Self-structuring processes in superficial layers of water studied using method of high resolution infrared thermography.

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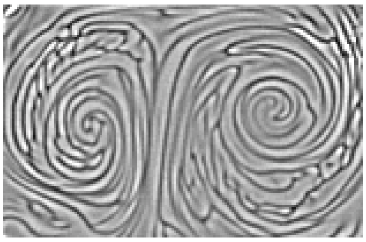
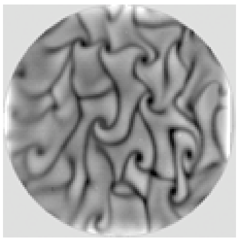
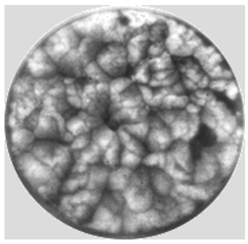
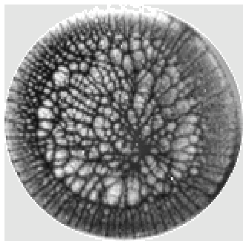
Most of the water being the main substance of living systems remains in boundary conditions. In the same time our knowledge about the properties of interfacial bounded water is quite weak comparing with properties of free water. For example the surface tension converts the interfacial layer of water into the substance which gains the properties similar to elastic liquid crystals.

Temperature distributions in superficial layers of water and multi-component water solutions were studied using the method of real-time infrared imaging. High sensitivity focal plane array (FPA) infrared (IR) camera with 3-5 micron spectral window of sensitivity was used in our studies. Temperature sensitivity (limited by thermal noise equivalent of IR camera) was better than 15 mK at 200 frames per second acquisition rate and the sensitivity could be improved up to 2 mK using the method of averaging and IR image processing. Such method makes it possible to visualize the difference between free and bounded water and to observe the dynamics of non-uniform structures in superficial layers of water and multi-component water solutions. Such structures are invisible in visual spectral range and the mechanism of their formation associated with convective and diffusion processes in thin superficial layer of water caused by thermal gradient, which appears due to evaporation or components mixing. Because of relatively high energy of evaporation the superficial temperature is 0.4-0.6 °C lower in comparison with the temperature 0.2-0.5 mm below the surface.

The formation of macroscopic structures in superficial layers of water due to its convection is a good illustration of the self-organization mechanism associated with chaos – order transitions that occur if temperature gradients are present.

Examples of IR patterns in superficial layers of water (left pare) and in multi-component water solutions (right pare) are presented below.

The shape of such patterns depends on many factors: water and room temperature, humidity, thickness of liquid, shape of container, viscosity and surface tension, initial temperature pattern and history of its evolution, and its time.

Mechanism of structure formation in multi-component water solutions and shape of patterns are much more complicated because in addition to evaporation dependent temperature gradients it is necessary to consider concentration gradients and temperature gradients which appear due to dissolving processes (for example – increase of temperature after mixing ethyl alcohol with water). Time-dependent behavior of such patterns and possible role of free/bounded water in self-structurization processes will be discussed.

Obtained results demonstrate that superficial layers of water could be considered as the system remaining in non-equilibrium stage for relatively long period of time.