Cooling a Bose gas by three-body losses

Max Schemmer[a*], Isabelle Bouchoule,[a]

a. Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris Sud 11, 2 Avenue Augustin Fresnel, F-91127 Palaiseau Cedex, France

* maximilian.schemmer@institutoptique.fr ≪corresponding author≫

The lifetime of Bose-Einstein condensates is limited by three-body recombination processes, which amount to three-body losses. These losses are typically associated with a heating. Here I present the first demonstration of cooling by three-body losses in a 1D Bose gas in the quasi-condensate regime, using an atom chip experiment. While three-body losses continuously reduce the density of the system the temperature T drops up to a factor of four.

To compare with theory, we extended the recent theoretical description of one-body losses in a homogeneous gas [1] to arbitrary j-body losses and to inhomogeneous gases. For 3-body losses occurring in a harmonically confined 1D quasi-condensate, we find that the ratio $k_BT/(mc^2)$ is expected to converge to 0.7, with c the speed of sound and m the atom mass. This ratio for our experimental data is close to this asymptotic value all along the observed time-evolution. We took different sets of data, corresponding to different effective 1D interaction strength g and different linear densities n. The dimensionless 1D interaction parameter $\gamma = mg/(\hbar^2 n)$ spans more than two orders of magnitude over the different sets of data, while the ratio $T/(mc^2)$ stay close to its asymptotic value of 0.7 (see Fig.1).

[1] Grišins, P., et al.. Degenerate Bose gases with uniform loss. Physical Review A, 93(3), 033634.

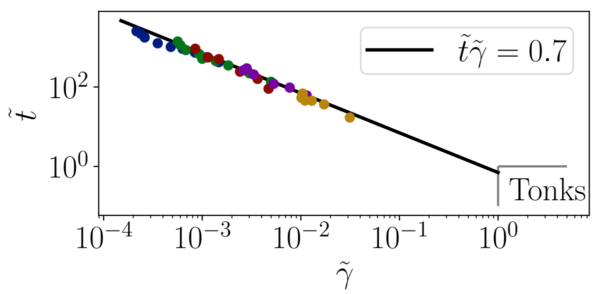

Figure 1: The thermodynamic properties of a 1D Bose are characterized by γ and the dimensionless temperature $t = \hbar^2 k_B T/(mg^2)$. The experimental data collapses on the line $t\gamma = 0.7$, which correspond to $T/(mc^2) = 0.7$.