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Critical Phenomenon in the gravitational collapse of charged dust cloud

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The gravitational collapse of electrically charged dust plays in important role in the formation of proto-planets, stars and other possible structures in molecular clouds. In the paper, we propose a thermodynamic model for the gravitational collapse of a cloud of charged dust in the plasma background. Using Gravito-Yukawa potential, an expression for the internal energy of an ensemble of dust particles in the mean field limit is obtained and from this corresponding expressions for Helmholtz energy and the pressure of the dust are obtained. Using a suitable scaling a universally true equation of state is obtained which shows the existence of a critical temperature T_C. For dust temperature $T > T_C$. the cloud is shown to be stable while for $T < T_C$ the cloud undergoes a spinodal decomposition showing phase coexistence and first order phase transition from a rare diffused state to s state with dense core. The phase coexistence obeys the law of rectilinear diameters while the critical exponents of the model show a universal behaviour. Hydro dynamically, the phase transition to a dense core can also be viewed as the nonlinear evolution and saturation of Jeans instability.

References

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