The extension of habitability, some ideas

Let's open our minds

Jean Schneider
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- Extension of the habitability concept

- Extension of the habitability zones

- Extension of biomarkers

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Striking a balance between freedom and discipline is hard to do

Jerome Rohtstein in « Generalized Life » 2

Extension of the habitability concept

Extensions of the concepts :

- « Definitions » of Life

1/ As a starting point, « life » is a word with emotional content.
    We call « living » objects,
        - which we perceive with our senses
        - which we describe only in **plain** language
        - with which we can make some identification with ourselves (autonomy etc)
==> There is no objective definition of Life.

    Living/non living is an **arbitrary convention** (cf human/non human for embryos)

Extension of the habitability concept

Extensions of the concepts :

- « Definitions » of Life

2/ There is a systematic correlation between these subjective judgements and properties of the objects when analyzed with physical concepts and expressed in **mathematical** language *e.g* . :
- very far from equilibrium dissipative structures
- carbon and water-based organic chemistry

3/ In the search for life on exoplanets our natural senses are inefficient.

Thus, we can only rely on observables based on abstract physical concepts.

Extension of the habitability concept

Extensions of the concepts

- Alternatives to very far from equilibrium dissipative structure ?
    Perhaps a good general concept,
    But note that in Quantum Physics the behavior of a measurement apparatus cannot be explained by its physical structure. It is « sui-generis ».

- Alternatives to carbon and water-based organic chemistry
    - Non water life. e.g. NH_3, H_2SO_4, CH_4, C_2H_6 (Neubauer et al. 2011)

    - Non carbon chemistry ? Silicon-based life excluded (SiO_2 solid etc)

    - Non luminous (photosynthesis) nor chemical (chemiotrops) sources of energy : e.g. radioactivity or mechanical energy

    - Non chemical life : e.g. :

        - Self-organized liquid crystals
        - Self-organized plasmas
        - Electronic structures in flexible systems (cf. electric properties of cells)
        - Self-organized dislocations in crystals (Schneider 1975)

Extension of the habitability concept

Extensions of the concepts

- Alternatives to carbon and water-based organic chemistry
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$$\sigma + \quad \Longrightarrow$$

Fig. 4. Schematization of the Frank-Read source mechanism.

For the physiology I seek, I suggest in a first model the use of several kinds of complex interlocking chains of dislocation loops like that shown on Figure 5.

These chains could be the material for some kind of 'molecular biology'. Some of them could play the role of DNA, others that of 'proteins'. Then the information can be represented by the topological type of these chains; the precise shape of the loops is here of no importance.

Fig. 5. Complex chain of dislocation loops.

The 'dislocational' reactions can be made of the elementary reactions shown in Figure 6.

We thus have complex chains which
– are stable,
– can contain rich information,
– can diffuse it into the surrounding through complex sets of dislocational reactions

$$\sigma + \quad + \quad \Longrightarrow$$

$$\sigma + \quad \Longrightarrow \quad +$$

Fig. 6. Schematization of a 'dislocational' reaction.

Extension of the habitability zones

- For standard carbon and water-based organic chemistry :

