Why nature never makes chiral twins – insights from cometary ice analogues and extra-terrestrial sample analyses.

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Introduction: 'How did life choose its handedness?' Just like our hands mirror each other, but cannot be superimposed on each other, amino acids and sugars exist in l*eft*- and *right-handed* forms. Even if there appears to be no biochemical reason to favor one enantiomer over the other, life on Earth uses almost exclusively *left-handed* amino acids and *right-handed* sugars. This is called biological homochirality and it is inevitable for building functional proteins and RNA/DNA. Several asymmetric processes have been experimentally tested to induce chirality in molecular systems, but those focusing on stellar circularly polarized light (CPL) appear to us to be most encouraging, especially given results reported on CPL-induced chirality in amino acids. The astrophysical origin of homochirality is strengthened by *i*) the detection of L-enriched amino and D-enriched sugar acids in meteoritic samples [1], *ii*) the detection of CPL in several star-forming regions [2] as well as *iii*) experiments studying the interaction of UV CPL with prebiotically relevant chiral species [3].

Results: In this talk, I will highlight significant results on our on-going cometary ice simulation experiments [4, 5] as well as on circular dichroism and anisotropy spectroscopy as a key tool to decipher the response of chiral molecules to UV CPL [6].

Chiroptical Spectroscopy. Experiments that use CPL require the knowledge of the chiroptical response of the targeted molecules prior asymmetric photoinduced processes to tune desired enantiomeric excesses (*ee*). Here we present the first CD and anisotropy spectra of amino acids recorded in the gas phase, where any asymmetry is solely determined by the genuine electric and magnetic transition dipole moments [7]. Moreover, our experimental results on propylene oxide – the first chiral molecule detected in interstellar space – may reveal the handedness of interstellar circular polarization at the dawn of molecular evolution. As L-enantioenriched amino acids have been detected in carbonaceous meteorites [1], our data provide new insights into original asymmetric photochemical reactions in interstellar environments, suggested to have triggered the selection of life's L-amino acids (Figure 1).

Universal symmetry breaking event. Moreover, I will present our major findings on recent asymmetric photosynthesis/photolysis experiments to discuss whether stellar UV CPL could have induced a common chiral bias across molecular families. 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. 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.

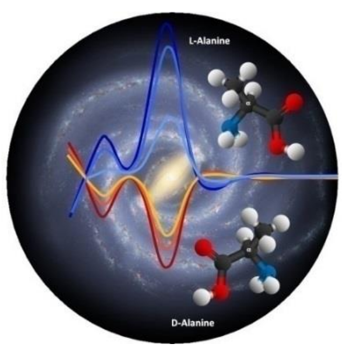

Figure 1: Selection of molecular handedness at the dawn of molecular cloud evolution.

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