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Equation of State for 2D Liquid Dusty Plasmas and Applications

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Laboratory dusty plasma is a mixture of electrons, ions, and micro-size dust particles which typically gain thousands of elementary charge negatively. Due to their extremely low charge-to-mass ratio, these dust particles are strongly coupled, arranging themselves like atoms in solids or liquids. The motion of dust particles is suitable for direct video imaging and tracking. Due to this powerful diagnostic method, dusty plasmas have been widely used as an experimental platform to study various physics processes in solids and liquids at an 'atomistic' scale level.

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, we have obtained a concise equation of state (EOS) for the 2D liquid dusty plasmas. From this EOS, different thermodynamical processes can be analytically derived, such as isotherms shown in Fig. 1. Also, various physical properties of 2D liquid dusty plasma can be derived, like the bulk modulus of elasticity, shown in Fig. 2. Using the obtained bulk modulus of elasticity here, we have predicted the sound speeds in different conditions, which agree well with previous studies using completely different approaches, as shown in Fig. 3.

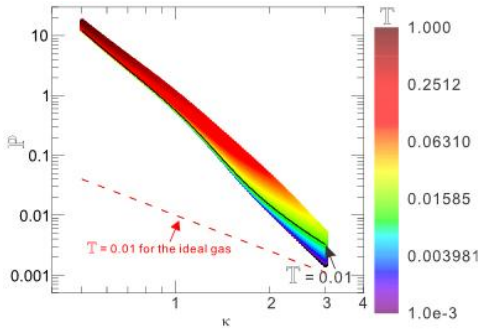

Figure 1: The isotherm contour plot for 2D liquid dusty plasmas, with the temperature changing from 1e-3 to 1.000. For comparison, the isotherm of 0.01 for the ideal gas is shown as the straight dashed line.

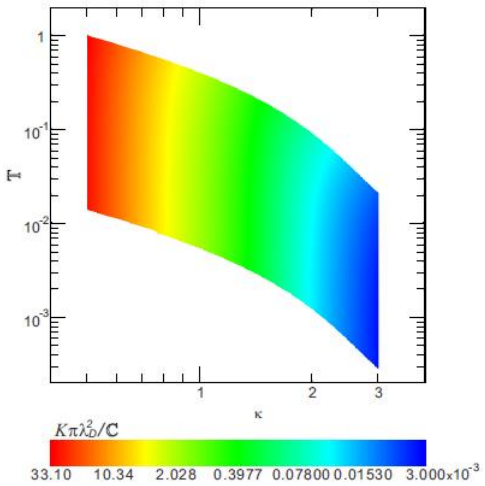

Figure 2: The bulk modulus of elasticity for 2D liquid dusty plasmas.

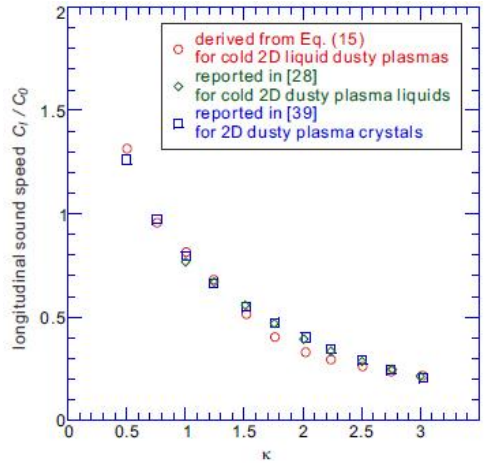

Figure 3: The derived longitudinal sound speed for 2D liquid dusty plasmas around the melting points, which agree well with previous studies of [28] and [39].

References

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