PHOSPHORUS IN STAR-FORMING MOLECULAR CLOUDS.

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Introduction: Phosphorus (P) is the fifth most important biogenic element after H, O, C and N. Chemical compounds containing phosphorus, such as phospholipids and phosphates, are essential for the structure and energy transfer in cells. Despite this, so far P-bearing molecules have been detected only in a few molecular clouds hosting star formation; hence, its interstellar chemistry is almost totally unknown.

Our team has recently detected several new star-forming regions in phosphorus nitride, PN [1], including clouds with relatively low turbulence and low gas temperature (Fig. 1). This poses challenges in theoretical models that invoke either high desorption temperatures or grain sputtering from shocks to release phosphorus into the gas phase [2,3]. Derived column densities are of the order of 10^{11-12} cm^{-2}, marginally lower than the values derived in the few high-mass star-forming regions detected previously.

Moreover, our team has detected for the first time the bond P-O, key to the formation of the backbone of the DNA double-helix, in two star-forming regions: W51 e1/e2 and W3(OH) (Fig. 2, [4]). The derived abundances indicate that the abundance of phosphorus in star-forming regions is more than ten times higher than previously thought [4]. The two studies are telling us that phosphorus is an important and relatively abundant ingredient before the formation of stellar systems like our own.

References: [1] Fontani et al. (2016), *ApJ, 822,* L30. [2] Charnley & Millar (1994), *MNRAS, 270,* 570. [3] Garrod & Herbst (2006), *A&A, 457*, 927. [4] Rivilla et al. (2016), *ApJ, 826,* 161. [5] Turner et al. (1990), *ApJ, 365*, 569.

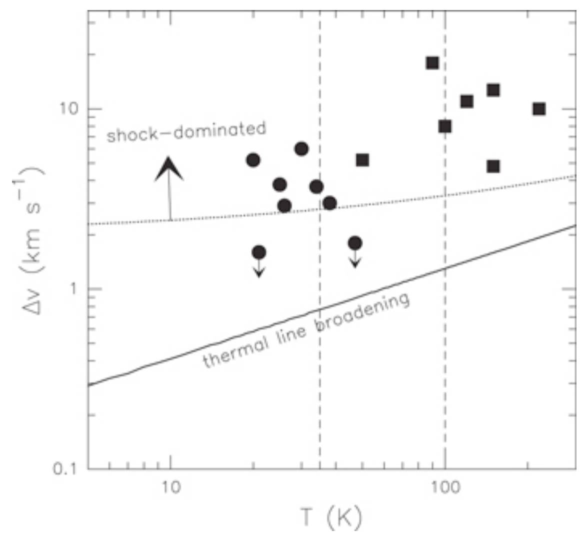

Fig. 1:

Line widths derived from the PN (2–1) line in [1] (circles) and in [5] (squares) against the gas kinetic temperature. All data have been obtained towards high-mass star-forming regions. The vertical dashed lines indicate the desorption temperatures predicted by the theoretical model of [2], i.e., 100 ± 15 K, and the possible smaller one derived from [3] of ~35 K. The expected thermal line broadening is indicated by a solid oblique line. Finally, the dotted line marks an arbitrary threshold of $\Delta v_{\text{non-th}}$ = 2 km s^{-1} (where $\Delta v_{\text{non-th}}$ represents the non-thermal component of the line), corresponding to about 10 times the thermal value for T~5K, in which the internal motions likely start to be affected by shock-induced turbulence. The two circles represent upper limits. From [1].

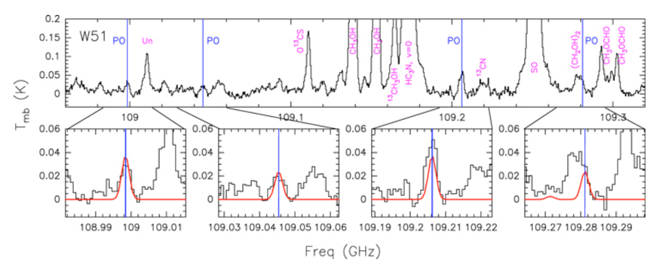

Fig. 2:

Spectrum observed at 3 mm with the IRAM-30m telescope toward the high-mass star forming region W51. The PO transitions are indicated with blue vertical lines. The lower panels show zoom-in views of the PO transitions. The red line is the LTE fit. From [4]. This is the first detection of PO in a star-forming region