Layers of Cold Dipolar Molecules in the Harmonic Approximation

J. R. Armstrong, N. T. Zinner, D. V. Fedorov, A. S. Jensen

(Submitted on 10 Jun 2011 (v1), last revised 15 Feb 2012 (this version, v3))

We consider the N-body problem in a layered geometry containing cold polar molecules with dipole moments that are polarized perpendicular to the layers. A harmonic approximation is used to simplify the hamiltonian and bound state properties of the two-body inter-layer dipolar potential are used to adjust this effective interaction. To model the intra-layer repulsion of the polar molecules, we introduce a repulsive inter-molecule potential that can be parametrically varied. Single chains containing one molecule in each layer, as well as multi-chain structures in many layers are discussed and their energies and radii determined. We extract the normal modes of the various systems as measures of their volatility and eventually of instability, and compare our findings to the excitations in crystals. We find modes that can be classified as either chains vibrating in phase or as layers vibrating against each other. The former correspond to acoustic and the latter to optical phonons. Instabilities can occur for large intra-layer repulsion and produce diverging amplitudes of molecules in the outer layers. Lastly, we consider experimentally relevant regimes to observe the structures.

Comments:	17 pages, 20 figures, accepted version
Subjects:	**Quantum Gases (cond-mat.quant-gas)**; Nuclear Theory (nucl-th); Quantum Physics (quant-ph)
Journal reference:	Eur. Phys. J. D 66, 85 (2012)
DOI:	10.1140/epjd/e2012-20611-x
Cite as:	**arXiv:1106.2102 [cond-mat.quant-gas]**
	(or **arXiv:1106.2102v3 [cond-mat.quant-gas]** for this version)

Submission history

From: Nikolaj Thomas Zinner [view email]
[v1] Fri, 10 Jun 2011 15:55:25 GMT (274kb,D)
[v2] Thu, 9 Feb 2012 21:33:15 GMT (280kb,D)
[v3] Wed, 15 Feb 2012 16:37:30 GMT (280kb,D)

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