Abstract Submitted
for the MAR10 Meeting of
The American Physical Society

Liquid crystal phases of ultracold dipolar fermions on a lattice
CHUNGWEI LIN, University of Pittsburgh, ERHAI ZHAO, George Mason University, VINCENT LIU, University of Pittsburgh — Motivated by the search for quantum liquid crystal phases in a gas of ultracold atoms and molecules, we study the density wave and nematic instabilities of dipolar fermions on the two-dimensional square lattice (in the $x-y$ plane) with dipoles pointing to the z direction. We determine the phase diagram using two complimentary methods, the Hatree-Fock mean field theory and the linear response analysis of compressibility. Both give consistent results. In addition to the staggered (π, π) density wave, over a finite range of densities and hopping parameters, the ground state of the system first becomes nematic and then smectic, when the dipolar interaction strength is increased. Both phases are characterized by the same broken four-fold (C_4) rotational symmetry. The difference is that the nematic phase has a closed Fermi surface but the smectic does not. The transition from the nematic to the smectic phase is associated with a jump in the nematic order parameter. This jump is closely related to the van Hove singularities. We derive the kinetic equation for collective excitations in the normal isotropic phase and find that the zero sound mode is strongly Landau damped and thus is not a well defined excitation. Experimental implications of our results are discussed.

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Date submitted: 18 Nov 2009 Electronic form version 1.4