The unified approach to the Zeno-line and the binodal diameter linearities

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The unified geometrical interpretation of the linear character of the Zeno-line (unit compressibility line $Z = P/(n\,T) = 1$) and the rectilinear diameter of the density n:

$$n_d = \frac{n_l + n_g}{2\,n_c} = 1 + A\,\frac{T - T_c}{T_c}\,,$$

is considered. We show that the properties of the Zeno-line states and the correlation with the rectilinear diameter line as well as other empirical relations can be considered as the consequences of the correspondence of the form:

$$n = n_*\,\frac{x}{1 + zt}\,, \quad T = T_*\,\frac{zt}{1 + zt}\,, \quad z = \frac{T_*}{T_* - T_c} \tag{1}$$

between the density and the temperature variables (n, T) of molecular fluids and those of the lattice gas (Ising) model (x, t). Here n_* and T_* are the characteristic scales for the density and the temperature. The explicit relation between the thermodynamic potentials of the lattice gas model and the fluid is derived in the linear diameter approximation. The mapping between the liquid binodal and that of the lattice gas is considered in 2D and 3D cases. It is shown that the Widom line serves as the natural border between the gas-like and the liquid-like states of the fluid.