Contribution to Heliosares : study of the molecular Double Ionization for Mars escape

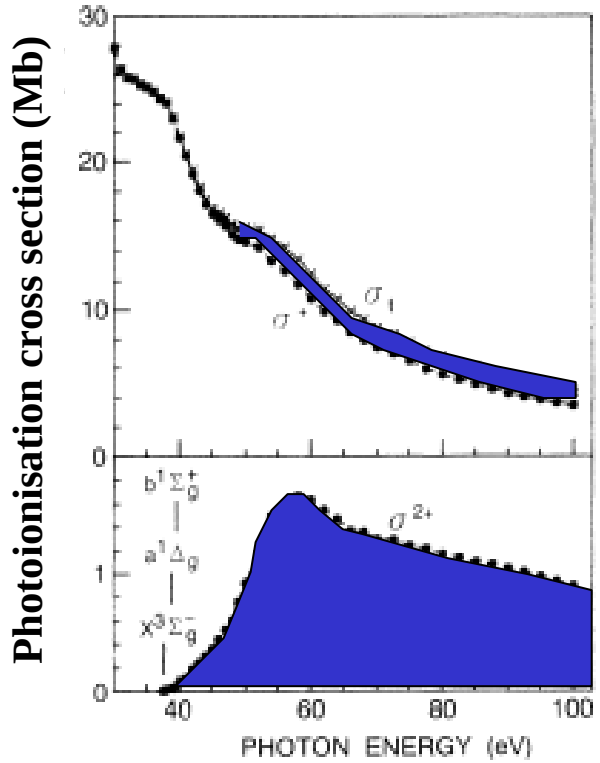
J. Lilensten, M. Barthélémy, H. Ménager, G. Gronoff, R. Thissen, O. Dutuit, O. Witasse, J.Y. Chaufray and F. Leblanc

Heliosares kick off meeting

5-6 Oct 2009

CO_2^{++} In Mars ionosphere ?

- Production of CO_2^{++} by photoionisation as well as electron impact
- Loss Channels ?
  - Natural lifetime (4 s for metastable)
  - Electronic Recombination
  - Chemical Reactivity

