Noise Thermometry with Two Coupled Bose-Einstein Condensates

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The effects caused by a thermal background play an important role for the experimental investigation of quantum physics with Bose-Einstein condensates. This is due to the fact that real experiments are always performed at finite temperature, even if the thermal background is not directly observable. By introducing an energy scale which is on the order of the thermal energy the effects arising from arbitrarily low temperatures become accessible. Since a Josephson junction consisting of two weakly coupled Bose-Einstein condensates allows for the adjustment of the tunnelling coupling and thus a tuning of the characteristic energy scale it is an ideal probe for the investigation of thermal effects.

Here we report on the experimental investigation of fluctuations of the relative phase between two Bose-Einstein condensates arising from the coupling to a thermal environment and show quantitative agreement with a classical model. Due to this agreement we can apply the measurements of the phase fluctuations as a tool for measuring the temperature in a regime where standard methods fail. With this we are able to monitor the heating up of a Bose-Einstein condensate and deduce the heat capacity of the degenerate weakly interacting Bose gas. The observed heat capacity agrees well with the prediction confirming the third law of thermodynamics.