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Quantum van der Waals theory of nuclear matter with quarkyonic phase

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We extend the Quantum van der Waals description of isospin symmetric nuclear matter at zero temperature to a high baryon density region by incorporating the continuous transition to quark matter in accordance with the recently proposed quarkyonic approach. The resulting equation of state exhibits the nuclear liquid-gas transition at $n_B \leq \rho_0$ and undergoes a transition to quarkyonic matter at densities $n_B \approx 1.5 - 2\rho_0$ that are reachable in intermediate energy heavy-ion collisions. The transition is accompanied by a peak in the sound velocity. The results depend only mildly on the chosen excluded volume mechanism but do require the introduction of an infrared regulator Λ to avoid an acausal sound velocity. We also consider the recently proposed baryquark matter scenario for the realization of the Pauli exclusion principle, which yields a similar equation of state and turns out to be energetically favored in all the considered setups.

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