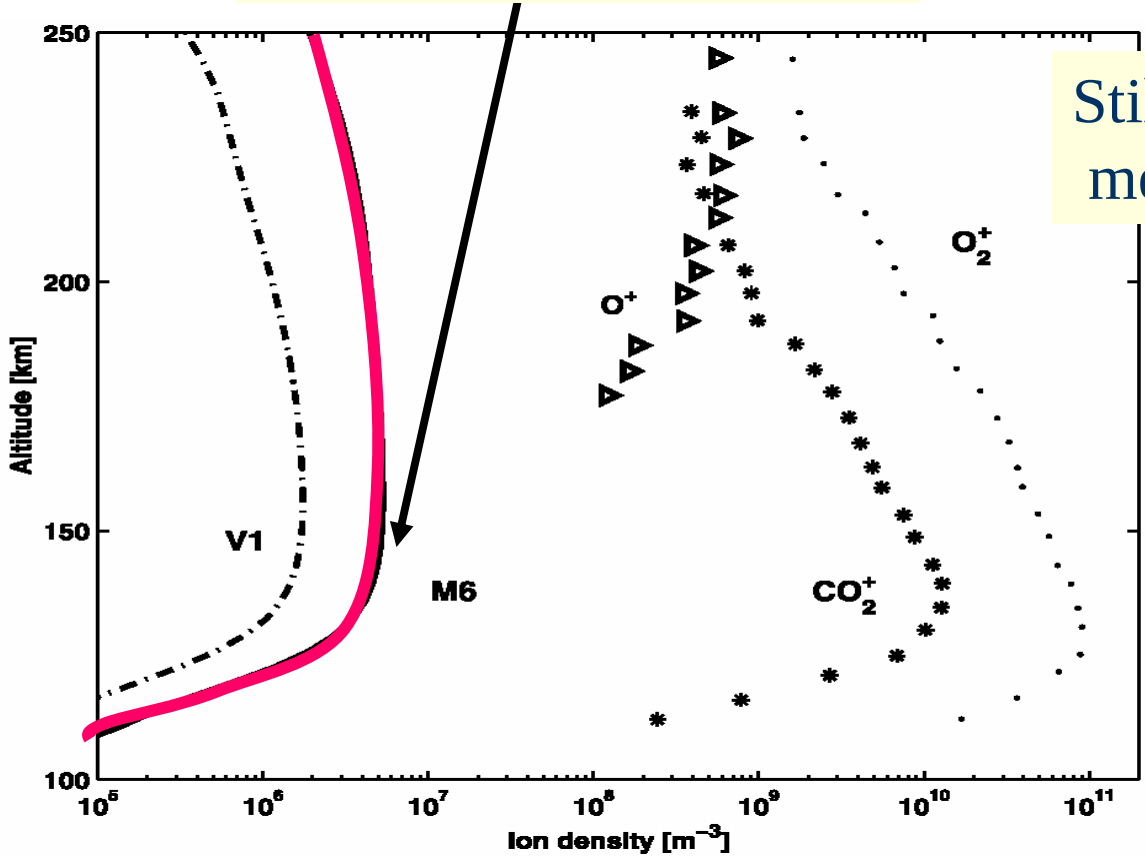


Cross section for single (σ^+) and double (σ^{++}) photoionisation of CO_2

prediction of a CO_2^{++} layer...

4.10^6 ions.m^{-3} at 145 km

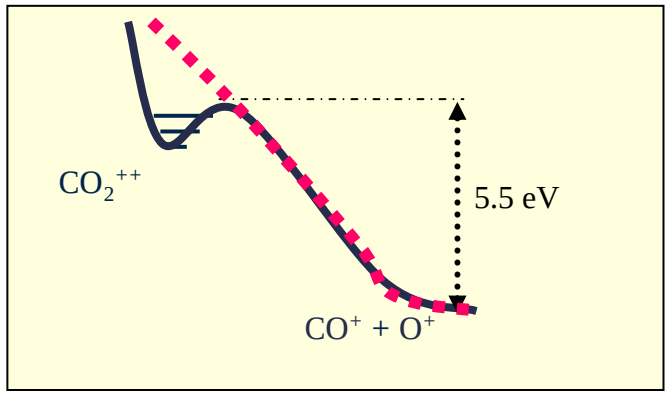
CO_2^{++} predicted in Viking or Mariner conditions

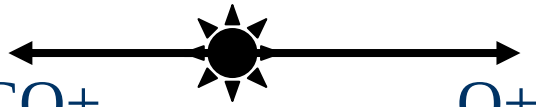


Still lacks in-situ measurement

Witasse et al. Geoph. Res. Lett., 29 (2002) 1029, and 30 (2003) 1360

Double ionization is essentially dissociative, and produces suprathermic ions (Coulomb rep)





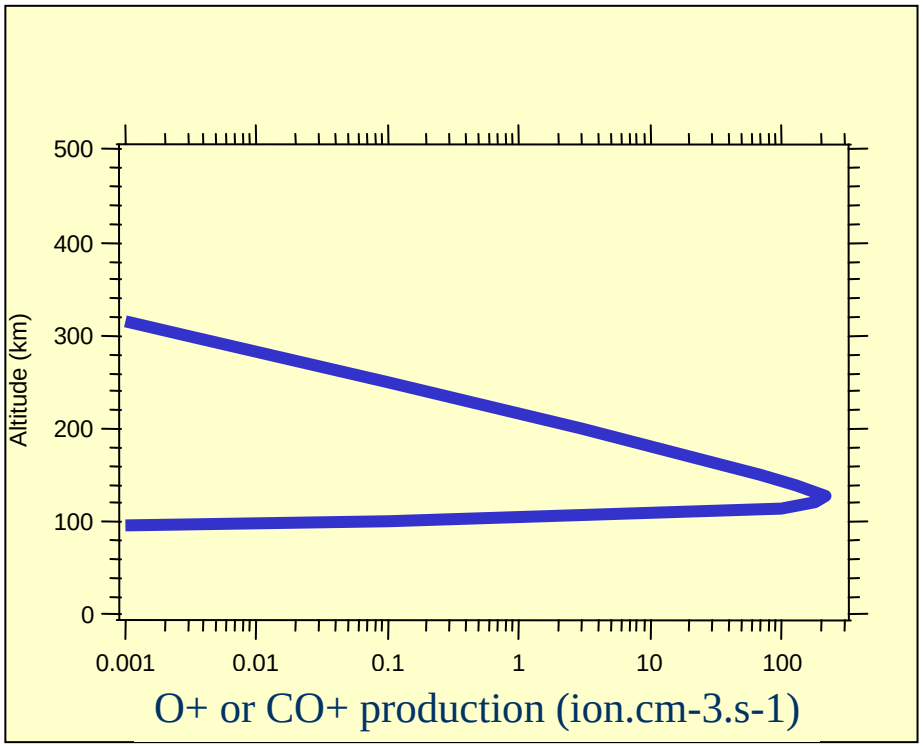
CO+
2 eV

O+
3.5eV
6.5 km/s

- Stabilization well for metastable molecular is shallow
- Ions naturally decay (4s) towards ion pair :

  CO^+ and O^+
- Excited states directly dissociate
- Kinetic energy release is at least 5.5 eV

