All-Optical Production of a Lithium Quantum Gas Using Narrow-Line Laser Cooling

TSUNG-LIN YANG, PEDRO M. DUARTE, RUSSELL A. HART, RANDALL G. HULET, Rice University — We have used the narrow $2S_{1/2} \rightarrow 3P_{3/2}$ transition in the ultraviolet (UV) to laser cool and magneto-optically trap (MOT) $^{6}$Li atoms. Laser cooling of lithium is usually performed on the $2S_{1/2} \rightarrow 3P_{3/2}$ (D2) transition, and temperatures of $\sim 300 \mu K$ are typically achieved. The linewidth of the UV transition is seven times narrower than the D2 line, resulting in lower laser cooling temperatures. We demonstrate that a MOT operating on the UV transition reaches temperatures as low as 59 $\mu K$. Furthermore, we find that the light shift of the UV transition in an optical dipole trap at 1070 nm is small and blue-shifted, facilitating efficient loading from the UV MOT. After loading from the UV MOT, $6 \times 10^6$ atoms with peak density $n_0 = 2.7 \times 10^{13} \, cm^{-3}$ remain at $T = 60 \mu K$, which corresponds to $T/T_F \approx 2.7$. Evaporative cooling of a two spin-state mixture of $^{6}$Li in the optical trap produces a quantum degenerate Fermi gas with $3 \times 10^6$ atoms in only 5 s.

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3M. Safronova, Personal Communication.