A comprehensive study of two-dimensional dusty plasma liquids using their equation of state

Yan FENG [1]

[1]Soochow University, China (P.R.C)

Laboratory dusty plasma is a mixture 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, like atoms in liquids or solids. Dust particles interact with each other through the Yukawa potential, due to the shielding effects of electrons and ions. 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, a quantitative and comprehensive study of properties of 2D liquid dusty plasmas over a wide range of plasma conditions is still lacking. Here, from molecular-dynamics simulations of Yukawa liquids, we have obtained a concise equation of state (EOS) for 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, various physical properties of 2D liquid dusty plasmas, like the bulk modulus of elasticity, can be analytically derived. Using the obtained bulk modulus of elasticity, we have predicted the sound speeds in different conditions, which agree well with previous studies using completely different approaches. Also, analytical expressions of the specific heats under both constant-volume and constant-pressure conditions have been achieved, well consistent with other studies. Finally, the adiabatic process has also been successfully derived using these newly obtained specific heats.

Work supported by the National Natural Science Foundation of China under Grant No. 11505124, the 1000 Youth Talents Plan, the Six Talent Peaks project of Jiangsu Province, and the startup funds from Soochow University.