PLANETARY SURFACE MEASURING ARRANGEMENT ACCORDING TO THE PRINCIPLES OF THE ONSAGER MATRIX TRANSPORTS: COMPLEXITY AND INTEGRATED SIMULTANEOUS SENSOR CELL-SYSTEM. *Sz. Bérczi[1], P.G. Vizi[2], Gy. Hudoba[3], I. Schiller[1], A. Róka[4], I. Gyollai[1], [1]Eötvös University, Inst. of Physics, Dept. Materials Physics, Cosmic Materials Space. Res. Group. H-1117, Budapest, Pázmány P. s. 1/a. Hungary (berczi szani@caesar.elte.hu), [2]MTA Wigner RCP H-1121 BUDAPEST, Konkoly Thege M. út 29-33. (vizi.pal.gabor@wigner.mta.hu) [3]Óbuda University, Alba Regia Univ. Center, H-6000, Székesfehérvár, Budai út 45, Hungary (hudoba.gyorgy@amk.uni-obuda.hu), [4]Eötvös University, Dept. Physical-Chemistry. H-1117, Budapest, Pázmány P. s. 1/a. Hungary, (foxy.andras@gmail.com),*

Introduction: In a wetland or a field on Earth we can identify soil characteristics by the observation of indicator plants (for example they refer to the pH). This plant indicator arrangement gives a cellular mosaic overview of the surface soils. A similar program should be realized by recognizing a Bell Lab. advertisement from the early 80's: how to measure simultaneously the compositional gradient and the thermal gradient? [1] (Fig. 1.) (Our program is part of the synthesis project in teaching planetary and environmental science at Eötvös University.)

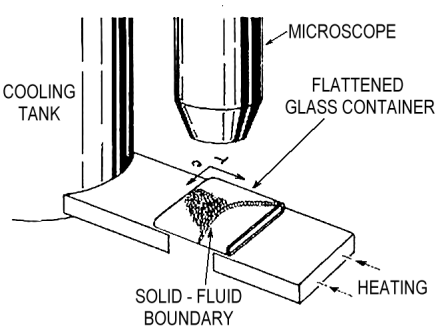

Fig. 1. The advertisement of Bell Lab (in the 80's) shows the synchronous measurement of chemical transport and heat transport with a gradient arrangement. The result is a c-T diagram for two compounds while they were in diffusion in the fine capillary cell.

The Onsager principle of transports in a matrix: In Onsager matrix the generalized „strains" (represented by the strains of intensive physical parameters - where pressure difference: P_1-P_2, chemical potential difference: μ_1-μ_2, temperature difference: T_1-T_2, etc. - are triggering the transporting the streams of the extensive physical quantities of volume, of mass, and of energy etc. If a cell mosaic arrangement – an array – is constructed according to such Bell Lab. type sensor units (not only for μ_1-μ_2, T_1-T_2, but for P_1-P_2, U_1-U_2 etc.) a complex simultaneous measuring array can measure the local field parameters. The benefit of such a system is that physical parameter mapping can be carried out by one complex measuring unit.

From our point of view this measuring arrangement gives a representation of the Onsager matrix in a 2x2 form of [2]. (Fig. 2.)

Stream of extensive quantities / Strain of intensive quantities	dV/dt	dE_b/dt	dn_s/dt	dQ/dt
mechanical p_1--p_2	MECHANICAL WORK **D'ARCY-POISEUILLE**	COMPRESSION EXPANSION	FILTRATION	PIEZZO-ELECTRICITY
thermal T_1--T_2	EXTENSION, ARCHIMEDES	THERMO ENERGY TRANS PORT, **NEWTON** COND.LAW	THERMO-DIFFUSION **SORRET** EFFECT	THERMO-ELECTRICITY, **SEEBECK** EFFECT
chemical potential μ_1--μ_2		DUFOUR EFFECT	DIFFUSION **FICK'S** LAW	ELECTRO-CHEMICAL EFFECT
electric potential difference U_1--U_2	ELECTRO-MECHANICAL WORK	**PELTIER** EFFECT	ELECTRO-CHEMICAL EFFECT	ELECTRIC FLUX **OHM'S** LAW

Fig. 2. The Onsager matrix of generalized physical „tensions" (thermodynamical drives, rows) and the transported streams of extensive physical quantities (columns).
The Bell Lab. experiment of Fig. 1. realized a representation of the yellow row temperature gradient of T_1-T_2, and the green row of chemical potential gradient μ_1-μ_2, while the image observed in the microscope was the visible product of diffusion effect boundaries (phases, pink) by the heat gradient (orange).

