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Creating a homogeneous Fermi gas in the BEC-BCS crossover and probing it with high-sensitivity rf spectroscopy

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Abstract

An inhomogeneous density broadening, induced by harmonic trapping, causes local averaging of observables and washes out sharp features found near phase transitions. To solve this problem, several groups demonstrated in recent years the creation of homogeneous ultracold gases. Here I present the first experimental realization of a homogeneous degenerate Fermi gas of ^{40}K atoms in an optical box potential. For the density to be uniform, it is not enough to introduce exquisitely sharp repulsive walls, but it is crucial also to cancel the gravitational potential. This requirement turns out to be extremely challenging to achieve with ^{40}K since the different spin states have different magnetic dipole moments, thus magnetic levitation cannot be used. We solve this problem by simultaneously applying a magnetic field gradient and applying an rf pulse that induces rapid Rabi oscillations between the two spin states. These oscillations average out the opposite potential felt by the two spin states. Using *in situ* absorption imaging, we find that this procedure yields a homogeneous density distribution for both spins and does not lead to heating. The momentum distribution, from which we infer the temperature, cannot be measured by the standard time-of-flight technique due to a relatively large initial trap size. Alternatively, we have developed a velocity-sensitive, two-photon Raman spectroscopy, which measures the *in situ* momentum distribution [1]. We probe the normal state of the homogenous gas in the BEC-BCS crossover regime using our recently developed high-sensitivity rf spectroscopy technique [2] and extract the contact parameter of a homogeneous gas with high precision, which can be used to benchmark many-body theories.

[1] Constantine Shkedrov, Gal Ness, Yanay Florshaim, and Yoav Sagi, Phys. Rev. A 101, 013609 (2020).

[2] Constantine Shkedrov, Yanay Florshaim, Gal Ness, Andrey Gandman, and Yoav Sagi, Phys. Rev. Lett. 121, 093402 (2018).

*Refreshment: 12:15

*כיבוד: 12:15

ההרצאה תתקיים ביום רביעי, ה-29.1.2020 בשעה 12:30
באודיטוריום המכון למצב מוצק, קומת כניסה

The lecture will take place on Wednesday, 29.1.2020 at 12:30*
at the Solid State Institute auditorium, entrance floor

Ph.D. Student of Assistant Professor Yoav Sagi