2nd World Congress and Expo on
Nanotechnology and Material Science
April 04-06, 2016 at Dubai, UAE

Tunable dual-species Bose-Einstein condensates of ^{39}K and ^{87}Rb

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Within the past decade, research on ultracold atoms has moved from the investigation of their fundamental properties to the application of ultracold samples in quantum simulation and precision metrology. The ability to tailor external potentials freely and to manipulate the interaction strength within the samples has led to numerous advances in the field. In particular mixed quantum gases have attracted considerable interest, since they offer a wealth of research opportunities. These include the creation of deeply bound dipolar molecules [1], the investigation of few-particle physics [2, 3], the observation of quantum phases in optical lattices [4] and precision measurements [5]. Such mixed quantum gasses can generally be realized by using a single atomic species in multiple quantum states, by using multiple isotopes of the same species, or by using different atomic species. Thus it is possible to realize Bose-Fermi, Bose-Bose or Fermi-Fermi mixtures. Since cooling techniques to achieve ultracold temperatures have become available for an increasing number of atomic species, this leads to a considerable number of possible mixtures. Here, we present the production of dual-species Bose- Einstein condensates of ^{39}K and ^{87}Rb. Preparation of both species in the $|F = 1, mF = -1\rangle$ state enabled us to exploit a total of three Feshbach resonances which allows for simultaneous Feshbach tuning of the ^{39}K intraspecies and the ^{39}K-^{87}Rb interspecies scattering length. Thus dual-species Bose-Einstein condensates were produced by sympathetic cooling of ^{39}K with ^{87}Rb. A dark spontaneous force optical trap was used for ^{87}Rb, to reduce the losses in ^{39}K due to light-assisted collisions in the optical trapping phase, which can be of benefit for other dualspecies experiments. The tunability of the scattering length was used to perform precision spectroscopy of the interspecies Feshbach resonance located at 117.56(2) G and to determine the width of the resonance to 1.21(5) G by rethermalization measurements. The transition region from miscible to immiscible dual-species condensates was investigated and the interspecies background scattering length was determined to 28.5 a0 using an empirical model. This paves the way for dual-species experiments with ^{39}K and ^{87}Rb BECs ranging from molecular physics to precision metrology.

References

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