Popular Short Description

Isaak Newton was the first one who indicated the key paths of the modern physics: the coherent link in a common picture of distinct phenomena, for instance the falling apple and the way of moving planets and comets in the Space. At the end of the 19^{th} Century Pierre Curie noted surprising similarities in the behavior of some physical properties for the gas – liquid critical point and the para- to ferro-magnetics transition. Understanding of the latter phenomenon resulted in the one of greatest achievements of the 20^{th} Century Physics: the *Physics of Critical Phenomena*. Regarding milestones of this scientific adventure: the Nobel Prizes of Lev. D. Landau (1962), Kenneth Wilson (1982) and Pierre G. de Gennes (1991). All these lead to the final formulation of the *Physics of Critical Phenomena*, which methodology and ideas are used also far beyond the physics nowadays: for instance in economic and financial analysis. The newest inspiration in the given topic is the 2016 Nobel Prize in Physics.

This Project is focused on the 'oldest and most classical' type of critical systems associated with the gas-liquid critical point (GLCP) and the liquid – liquid (CCP) critical consolute point in mixtures of limited miscibility. In the last years surprising new phenomena and cognitive gaps have been found there. One can recall here the existence of two, still mystic, dynamical domains in the hypothetically homogeneous supercritical region, problems with pressure dependences of the critical temperature and the critical concentration (for CCP). For the broad band dielectric spectroscopy (BDS) the insight, regarding both experiment and theory, is in practice limited only to the basic case of dielectric constant. This Project addresses all these issues, what is possible due to extraordinary high pressure facilities (for pressure $P < 2.2$ GPa, for temperatures between– 30 ^{o}C and + 1600 ^{o}C and for large pressurized volumes) matched with the possibility of *in situ under pressure* monitoring of BDS, NDS (nonlinear dielectric spectroscopy), heat capacity and density. All these can yield a unique and coherent set of experimental reference evidences for the subsequent modelling and theoretical analysis.

Within the Project there will be also carried out the first studies *in situ* of the supercritical extraction (SCF), also exploring the recently discovery of IHPP PAS (2016) that the hybrid (supercritical and ultrasound) actions yield the direct experimental access to the diameter of the coexistence curve, what seemed to be impossible.

Within the Project two innovative experimental set-up will be build, namely:

(i) The system for the precise and software controlled determining of two- and multi- phase equilibria in mixtures of limited miscibility

(ii) The system for precise fundamental studies of the supercritical extraction, including the hybrid option linking the action of the supercriticality and ultrasound

This Project is focused on problem related to the fundamental issues physics, but its results can have direct impact on important industrial and societal issues, due to the fact that the unusual properties near the critical point constitute the reference for '*green technologies*' important from the pharmaceutical industry to the environment protection.