A Microwave Plasma Discharge in Rare Gases as a VUV Source for Planetary Atmospheric Photochemistry
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To cite this version:
Sarah Tigrine, Nathalie Carrasco, Ludovic Vettier, Guy Cernogora. A Microwave Plasma Discharge in Rare Gases as a VUV Source for Planetary Atmospheric Photochemistry. VUVX2016, the 39th International conference on Vacuum Ultraviolet and X-ray Physics, Jul 2016, Zürich, Switzerland. 2016, <https://indico.psi.ch/conferenceDisplay.py?confId=3461>. insu-01348919

HAL Id: insu-01348919
https://hal-insu.archives-ouvertes.fr/insu-01348919
Submitted on 26 Jul 2016

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The aim of this work is to show that micro-wave discharges in rare gases, can be an efficient windowless VUV photon source for planetary atmospheric photochemistry experiments. In this context, we perform a microwave discharge (surfatron) in a neon gas flow. We characterize the VUV photon flux emitted in different conditions, when working in the mbar pressure range, and compare it to synchrotron VUV fluxes also used for similar applications.

**Experimental Setup**

*Neon plasma discharge:* 40-cm length quartz tube, 8 mm I.D. surrounded by a microwave surfatron resonance cavity designed for 2.45GHz.

*Gas flow:* from 1 to 10 sccm.

*Pressure:* measured upstream with a capacitor gauge, from 0.4 to 1.7 mbar.

*Monochromator:* Mac Pherson NOVA 225 VUV 1-m focal-length.

*Output Voltage (V):* 0-8 V.

*Gas flow:*
- from 1 to 10 sccm
- for a 200 µm spot [4].

*Results*

The photon flux is calculated taking into account:

- the slits surfaces: 75µm width by 4 mm height.
- as Ne is injected in the monochromator, the absorption is calculated along the 2m optical path using the Beer Lambert law and the Ne absorption cross section $\sigma = 9 \times 10^{-17}$ cm$^2$ at 75 nm [2].
- the grating efficiency 6% at 75 nm.
- the Optodiode AXUV 100 detector efficiency 0.22 A W$^{-1}$ at 75 nm.
- and the amplifier gain 1 V for 1 nA.

The VUV photon flux emitted at 73.6 nm can be tuned from $2 \times 10^{10}$ ph.s$^{-1}$.cm$^{-2}$ to $4 \times 10^{14}$ ph.s$^{-1}$.cm$^{-2}$ by changing the pressure conditions. These photon flux can be compared with the VUV DESIRS beamline of the synchrotron SOLEIL: at 17 eV (~75 nm) and for a resolving power of 1000, the VUV photon flux can be tuned from $7 \times 10^{10}$ ph.s$^{-1}$.cm$^{-2}$ (for a 4 mm×8mm spot) to $10^{16}$ ph.s$^{-1}$.cm$^{-2}$ (for a 200 µm×100µm spot) [4].

**Application:**

*Atmospheric Photochemistry*

The simulation of Titan’s atmosphere with a N$_2$ - CH$_4$ mixture (95% - 5%).

**First results for photochemistry**

The surfatron based low-pressure micro-wave discharge is an efficient tool as a VUV windowless source for planetary atmospheric photochemistry. The photon flux can be tuned by changing the working conditions (pressure and microwave power) of the discharge.

**Conclusion**

S. Tigrine thanks the IDEX Paris Saclay for her PhD thesis grant. N. Carrasco thanks the ERC Starting Grant PRIMCHEM, grant agreement n°636629. The Centre National d’Etudes Spatiales (CNES) supported the design of the APSIS reactor. All the authors also wish to thank L. Nahon for his kind support and advices.

**References**


**Fig. 1:** Ne discharge in front of the VUV monochromator.

**Fig. 2:** The recorded Ne resonance lines.

**Fig. 3:** Photon flux emitted at 73.6 nm in different conditions of power versus the pressure.

**Fig. 4:** Compared photon flux of the two neon lines at 73.6 and 74.3 nm for an microwave power of 70W and their quadratic and linear fits (respectively).

**Fig. 5:** The APSIS reactor designed for planetary atmospheric studies [3] (APSIS: Atmospheric Photochemistry Simulated by Synchrotron).

**Fig. 6:** Time-monitored mass spectrum
- top: consumption of the reactive CH$_4$
- bottom: production of HCN (27) and C$_3$N$_2$ (52)