Ultraviolet circularly polarized light induced symmetry breaking in space

Bocková, J.,[1]* Jones, N.C.,[2] Hoffmann, S.V.,[2] Nahon, L.,[3] Le Sergeant d'Hendecourt, L.,[4] Meierhenrich, U.J.,[1] Kaiser, R.I.,[5] Meinert, C.M.[1]
*presenter
[1]jana.bockova@univ-cotedazur.fr, CNRS UMR 7272, Institut de Chimie de Nice, Université Côte d'Azur, France
[2] ISA, Department of Physics and Astronomy, Aarhus University, Denmark
[3] Synchrotron SOLEIL, France
[4] CNRS UMR 7345, Laboratoire de Physique des Interactions Ioniques et Moléculaires, Aix-Marseille Université, France
[5] Department of Chemistry, University of Hawaii at Manoa, USA

'How did life choose its handedness?' Just like our hands mirror each other, key building blocks of life – amino acids and sugars – exist in left- and right-handed forms (so-called enantiomers). Even if there appears to be no biochemical reason to favor one enantiomer over the other, life on Earth uses almost exclusively left-handed (L-) amino acids and right-handed (D-) sugars. Several synthetic routes have been proposed for the formation of building blocks of life both in space and on the early Earth. Notwithstanding, the origin of chiral preference – a key prerequisite for life – remains an unresolved puzzle. Asymmetric photochemistry induced by stellar ultraviolet circularly polarized light (CPL) in cold interstellar environments is often considered to be the most plausible origin of symmetry breaking.[1] In addition to the detection of infrared CPL in space,[2] numerous detections of L-enriched amino acids and D-enriched sugar acids in meteorites[1] support the *astrophysical CPL scenario*. In the present talk I will highlight the most significant results of our cometary ice simulation experiments[3–5] in support of the astrophysical origins of life. These will be complemented by long-awaited first solid-phase anisotropy spectroscopy and asymmetric photolysis experiments on isovaline using our newly built tunable laser table set-up.[6] Isovaline – a non-proteinogenic amino acid resistant to racemization – is extremely rare in the Earth's biosphere, but it was found in meteorites in L-excess of up to about 20%. It therefore represents a valuable test case for supporting stellar CPL as the initial cause of how life lost its symmetry.

Support by the European Research Council under the EU's HORIZON 2020 research & innovation programme [grant agreement 804144] is gratefully acknowledged.

---

[1] Glavin, D. P.; Burton, A. S.; Elsila, J. E.; Aponte, J. C.; Dworkin, J. P. The search for chiral asymmetry as a potential biosignature in our solar system. *Chem. Rev.* **2020**, *120*, 4660.
[2] Kwon, J.; Tamura, M.; Lucas, P. W.; Hashimoto, J.; Kusakabe, N.; Kandori, R.; Nakajima, Y.; Nagayama, T.; Nagata, T.; Hough, J. H. Near-infrared circular polarization images of NGC 6334-V. *Astrophys. J. Lett.* **2013**, *765*, L6.
[3] Modica, P.; Meinert, C.; de Marcellus, P.; Nahon, L.; Meierhenrich, U.J.; d'Hendecourt, L. Enantiomeric excesses induced in amino acids by ultraviolet circularly polarized light irradiation of extraterrestrial ice analogs: a possible source of asymmetry for prebiotic chemistry. *ApJ* **2014**, *788*, 79.
[4] Meinert, C.; Myrgorodska, I.; de Marcellus, P.; Buhse, T.; Nahon, L.; Hoffmann, S.V.; Le Sergeant d'Hendecourt, L.; Meierhenrich, U. J. Ribose and related sugars from ultraviolet irradiation of interstellar ice analogs. *Science* **2016**, *352*, 208.
[5] Turner, A.M.; Abplanalp, M.J.; Bergantini, A.; Frigge, R.; Zhu, C.; Sun, B.-J.; Hsiao, C.-T.; Chang, A.H.H.; Meinert, C.; Kaiser, R.I. Origin of alkylphosphonic acids in the interstellar medium. *Sci. Adv.* **2019**, *5*, eaaw4307.
[6] Bocková, J.; Jones, N.C.; Topin, J.; Garcia, A.D.; Hoffmann, S.V.; Meinert, C. Anisotropy spectra and UV circularly polarised light-driven photochemistry in isovaline. Angew. Chem. Int. Ed. **2022**, *in preparation*.