Features of phase transitions in non-ideal plasmas

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The problem of both conventional (of van-der-Waals type) and non-standard phase transitions (PTs) in strongly nonideal plasma is discussed. This problem was one of the central for Vladimir Fortov, who passed away tragically few months ago. The first one is the very old and scandalous problem of great uncertainty in our knowledge for the high-temperature parameters and critical point location of gas-liquid phase coexistence in uranium and several "bad" metals. The second one is another old and scandalous problem of great uncertainty in our knowledge and in ability of correct theoretical description for the so-called non-congruent phase coexistence of fluid–fluid type in wide number of non-ideal plasma systems, e.g., plasma of metallic alloys, or that in high-temperature decomposition products for chemical mixtures and compounds like oxides, hydrides, nitrides, melting salts etc up to the exotic realization of non-congruence in dense nuclear matter and quark-hadron phase transformation. The last discussing topic is the problem of important but poorly recognized subclass of so-called entropic ("delocalization-driven") phase transitions in non-ideal plasmas of cosmic and terrestrial applications. The point there is that not only this type of (fluid–fluid) phase transitions themselves, but also a great accompanying region of anomalous thermodynamic properties (close to its critical point) are macroscopic manifestation for remarkable feature for entropic PTs—the multilayered structure of thermodynamic surfaces entropy, temperature and internal energy, $S(P,V)$, $U(P,V)$ and $T(P,V)$, within and around such phase transitions. Perspectives of experimental verification (both, real and numerical) for all mentioned above features concludes the discussion.