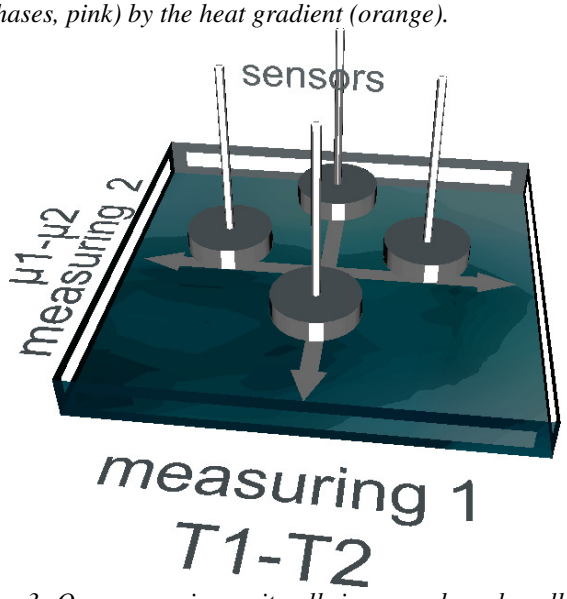

Fig. 3. One measuring unit cell, in a quadrangle cell representation, with 2 streams and 4 sensors.

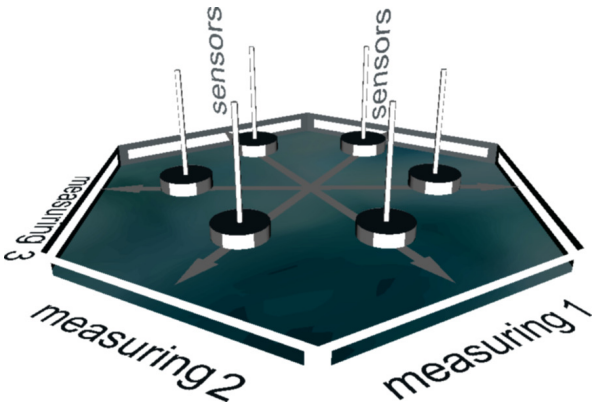

Fig. 4. One measuring unit cell, in a hexagonal cell-mosaic representation, with 3 streams and 6 sensors. The transported streams of extensive physical quantities are (columns).

The von-Neumann principle of cellular automata [3]: a mosaic system array:

The sensorial unit cells can be realized in an array of square prisms with two types of transport acting between the two parallel faces (Fig. 3.) or in a hexagonal prisms form with three types of transport acting between the three parallel faces (Fig. 4.), while the top and bottom surface is used for the sensors which observe the streams running between the parallel sides.

Measurements [4]: The system array can be used: (1) - Invasive mode (interfering signal is applied) (2) - Passive (non-invasive) mode (no interfering signal is applied) (3) - Combined mode: passive mode and active (invasive) signal combined. (transport between side walls through the adjacent cells). A special case to measure interdiffusion (cross-diffusion) matrix for 3 chemical compounds simultaneously (combined layout with quadratic or hexagonal units) (Fig. 5.).

Planetary soil measuring mode: the cell-mosaic system is placed on the soil surface.

Bottom open, top closed version: the cell-walls form a grid (a frame), and the soil fulfills the cells, which are open at bottom, but closed on the top (on the top wall are the sensors) (Fig. 4.)

Example situations: The system observes the interdiffusion transports (cross-diffusions of the Fick matrix element in the Onsager matrix). One sensor array observes the pH-changes, other for the optical changes in soil (or fluid) units.

Conclusion: The simultaneous measuring with application of the "Onsager matrix array" (square or hexagonal cell-mosaic arrangement) can encourage students to develop new strategy in data collecting in planetary missions. Application of this construction method in education of space and planetary science gives challenges to the students for planning measurements. In this way measurements are not alone, done not for a single parameter, but for the observation of joint changes of several parameters.

μ flux	d μ /dt	dn/dt	dm/dt
chemical potential μ_1--μ_2	**FICK**'S DIFFUSION for μ	interdiffusion	interdiffusion
chemical potential n_1--n_2	interdiffusion	**FICK**'S DIFFUSION for n	interdiffusion
chemical potential m_1--m_2	interdiffusion	interdiffusion	**FICK**'S DIFFUSION for m

Fig. 5. Interdiffusion transports form a sub-array in the Fick law element of Fig. 2. matrix.

This Onsager-array is a future development for Hunveyor, Husar educational space probe models of the Competition of Applied Engineering Sciences (magyarokamarson.hu) [5]. After earlier single pH [6], single optical heating for gases [7], magnetic carpet [8] experiments it applies joint measuring systems [9].

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