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## II. MOLECULAR DIPOLES AND CHIRALS

All molecules are in continuous random motion known as the Brownian movements which are a classical example of randomness studied by Albert Einstein in 1905 as due to the bombardment of dust particles by the surrounding water molecules in thermal motion. They are a classical example of randomness which gathers more information than it makes go away and thereby generates what it came to be called chaos (see Thom, 1972 in **III**).

The irregular oscillations of chaotic behaviour are scaled from the microscopic, thermal chaos to the macroscopic, non-equilibrium and turbulent chaos, between which are sandwiched Prigogine's dissipative structures (see Peacocke, 1983 in **III**). Chaotically moving molecules must be polarly ordered to contribute to a process such as the basic transport mechanism by diffusion in living things, a directional process which necessarily should act against chaos (see "antichaos", Kauffman, 1991 in **VII**). There is therefore order in chaos and randomness has an underlying geometric form (Crutchfield *et al.*, 1986). The question of what would such classical chaos do to quantum mechanics, first asked in 1917 by Einstein, has since been positively answered in the way that "symptoms of chaos enter even into the wave patterns associated with atomic energy levels" as imaged by the wave patterns of a highly excited hydrogen atom or Rydberg atom in a strong magnetic field (Gutzwiller, 1992, relevant references herein).

Chaos is exhibited by a wide variety of systems governed by nonlinear dynamic laws (Gleick, 1988). As best-studied chaotic chemical system, the Belousov-Zhabotinsky reaction based on the autocatalytic oxidative bromination of malonic acid (see Gray and Scott, 1990) has been described in terms of a set of differential equations containing only three variables (Györgyi and Field, 1992).

### A. DIPOLE MOMENTS

#### 1) *Electric polarizability*

Molecules of ferroelectric crystals are polar because of the dissymmetrical distribution of their + and - charges. Thus endowed with dipolar electric moment, they orient themselves spontaneously or under the influence of an electric field. Such polarization phenomena are displayed by crystals with hydrogen bonds (phosphates, sulfates, etc.) and by double oxides such as titanate (see **I, II**).

#### 2) *Magnetic polarizability*

In a magnetic field, positive and negative charges move in opposite circular trajectories leading to a magnetic dipole moment. The constant of proportionality between the induced moment and the applied field is the magnetic polarizability  $\beta_M$ .

## B. MINERAL DIPOLES

### 1) *Dipolar water*

The conformation of biomolecules in a three-dimensional network of water and the regulation of the electrochemical potential across biomembranes have been reviewed (Vasilescu *et al.*, 1990).

Liquid water is symmetrical but, eventually, through its phase transition to ice crystals its symmetry is broken. Its strong, totally connected random tetrahedral network of hydrogen bonds should confer it rigidity rather than its familiar fluidity which can be ascribed to defects characterized geometrically by the presence of an extra, fifth molecule in the first coordination shell, or topologically by the presence of "bifurcated" hydrogen bonds (Sciortino *et al.*, 1991 and refer. herein).

From the experimental study of ice nucleation by bacterial proteins involving the freezing of water droplets on the hydrophobic surface of paired amino acids crystals, one chiral (D or L), the other racemic (D/L), emerged the following pattern: "in every pair the nonpolar crystal, where successive molecular layers are arranged so that the electric dipolar field cancel, is a less effective nucleator than the polar crystal, where the dipoles of successive layers reinforce" (McBride, 1992).

## C. ORGANIC DIPOLES

### 2) *Multiple molecules (polar chains)*

Polar multilayers of molecules can be formed by the well-known Langmuir-Blodgett procedure. The molecular orientation in solids has been obtained by a self-assembly strategy implicating the formation of polar dye multilayers either by a complex sequence of substitution reactions at Si and C atoms to form dye monolayers (Li *et al.*, 1990) or by a simple self-assembly procedure in which solid surfaces are joined by zirconium phosphate-phosphonate interlayers (Katz *et al.*, 1991).

Upon photoexcitation of a probe neutral molecule which contains two electron-rich donors and an electron-poor acceptor, charge separation occurs. A conformational change results from this fast intramolecular electron transfer described by Brouwer *et al.*, (1991) as "harpooning", a photoinduced process in which the charged centers are drawn together. The two opposite charges present within a single molecule would cause a profound increase in the molecular dipole moment.

## D. CHIRAL MOLECULES (CHIRALITY)

Crucial molecules of life such as building blocks of DNA and proteins are chiral. Chiral symmetry is fundamentally a property of quark interactions on which is based polarizability (see chapter I.C.2). This handedness is slightly broken in Nature by the

small but finite quark masses (Holstein, 1991). Since introduction of the concept of antimatter by Dirac in 1928, antiatoms, the most suitable being antihydrogen results of the interaction of a positron and an antiproton (Hughes, 1991). Helical electrons do distinguish between molecules of opposite chirality (Garay and Ahlgren-Beckendorf, 1990) and an interdisciplinary treatment of chirality related to elementary particle physics has just been edited (Janoschek, 1991).

Chirality has been related to “cold prehistory of life” based on the phenomenon of molecular tunnelling (Goldanskii, 1979; Goldanskii and Kuzmin, 1991). Ulbricht (1959) had invoked the parity-violating weak interaction as the cause of biological homochirality (see chapter I). Morosov (1979) has then presented other hypotheses about the abiotic and the biotic origin of molecular asymmetry. As Pasteur (1884) and Wald (1957), he favored the hypothesis of a biological origin of chirality which assumed that “the very nascence and development of life ruined one type of the chirality of molecules”. It would thus be by a process of spontaneous mirror symmetry-breaking that chiral purity resulted rather than from the gradual accumulation of an enantiomeric excess (Frank, 1953 in I; Morosov, 1979). This confirms that mirror-image chemistry of life is based on enantioselectivity.