  - Planetary configurations

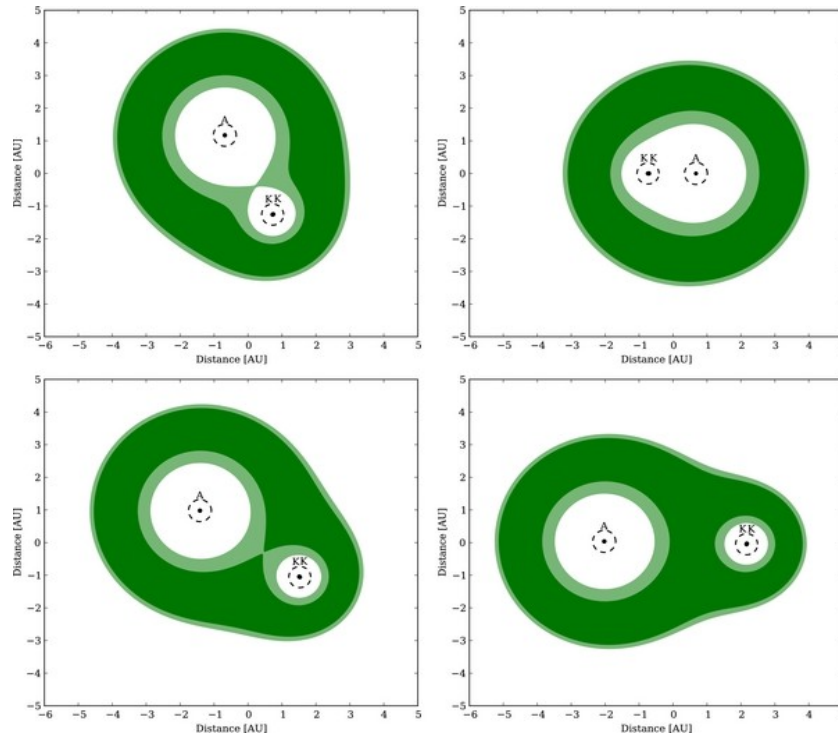 - Stellar configurations

  - Other bodies

Extension of the habitability zones

- For standard carbon and water-based organic chemistry :

  - Planetary configurations

    - Restricted planetary areas of unhabitable planets

      - Polar caps (planet too hot)
      - Equatorial zones (planet too cold)
      - Caves (source of energy : radioactivity)

    - Exo-moons : around habitable planets or tidally heated par parent planet

    - Deep oceans (energy source radioactivity)

    - Cold free-floatting planets (energy source radioactivity)

Extension of the habitability zones

- For standard carbon and water-based organic chemistry

    - Stellar configurations

        – Binary stars (see also Georgakarakos talk)

            - Circumbinary planets
            - S-type planets

Mûller & Haghighipour 2014

Extension of the habitability zones

- For standard carbon and water-based organic chemistry

  - Stellar configurations

    – White dwarfs and pulsars : high energy photons may be « thermalized » into low energy (visible) photons in atmospheric showers

    – Flare stars : luminous energy source restricted to flares

       heat buffered in the planet

    e.g. M-dwarf UV flares

       Welsch et al . 2007
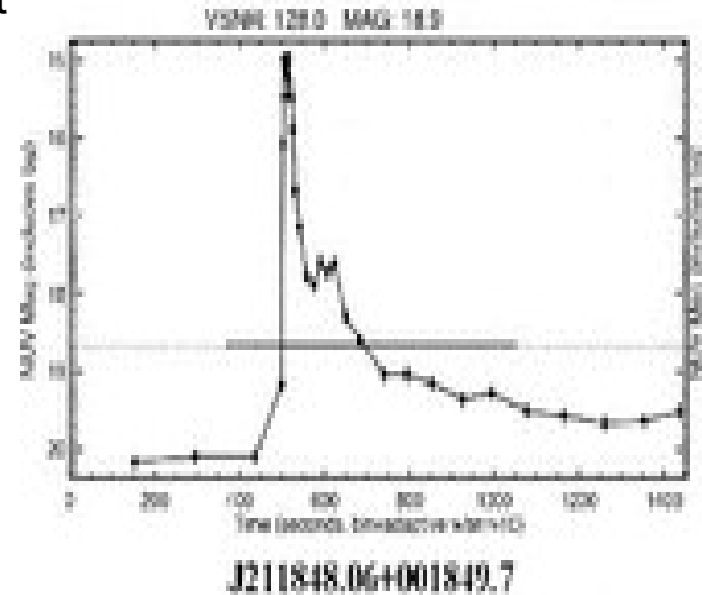
  - Other bodies

    Grains (and free floating stones and rocks?) in complex molecular clouds

Extension of the habitability zones

- For non standard life:

  - Non water life : other temperatures

| Solvant	NH_3	SO_4H_2	CH_4	C_2H_6	H_2O
Temp. Range (C)	(-80,45)	(10,340)	(-180,-160)	(-180,-90)	(0,100)

  - Non luminous sources of energy :

