

IONIZE HARD: INTERSTELLAR PO⁺ DETECTION

Víctor M. Rivilla¹, Juan García de la Concepción¹, Izaskun Jiménez-Serra¹, Jesús Martín-Pintado¹, Laura Colzi¹, Belen Tercero², Andrés Megías¹, Álvaro López-Gallifa¹, Antonio Martínez-Henares¹, Sara Massalkhi¹, Sergio Martín^{3,4}, Shaoshan Zeng⁵, Pablo de Vicente², Fernando Rico-Villas¹, Miguel A. Requena-Torres^{6,7}, Giuliana Cosentino⁸

¹Centro de Astrobiología (CAB, CSIC-INTA); ²Observatorio Astronómico Nacional (OAN-IGN); ³European Southern Observatory; ⁴Joint ALMA Observatory; ⁵Star and Planet Formation Laboratory, RIKEN; ⁶ University of Maryland; ⁷Towson University; ⁸Chalmers University of Technology

- ★ The interstellar chemistry of **PHOSPHORUS (P)** is still poorly known.
- ★ Only two P-bearing molecules (PN and PO) have been detected in molecular clouds and star-forming regions.
- ★ We need to detect more P-bearing species !!!



G+0.693-0.027 MOLECULAR CLOUD

THE CENTRAL MOLECULAR ZONE (CMZ) OF THE GALAXY
Credit: SRAO, Heywood et al. (2022) / J.C. Muñoz-Mateos

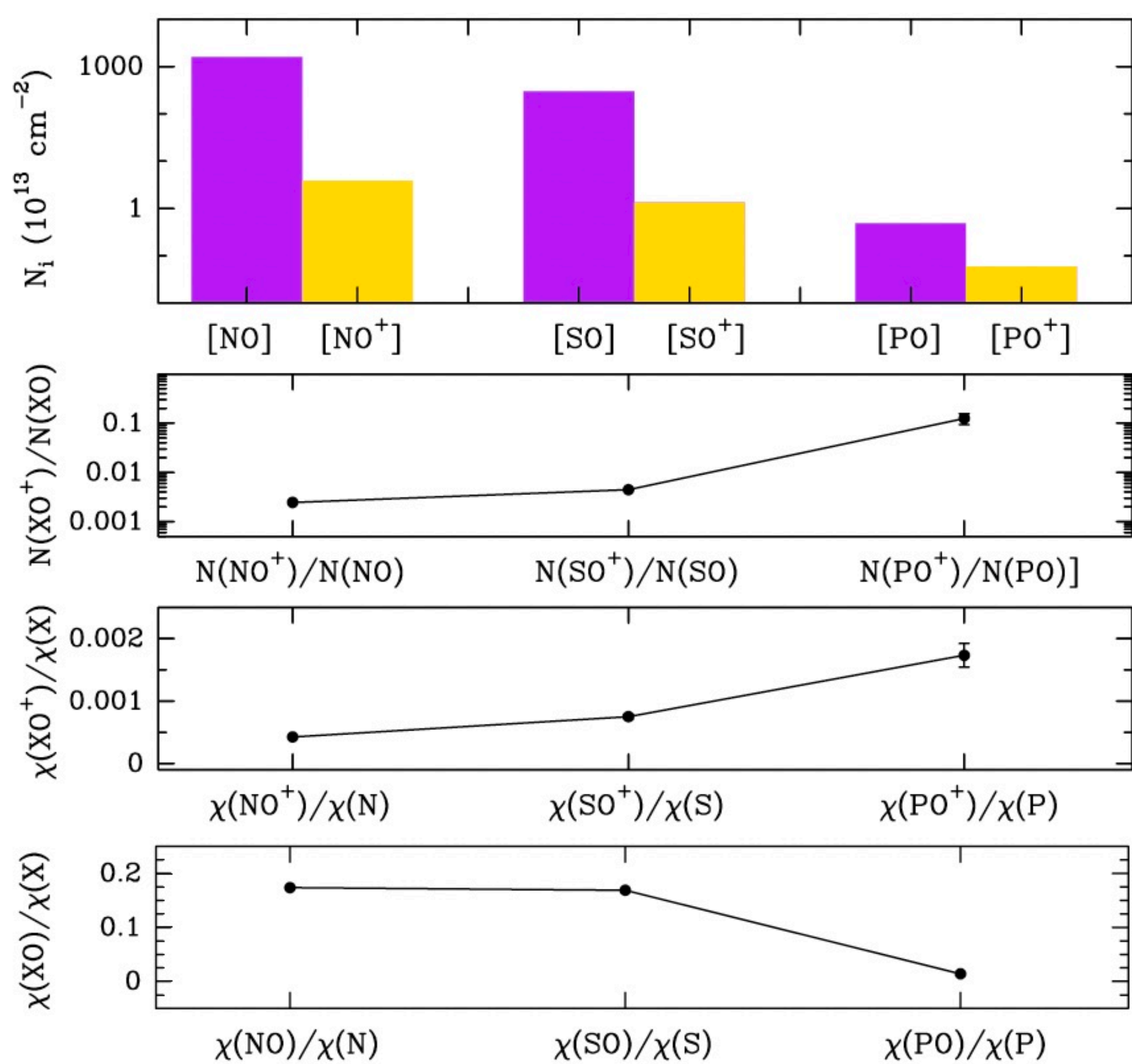
FIRST DETECTION OF PO⁺ IN THE ISM

Yebes 40m and IRAM 30m deep spectral survey

Rivilla et al. (2018)

Rivilla et al. (2022b)

- High PO⁺/PO and PO⁺/P compared with N and S analogues.
- P is more efficiently ionized than N and S in the ISM.



- Shocks sputter the icy grain mantles, releasing into the gas phase most of their P content (mainly PH₃), which is rapidly converted into atomic P, and then ionized efficiently by **cosmic rays**, forming P⁺.
- Further reactions with O₂ and OH produce PO⁺.
- The **cosmic-ray ionization of PO** might also contribute significantly forming PO⁺, which would explain the high PO⁺/PO ratio observed.
- Observed abundance of PO⁺ is well reproduced with **high values of cosmic-ray ionization rates (10⁻¹⁵ – 10⁻¹⁴ s⁻¹)**.

CHEMICAL MODELLING

