PHOSPHORUS AT THE EDGE OF THE GALAXY: DETECTION OF PO AND PN BEYOND 16 kPC

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The Galactic Habitable Zone (GHZ) is characterized by orbital kinematics, star formation rates, lack of SN explosions, time, metallicity, and, specifically, the NCHOPS elements – those required for life. Recently, molecules containing all the NCHOPS elements have been identified in dense clouds located in the Outer Galaxy ($>$16 kpc from the Galactic Center), with the exception of phosphorus. Because this element is integral for biological chemistry, a search was conducted for P-bearing molecules in dense clouds in the Outer Galaxy using the 12 m telescope of the Arizona Radio Observatory (ARO) at 2 mm in wavelength and the 30 m telescope of the Institut de radioastronomie millimétrique (IRAM) at 3mm. The J=2$\rightarrow$1 and J=3$\rightarrow$2 rotational transitions of PN were detected in WB89-621, located 22.6 kpc from the Galactic Center, as well as four hyperfine components of the J=2.5$\rightarrow$1.5 of PO. The fractional abundance, relative to H_2, of PN was determined to be 3.0($\pm$1.6) $\times 10^{-12}$, and that of PO to be 2.0($\pm$1.1)$\times 10^{-11}$. The identification of PN and PO at the edge of the Galaxy represents the furthest detection of phosphorus from the Galactic Center. All the NCHOPS elements have now been confirmed in out to $\sim$ 20 kpc, possibly extending the GHZ to the outer regions of the Galaxy.