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The Richard T. Cox Lecture: Liquid State as an Occasional Result of Competing Interactions

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Now it is even strange to think that in the early 50-ies the second order transitions and the liquid – vapor critical point were considered as different fields of physics. In the USSR this lack of understanding (as everything in the USSR) had also a political dimension. Being a graduate of Kharkov University (domain of L.Landau) I was inclined to work in a framework of Landau-theory of the critical point. Having carefully analysed the published experimental data I discovered that the scattering of the data in the vicinities of both critical points and phase transitions was much higher than the implemented equipment had allowed [1]. For me it was a true sign of wrong conditions of measurements. As a result I had adjusted my experiment to the specific condition of the critical point. We worked together with the group of students of Kharkov University who had shared my enthusiasm. When we were already on a halfway of our own measurements I was deeply impressed by the excellent result of M.J.Buckingham and W.M. Fairbank on the λ-point of Helium [2]. Their achievement had turned our own measurements into a sort of experimen-tum crucis: should one expect a singularity also in the critical point or shouldn't? Experimental data on isochoric heat capacity near the critical point looked really similar (but not identical) to the singularity near the λ-transition. Both found their common ground in lattice models of different kinds [3]. The scaling concept was suggested to explain the universal features of both phenomena originated from developing fluctuations [4]. Our work was noticed first by C.Domb and M.Fisher in England. Michael was especially persistent in his demands that the Sovjet authorities would allow us a free communication. He produced a sort of frustration in their bureaurocratic heads. But it was great to feel not to be condemned for an eternal isolation in the USSR. All this development (now international) has opened way to express the properties of all liquids (including mixtures) in the vicinities of the singular points by the universal functions of reduced coordinates [5]. But the very existence of the critical point (and the liquid state itself) is in fact not an universal property of matter [6]. The freezing is depen-dent on a symmetry of packing and on a form of a potential well. It means the lower limit of the liquid state cannot be universal. However, if the freezing is somehow avoided the metastable critical point may be achieved instead [7]. And the universal features of the critical phenomena may be observed there again. Literature: [1] A. Voronel, M. Gitterman, Zh. Exp. Teor. Fiz. 39, 1162 (1960). M.Bagatsky, A.Voronel, V.Gusak., Zh. Exp. Teor. Fiz. 43, 728 (1962). See also a review: A. Voronel "Thermal measurements and Critical Phenomena in Liquids." in PHASE TRANSITIONS AND CRITICAL PHENOMENA, vol. 5B, ed. by C.DOMB & M.S.GREEN, 1976, Academic Press, London, New York, San Francisco. [2] M.J.Buckingham, W.M.Fairbank in 111,60, "PROGRESS IN LOW TEMPERATURE PHYSICS"(ed. by C.J.Gorter) North-Holland Pub.Co., Amsterdam, 1961. [3] M.E.Fisher,"The Nature of Critical Points", University of Colorado Press, Boulder, 1965; [4] A.Patashinsky,V.Pokrovsky, Sov.Phys.JETP,23,292,(1966); L.P.Kadanov, Physics, 2,263, (1966) [5] M.E.Fisher, Phys.Rev.,176, 257, (1968); M.A.Anisimov, A.V.Voronel, E.E.Gorodetsky, Zh.Exp.Teor.Fiz.,60,1117, (1971) [6] H.J.Hagen,D.Frenkel,H.Lekkerkerker, Nature, 365, 425, (1993); D.Frenkel, Physica, A 263, 26, (1999). G.Vliegenthardt, H.Lekkerkerker, Physica, A 263, 378, (1999). [7] O.Mishima,H.E.Stanley, Nature, 392, 164, (1998).