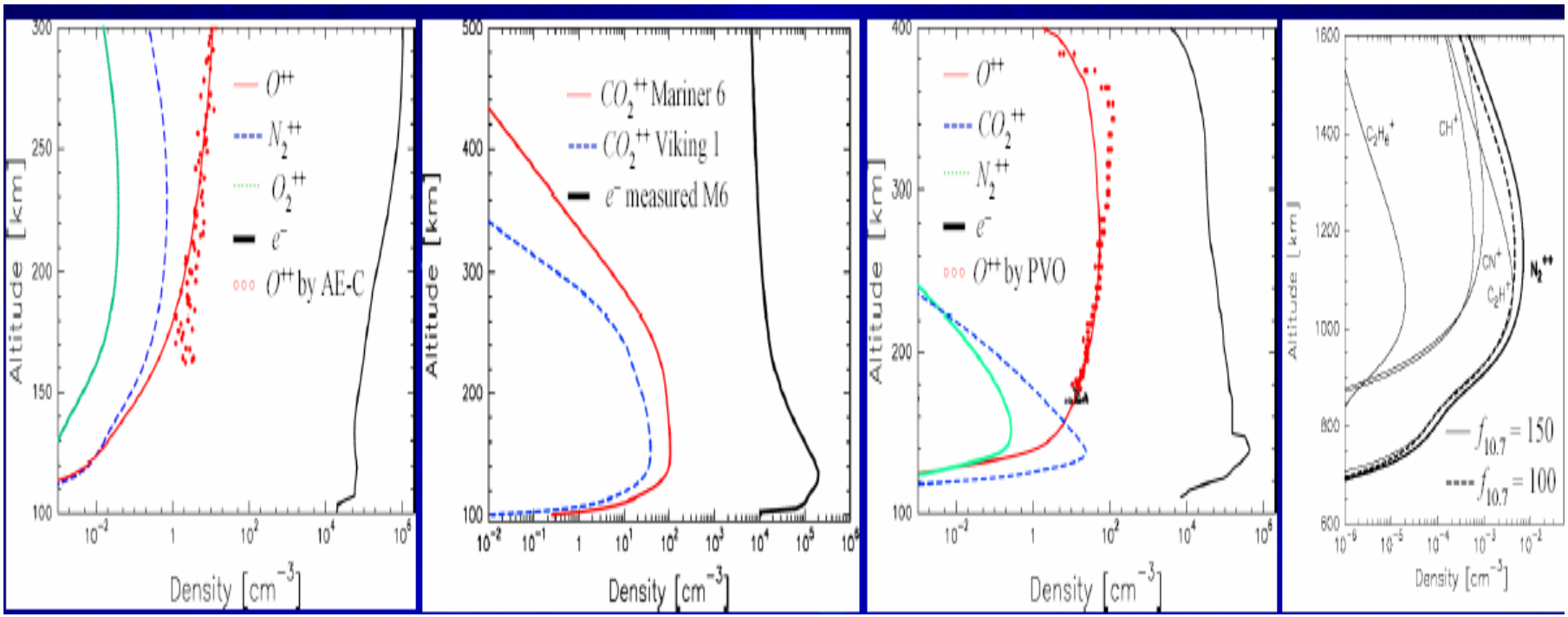
Modelisation of suprathermic ions due to double ionization



- Production estimated in the mariner 6 conditions
- Using the Transcar Model from Lilensten and Witasse
- Production is peaking at 220 ions.cm^{-3}.s^{-1} and 128 km

Modelisation of suprathermic ions due to double ionization

- Or first estimate was that the contribution of these ions to the escape was negligible.


Altitude [km]
Density [cm^{-3}]
O^{++}
N_2^{++}
O_2^{++}
e^-
O^{++} by AE-C
CO_2^{++} Mariner 6
CO_2^{++} Viking 1
e^- measured M6
O^{++} by PVO
$C_2H_6^+$
CH^+
CN^+
C_2H^+
N_2^{++}
$f_{10.7} = 150$
$f_{10.7} = 100$

- 5.5 eV KERD was a lower estimate
- It can go up to 10 eV
- Triple ionization can take place from 70 eV above, and leads to larger KERD.
- **Stable CO2++ correspond to about 1/10 of total production**

In the Heliosares context:

- Modeling of multiple ionization (++) is ongoing with updated cross sections and taking unstable ions into account
- The set of cross sections will be made available to Heliosares (ready since last month)
- The contribution of the doubly charged ions to the atmospheric escape will be finished within the Heliosares time

In the Heliosares context:

- TRANS_mars kinetic updated code will be made available to Heliosares community
- Within WG3, coupling with 3D models will be studied. Work started with A. Aylward (UCL)