Experiments with Dense 2D Atomic Hydrogen Gas on Liquid Helium Surfaces

S. Vasilyev, J. Järvinen, and S. Jaakkola
University of Turku (Turku, Finland)

In our experiments we study 2D gas of spin-polarized atomic hydrogen adsorbed on the surface of superfluid helium film at temperatures 50...100 mK. Two methods of local compression are utilized to boost the value of phase space density: magnetic compression and thermal compression. A signature of the formation of a quasicondensate was observed in magnetic compression experiments with the 2D gas of atomic hydrogen adsorbed on the surface of liquid helium [1]. However, in these experiments direct studies of the 2D hydrogen and its quasicondensate were not possible due to the strong field inhomogeneity required by the magnetic compression. To make direct studies possible we implemented thermal compression, which utilizes enhanced adsorption of the bulk gas on a 1.5 mm diameter "cold spot" on the sample cell wall. Due to the absence of magnetic field gradients the method allows a sensitive ESR detection of the surface atoms. The absorption lineshape of the 2D gas gives information on the surface density profile in the cold spot region. We achieved surface densities exceeding 5×10^{12} cm^{-2} at temperatures of ≈ 100 mK which corresponds to the 2D phase-space density > 1.5.

An independent measurement of recombination rates allowed us to make a first direct determination of the three-body recombination rate constant L_{3b}. The result $L_{3b} \approx 2 \times 10^{-25}$ cm^4/s is an order of magnitude lower than previously reported indirect values. Due to the small rate constant three-body recombination on the spot was not the dominating atom loss mechanism, but one- body relaxation on the sample cell walls was the main limitation. In future experiments reduction of the one-body relaxation rate will make it possible to reach higher phase-space densities and the conditions needed for the quasicondensate formation and the Kosterlitz-Thouless transition to 2D superfluidity.

References

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[2] S. Vasilyev, J. Järvinen, A.I. Safonov and S. Jaakkola , Phys. Rev. A. **69**, 023610 (2004)