MAR06-2005-006130

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

Condensed Matter and its Orderings: The Pressure Variable.[1]

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Advances in experimental high pressure condensed matter physics have led to near order-of-magnitude static isothermal compressions (high densities are also realizable in dynamic compressions). In sufficiently light systems the new realms of density have associated zero-point effects, which are substantial. Also generally anticipated are significant changes in electronic structure (band widths not always increasing with density, however) and effective state dependent interparticle potentials. Propitious use of the pressure variable can elucidate the many-body problem in incisive ways through new orderings including structural, magnetic and especially superconducting. Significant challenges to theory include the appearance at higher densities of exceedingly complex structures in systems hitherto regarded as 'simple'. Invasion of the valence electron domain by core space appears to impel an interesting clash of length scales. Not unrelated to the rise of quantum effects is the possibility (and even observation) of depression of melting points in low mass systems. Hydrogen, a tenacious insulator (but now a decreasingly reluctant alkali) remains a candidate for significant superconductivity in a metallic state, one which may also be manifested as a quantum liquid. In combination with other light elements further orderings are also predicted, but at pressures less than anticipated for pure hydrogen itself. For the future, this area of experimental investigation appears to be ideally matched to advanced electronic structure and simulation techniques.

[1]Work supported by the National Science Foundation.