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Equation of state for two-dimensional dusty plasma liquids and its applications.¹

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Laboratory dusty plasma consists of free electrons, free ions, and micro-sized dust particles with thousands of negative elementary charges. Due to their extremely low charge-to-mass ratio, these dust particles are strongly coupled, arranging themselves like atoms in liquids or solids. Due to the shielding effects of electrons and ions, dust particles interact with each other through the Yukawa potential, so that simulations of Yukawa liquids or solids are used to study properties of dusty plasmas. In the past two decades, the properties of liquid 2D dusty plasmas have been widely studied from experiments to theories and simulations. However, from our literature search, we have not found a quantitative and comprehensive study of properties of 2D liquid dusty plasmas over a wide range of plasma conditions. Here, from molecular-dynamics simulations of Yukawa liquids, we have obtained a concise equation of state (EOS) for the 2D liquid dusty plasmas from empirical fitting, which contains three quantities of the internal pressure, the coupling parameter, and the screening parameter. From this EOS, different thermodynamical processes can be directly derived, such as isotherms, isobars and isochores. Also, various physical properties of 2D liquid dusty plasmas, like the bulk modulus of elasticity, can be analytically derived, so that the sound speeds can be obtained. Finally, an analytical expression of the specific heat for 2D liquid dusty plasmas has been achieved.

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