competing time-scales. In addition, important limitations on the pulse durations are imposed by the "healing" time considerations due to mean-field interactions. We give a detailed numerical calculation based on a modified mean-field (Gross-Pitaevskii type) theory, and show how the results scale with pulse duration and intensity.

We assume that the two laser fields couple the ground electronic state of Rubidium to a single electronically excited molecular state with Rabi frequencies $\Omega_{\text{p}} = \frac{1}{\hbar} \text{d}_\text{R} B_{\text{R}}^0$, where $\text{d}_\text{R}$ is the molecular electric dipole matrix element connecting these two states. We estimate that up to 85% conversion efficiency may be achieved (see Fig. 1), but with a peak Rabi frequency of $\Omega_{\text{p}}^{(1)} = 10^{15} \text{s}^{-1}$ for the free-bound transition. This would be realized with around 1 W peak laser power (at a waist size of about 10 μm), which is not impossible—much higher than we would estimate without the combined effects of spontaneous emission, collisions between atoms and a three-dimensional mode-structure.

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Critical Collisional Opacity in a Bose-Einstein Condensate
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In a Bose-Einstein condensate due to the very low temperature the s-wave scattering length can be used as a measure for the strength of the atom-atom interaction. Under typical experimental conditions this interaction is weak and, hence, can be treated in terms of a mean field. However, when the scattering length is large or the density is high, the mean field approximation breaks down. In this collisional (hydrodynamic) regime, effects of the interactions such as quantum depletion or shifts in the frequencies of the elementary excitations become large. It is therefore of great interest to study condensates close to or in the collisional regime. It has been demonstrated in recent experiments that the scattering length and thus the interactions among the atoms can be tuned by means of a Feshbach resonance. In the vicinity of Feshbach resonances, however, the increase of the cross-section for elastic collisions is accompanied by a dramatic increase of particle losses.

In this paper we report on the observation of anomalous losses from a $^{85}$Rb condensate with a high column density in the absence of an inelastic scattering resonance. We identify a loss process that limits the achievable column density of ultracold trapped gas in the off-resonant regime as well as in the vicinity of a Feshbach resonance. It is based on collisional avalanches that are triggered by inelastic collisions between trapped atoms or sometimes even by background gas collisions. In the avalanche a considerable part of the kinetic energy that the particles have gained in the inelastic collision is distributed among the trapped atoms by secondary elastic collisions. In our experiment this results in an 8-fold increase of the initial loss rate with respect to the prediction accounting for known loss mechanisms. We present a model accounting for avalanche-like losses which is in good agreement with the observed anomalous decay of our condensate. Our analysis reveals that the collisional opacity of an ultra-cold and dense gas exhibits a critical value. When the critical opacity is exceeded, losses induced by inelastic collisions are substantially enhanced.

References