    - Thermal (hot springs) oceans

    - Mechanical : solid planetary crusts

    - Radioactivity : any planet

  - Non chemical life

    - Cool stars

    - Any planet

    - Complex plasma in molecular cloud (cf « Black Cloud » by F . Hoyle)

Extension of the habitability zones

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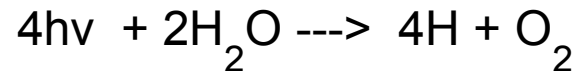
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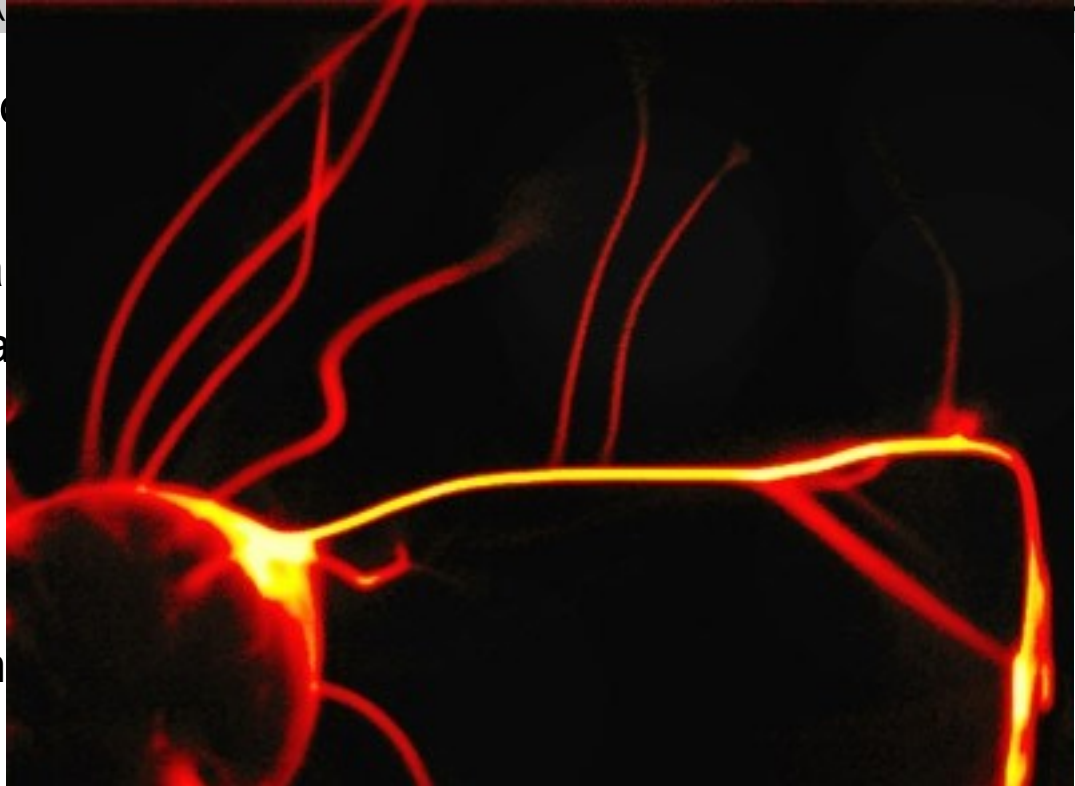
Extension of biomarkers

Hints for biomarkers for non-standard life

- Solvants other than water (NH_3 SO_4H_2 CH_4 C_2H_6)

    Idea : O_2 is a biomarkers of water-based life (photodissociation of water catalyzed by bio-molecules) :

$$4h\nu + 2H_2O ---> 4H + O_2$$

    Similarly :
    - NH_3 photodissociation yields : $N + NH_2$
    - SO_4H_2 photodissociation yields : SO_3 and H_2O
    - CH_4 photodissociation yields : H and H_2
    - C_2H_6 photodissociation hields : C_2H_2 and CH_4

- Non luminous energy source for organic chemistry : open

- Non chemical life :
    - Electronic life : electromagnetic signals
    - Structures in liquid crystals : open

- Other approach : non intentional « technosignatures » (« city lights », « factories »)