The Zeno line in plasma

Apfelbaum E M

Joint Institute for High Temperatures of the Russian Academy of Sciences, Izhorskaya 13 Bldg 2, Moscow 125412, Russia

apfel_e@mail.ru

The similarity laws are the general regularities connecting various thermodynamical values, which are valid for different systems independently of their interaction potentials. These regularities are known for more than a century and now they present one of the main approaches for investigation of phase diagrams of various liquids and gases. The similarity concerning the line of the unit compressibility factor has, possibly, the widest area of applicability [1]. This line (below we will denote it as the Zeno line) presents a contour at the phase plane, along which the pressure of a system coincides with the pressure of an ideal gas. Such a contour can be considered in various coordinates. But within the density-temperature plane it appears to be the straight line for all possible densities for disordered phases (i.e. from the zero density and up to the melting line). Initially this property was obtained for van der Waals equation. But later it was found that it is kept for substances, which are described by completely different equation of states (EOS). In particular, among 150 substances of NIST database only dozen of them have show the non-linear forms of this contour [1]. Such universal behavior gave rise to the other new similarity relations for many gases and liquids and the meals in liquid phase [1].

All this properties refer to the systems without charged components under relatively low temperatures. One can expect that the presence of charges will violate the discussed similarities. Really, at low densities for purely Coulomb systems it is possible to construct the analog of virial expansion, but it is non-analytical. As a consequence the straight form of the Zeno line is violated. However it is possible to show that a weaker similarity is still valid even for the systems with Coulomb components [2].

[1] Apfelbaum E and Vorob'ev V 2020 *Int. J. Thermophys.* **41** 1–14
[2] Apfelbaum E 2023 *Plasma Phys. Rep.* **49** 984–990