POLARIZED SPACE RADIATION AND BIOLOGICAL HOMOCHIRALITY

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Introduction: The origin of biological homochirality in terrestrial organisms (proteinogenic amino acids with L-form enatiomar dominant and sugars in DNA and RNA with D-form enatiomar dominant) is one of the most important but unsresolved problems in astrobiology. A most attractive scenario by the astrobiological contexts is that the single-handedness phenomenon was originated by asymmetric chemical reactions under asymmetric interstellar/circumstellar conditions stimulated by polarized space radiation.

Typical polarized radiation sources in space which can induce asymmetric chemical reactions is circularly polarized light (CPL) [1]. This CPL scenario is supported by the occurrence of L-enantiomer-enriched amino acids in carbonaceous meteorites [2], and the observation of CPL of the same helicity (left- or right-handed circular polarization) over large distance scales in the massive star-forming region of Orion [3] and NGC 6334-V [4] nebulae.

One of the serious drawbacks of the CPL hypothesis above is that polarization direction (left- or right-handed) depends on relative position to radiation sources. Another possible hypothesis is based on the radiation source with absolutely determined polarization direction. It is well known that electrons from beta-decay radiation are spin-polarized, that is, the spin angular momentum is polarized to the direction of motion due to parity non-conservation law in the weak interaction. The helicity (the projection of the spin angular momentum onto the direction of kinetic momentum) of beta-ray electrons is universally negative (left-handed). Spin polarized electrons (SPE) can be emitted as beta-decay electrons from radioactive nuclei or from neutron fireballs in supernova explosion [5].

Experiments: Ground simulation experiments for the extraterrestrial homochirality scenario have been conducted by using CPL from synchrotron radiation (SR) facilities. Solid films of achiral hydantoin (a precursor molecule of achiral glycine) were irradiated with CPL at 215 nm from a free electron laser (FEL) of UVSOR-II (IMS, Japan). As the results of the circular dichroism (CD) spectra measurement of the CPL irradiated hydantoin, opposite CD spectra depending on the polarization direction was observed ilike as DL-amino acid experiments [6].

The same kind of ground simulation experiments by using SPE from beta-decay radioactive nuclei have also being conducted. DL-Isovaline (Iva) films were irradiated the with a flux of SPE from high-dose beta-decay radioactive isotope source (^{90}Sr - ^{90}Y) of the Russian Federal Nuclear Center. In the CD measurements using beamline-15 of HiSOR, the samples were set so that the film-deposited surface of them faced to the source of the CD-probe SR beam. The samples were rotated around the axis of CD-probe SR beam. Furthermore, linear dichroism (LD) spectra of the samples also simultaneously measured by using a laboratory spectropolarimeter including LD measuring equipment. As the results of these measurements, the prospective emergence of optical anisotropy in the irradiated DL-Iva films was successfully detected [7]. The experiments by using SPE from spin-polarized electron accelerators, by which the polarization direction of SPE can be well-controlled, are also planning.

Summary: The measured CD spectra of our CPL- and SPE-irradiated amino acid films showed apparent emergence of optical anisotropy presenting the irradiation effects of polarized spase radiation. Present results can be important for the solution of biological homochirality problems.

References:

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