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Virial Expansion for a Strongly Correlated Fermi Gas

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Few-body physics can give considerable insight into the challenging many-body problem. A concrete example is the exact Tan relations [1] linking the "hard" (few-body) physics at short distance, large-momentum and high frequency to the "soft" physics of the equation of state via a contact parameter. This has been demonstrated clearly using the operator product expansion (OPE) method [2] which separates in a natural way few-body from many-body physics. In this talk, we present another example: the quantum virial expansion that bridges few-body and many-body physics. At large temperatures, the properties of a strongly correlated Fermi gas, either static or dynamic, can be expanded in terms of virial coefficients or expansion functions, calculable from the few-fermion solutions [3]. For the equation of state in the resonant unitarity limit [3], we obtain for the first time an accurate third order virial coefficient. This has been experimentally verified in a measurement at ENS (Paris) [4]. For the single-particle spectral function [5], we demonstrate that an expansion up to second order is able to explain the main features of momentum-resolved RF spectroscopy in a resonantly interacting Fermi gas, as recently reported by JILA [6]. We also obtain a virial expansion of the dynamic structure function, as measured at Swinburne University (Melbourne), and check that the second order expansion functions give the correct OPE coefficients in the limit of large momentum and frequency. The important feature of this expansion is the existence of a small parameter, the fugacity, even for strong interactions. In the future, we anticipate that higher-order virial expansions of dynamic properties such as the single-particle spectral function may provide useful insights into clarifying the debate on the pseudo-gap issue in resonantly interacting Fermi gases.

[1] S. Tan, *Ann. Phys.* **323**, 2952 (2008); **323**, 2971 (2008).
[2] E. Braaten, and L. Platter, *Phys. Rev. Lett.* **100**, 205301 (2008).
[3] X.-J. Liu, H. Hu, and P. D. Drummond, *Phys. Rev. Lett.* **102**, 160401 (2009).
[4] S. Nascimbène et al. *Nature* **463**, 1067 (2010).
[5] H. Hu, X.-J. Liu, and P. D. Drummond, *Phys. Rev. Lett.* **104**, 240407 (2010).
[6] J. T. Stewart, J. P. Gaebler, and D. S. Jin, *Nature* **454**, 744 (2008).