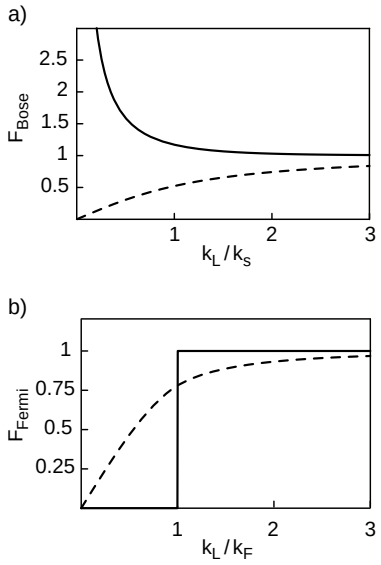
Enhancement and suppression of spontaneous emission and light scattering by quantum degeneracy

Quantum degeneracy modifies light scattering and spontaneous emission. For fermions, Pauli blocking leads to a suppression of both processes. In contrast, in a weakly interacting Bose-Einstein condensate, we found spontaneous emission to be enhanced, while light scattering is suppressed [1]. This difference is attributed to many-body effects and quantum interference in a Bose-Einstein condensate.

Generally, transition rates between an initial state with population N_1 and a final state with population N_2 are proportional to $N_1(1+N_2)$ for bosons and to $N_1(1-N_2)$ for fermions. This simple derivation of transition rates using occupation numbers becomes subtle or even invalid for correlated many-body states such as an interacting Bose-Einstein condensate ground state. We analyzed under which circumstances the simple approach can be used to reproduce the correct results for the interaction between light and a BEC. We showed theoretically that spontaneous emission in a weakly interacting BEC is enhanced, consistent with the description using occupation numbers, and calculated the enhancement factor. We compared this result to light scattering in a BEC, which is suppressed due to many-body interference effects not included in the simple derivation, as we have shown experimentally and theoretically in previous work [2]. In contrast, in fermionic systems quantum degeneracy leads to a suppression of *both* spontaneous emission and light scattering.



Modification of spontaneous emission (solid line) and light scattering (dashed line) due to quantum degeneracy. In (a) we have plotted the enhancement factor for spontaneous emission and the suppression factor for light scattering for a weakly interacting Bose-Einstein condensate as a function of the light wave vector k_L in units of k_s, the wave vector of an atom moving at the speed of sound. In (b) the suppression factors for spontaneous emission and light scattering in a Fermi gas at zero temperature are plotted as a function of k_L in units of the Fermi wave vector k_F.

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2. D.M. Stamper-Kurn, A.P. Chikkatur, A. Görlitz, S. Inouye, S. Gupta, D.E. Pritchard, and W. Ketterle, Phys. Rev. Lett. **83**, 2876 (1999).