Equation of state based on Migdal's phenomenological theory

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A method for constructing a unified fundamental equation of state (UFEoS) is proposed within the framework of Migdal's phenomenological theory of the critical point [1]. The proposed method for constructing the UFEoS is based on a new representation of the scale hy-pothesis [2], the Benedek's hypothesis and the scale function $h(x)$ [3], developed on the basis of [1] $h(x) = A\left[(x+x_1)^{\gamma} - \varphi_0(x+x_1)^{\gamma-2k\beta}\right]$. Here $k \in \mathbb{N}$; $x = \tau/|\Delta\rho|^{1/\beta}$ is the scale variable; $\tau = T/T_c - 1$; $\Delta\rho = \rho/\rho_c - 1$; ρ_c is the critical density; T_c is the critical temperature; β and γ are the critical indices; A and x_1 are the individual constants of substance; φ_0 is the constant that is found from the equality $h(x = -x_0)$, where $x = -x_0$ is the equation of the saturation line in the asymptotic neighborhood of the critical point. Within the framework of the proposed approach, an UFEoS has been developed that satisfies the scale theo-ry of the critical point. This UFEoS has been tested in describing the thermodynamic surface of methane in the range of parameters of state: temperature 90–620 K, pressure up to 1000 MPa. Analysis of the UFEoS showed that its accuracy in describing the p-ρ-T properties and isochoric heat capacity of methane is higher than in the case of known equations that take into account the features of the critical region: the combined equation of state (CEoS) (Bezverkhii and Dutova, 2023), the cubic crossover equation of Kiselev and Ely (2003) and the crossover equations of Kiselev (1997). It is shown that the working area of the UFEoS is significantly wid-er than the working area of the listed EoSs in both temperature and pressure.

[1] Migdal A A 1972 *J. Exp. Theor. Phys.* **62** 1559

[2] Kudryavtseva I V, Rykov V A and Rykov S V 2019 *J. Phys.: Conf. Ser.* **1385** 012009

[3] Kudryavtseva I V and Rykov S V 2016 *Russ. J. Phys. Chem. A* **90** 1493