and applications to chemical models. Thus, we are directly mea-
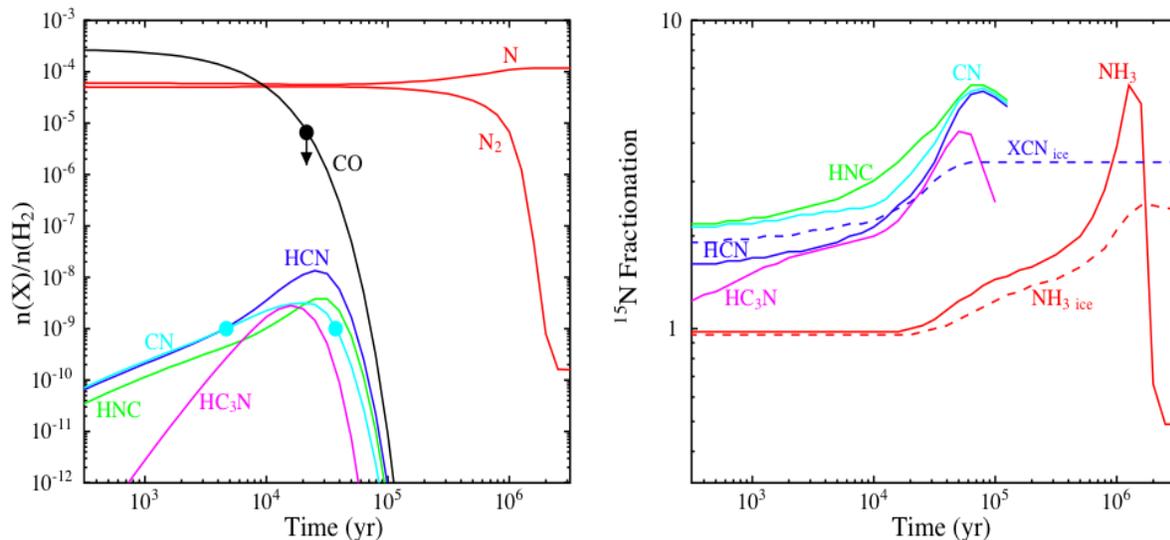

Figure 1: Nitrogen chemistry and ^{15}N-enhancements (elemental $^{15}N/^{14}N$ = 1/400). Values for gas-phase nitriles are not plotted after ~10^5 yr because the abundances of both isotopologues are essentially zero due to freeze-out. The line for XCN ice shows the bulk isotope ratio in solid-phase HCN, HNC, and CN. A 200 K barrier for the reaction of CN+N $\rightarrow$ N_2+C. The filled circles on the CN and CO curves indicate the observed range and the minimum CO depletion factor in L183 [12]. From Ref. 10.
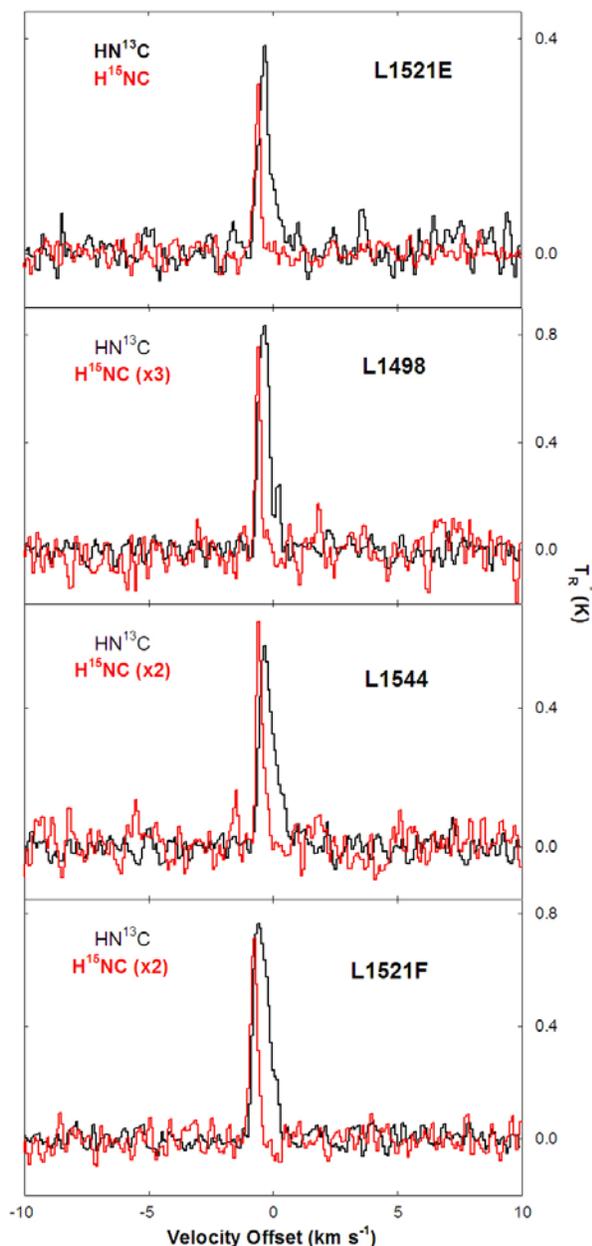
Figure 2. Arizona Radio Observatory spectra of the J = 1→0 emission lines of HNC, ^{13}C and ^{15}N isotopologues, in four dark cloud cores (Milam & Charnley 2011, in preparation).

suring all isotopologues for a given species and employ a direct analytical method for determining abundances and thus the isotope ratios.

Results and Discussion: A preliminary study has been conducted towards four dark cloud cores observed to have varying levels of depletion. Some work on the ^{14}N/^{15}N ratio has been done on L1521E, L1498 [7], and L1544 [8, 9]. The analysis of the first objects employed double isotope ratio methods assuming a local ISM ^{12}C/^{13}C ratio of 60 or the value obtained from measurements of ^{12}CO/^{13}CO, which is not likely to represent the same carbon-fractionation chemistry. Studies for L1544 were done with N_2H^+ and NH_3 and obtained a nitrogen isotope ratio of 446 and >700, respectively. The discrepancy observed in these two measurements suggests a strong chemical dependence on the fractionation of nitrogen.

To further investigate this, and test current theoretical studies on variations in fractionation chemistry (e.g. Ref. 3, 9, 10), we have conducted preliminary observations of nitriles, namely HCN and HNC, towards a few select cores, L1521E, L1498, L1544, and L1521F (see Figure 2). Here the isotopologues of HNC are plotted in high resolution comparing the ^{15}N-isotopologue to its corresponding ^{13}C counterpart for each object; the main isotopes are not presented here. Ideally, one can obtain ratios for carbon, nitrogen, and deuterium from isotopologues of the same molecule. Ratios obtained in this manner are likely tracing the same chemical heritage and are most likely directly comparable within a given source. From these data, an assessment of fractionation for the nitriles in both carbon and nitrogen can be determined for starless and prestellar cores at various stages of evolution. Results and comparisons between the protostellar evolutionary state and isomer isotope fractionation will be presented.

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