G. S. Singh: *Effect of synthetic spin-orbit coupling on statistical interactions in atomic quantum gases*

Exact analytical expression for the grand potential of noninteracting atomic quantum gases having Weyl spin-orbit (SO) coupling, the three-dimensional analogue of the Rashba coupling, has been developed. The final expression is in terms of polylogarithmic functions, and further a unified form has been achieved by introducing in the distribution function a parameter which takes the values -1, 0, and +1 for Fermi, Boltzmann and Bose gases, respectively. The expression for the grand potential so obtained has been utilized to study complete thermodynamics and we have presented the results for chemical potential, internal energy, free energy, entropy, specific heat, isothermal compressibility, P – v isotherms (v = V/N) and P - T isochores for various SO coupling strengths.

It is found that the pressure decreases with increase in the coupling strength at any fixed temperature for fermions whereas there is reverse trend for bosons implying thereby that coupling weakens the “statistical interactions" for fermionic as well as bosonic systems as compared to the corresponding ideal gas without coupling. This result is corroborated by plots of isothermal compressibility and also analytically by the virial expansion. Our studies suggest that many intriguing features of SO-coupled systems studied by various researchers could straightforwardly be understood as many-body phenomena arising as a consequence of modifications in statistical potentials whereas some of these properties have been explained in the literature plausibly in terms of enhancement in single-particle density of states. The temperature-dependence of chemical potential, specific heat and isothermal compressibility for a Bose gas is found for very weak coupling to have signature of the incipient Bose-Einstein condensation although the system does not really go in the Bose-condensed phase due to presence of coupling-weighted one-dimensional character in the density of states. Also, anomalous behavior of some thermodynamic quantities, typically akin to that in dimensions less than two, appears for fermions as soon as the Fermi level goes down the Dirac point on increasing the coupling strength.