VUV Circularly-Polarized Light as a symmetry-breaking driving force: implications for the origin of life's homochirality

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Circularly Polarized Light (CPL) is a chiral object, and as such its interaction with chiral matter may induced enantio-specific photo-processes which could be involved in an astrophysical scenario linked to the origin of life's homochirality, the fact that in the biosphere only L-amino acids and D-sugars are found. Assuming an extra-terrestrial formation of building blocks of life such as amino acids (aa), a possible abiotic explanation for the selection of L-amino acid could then be the exposure to CPL in space.

We have been using synchrotron radiation to simulate the VUV spectrum of light encountered in the Inter-Stellar Medium, and especially the DESIRS beamline [1] at SOLEIL providing an intense and tunable VUV CPL radiation allowing the study of photon-induced processes leading to noticeable enantiomeric excesses (e.e.) on aa.

After a broad introduction on chirality, homochirality and CPL, and on the instrumentation available on the DESIRS beamline, we will present several asymmetric photon-induced processes such as:
(i) The photon wavelength-controlled enantio-selective photolysis of racemic solid-films on alanine leading to e.e. of up to 4 % [2].
(ii) The asymmetric photochirogenesis on CPL-irradiated interstellar achiral ice analogs (H_2O, NH_3, CH_3OH) leading to the asymmetric production of several aa with e.e. up to 2.5 % for alanine [3].
(iii) The one-photon photoelectron Circular Dichroism (PECD) on gas phase aa. PECD is new type of Circular Dichroism in the angular distribution of photoelectrons produced by CPL-ionization of pure enantiomers. This chiroptical effect is observed as a very intense (up to 35 %) forward/backward asymmetry (for a review see Ref. [4]). PECD happens to be a subtle probe of molecular structures such as conformers [5], chemical substitution and isomers [6]. After a large introduction to PECD and some of its properties, we will show how the asymmetric photoemission process may lead to e.e of up to 4 % in the case of alanine [7] and 12 % for proline [8,9] at the astrophysical-relevant Lyman-α wavelength.

REFERENCES
[1] L. Nahon *et al.*, J. Synchrotron Rad. 19, 508 (2012).
[2] C. Meinert *et al.*, Angew. Chem. Int. Edit. 53, 210 (2014).
[3] P. Modica *et al.*, Astrophys. J. 788, 79 (2014).
[4] L. Nahon *et al.*, J. Electron Spectros. Relat. Phenomena 204, 322 (2015).
[5] J. Dupont *et al.*, J. Phys. Chem. Lett. 13, 2313 (2022).
[6] L. Nahon *et al.*, Phys. Chem. Chem. Phys. 18, 12696 (2016).
[7] M. Tia *et al.*, J. Phys. Chem. Lett. 4, 2698 (2013).
[8] R. Hadidi *et al.*, Adv. Phys. X 3, 1477530 (2018).
[9] R. Hadidi *et al.*, Commun. Chem. 4, 72 (2021).