Cold atoms and microstructures

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Abstract

Employing a structured metallic surface into cold atom physics allows one to obtain sophisticated magnetic or optical potentials which ensure precise manipulation of atoms movement what in turn is the key issue for studying fundamental quantum phenomena. Neutral atoms may be controlled in atomic dipole mirrors (optical potentials) or by using atom chips (magnetic potentials).

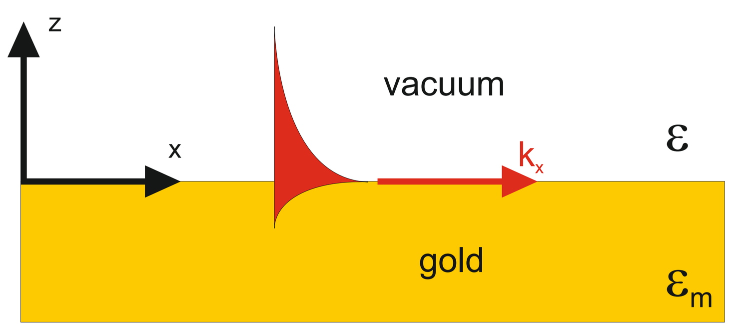
In Laboratory of Cold Atoms Near Surfaces we plan to use a microstructured matallic surface to assure a high intensity gradient necessary for dipole mirror operation. Surface plasmon polaritons, electromagnetic charge-density waves propagating along a metallic surface, are created on a gold grating with a period comparable to the wavelength of incident light in close-to-normal incidence (see picture). Calculations and preliminary results are presented.

We also briefly present a progress in our attempt to create a Bose-Einstein condensation in an atom chip based setup (RuBECi from Cold Quanta).

Surface plasmon polaritons and an optical dipole mirror for cold atoms

surface plasmon polaritons (SPPs)

$$E_{SP}(x,z) = E_0 e^{ik_x x - k_z |z|}$$



dispersion relation

$$k_x = k_0 \sqrt{\frac{\epsilon_m \epsilon}{\epsilon_m + \epsilon}}$$

SPP field decay determined by k_z

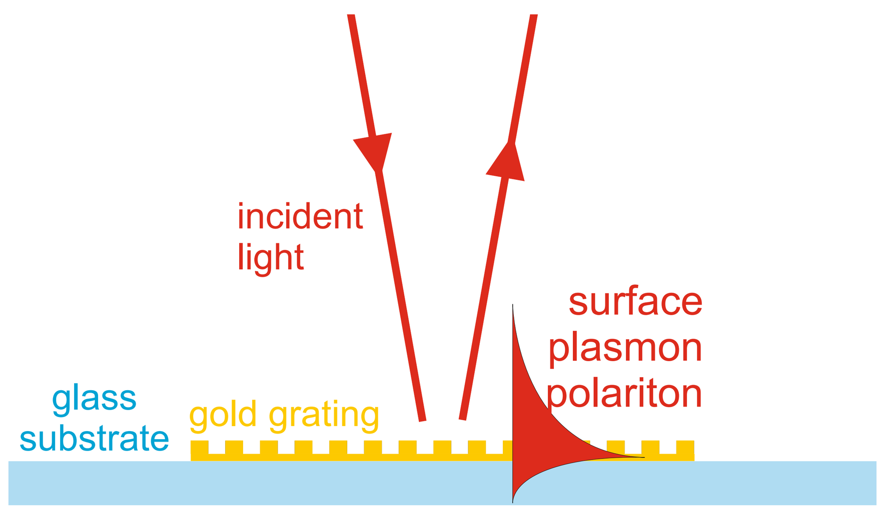
$$k_z = \sqrt{k_x^2 - \left(\frac{\omega}{c}\right)^2 \epsilon}$$

propagation length and SPP wavelength

$$L = \frac{1}{2Im(k_x)} \qquad \lambda = \frac{2\pi}{Re(k_x)}$$

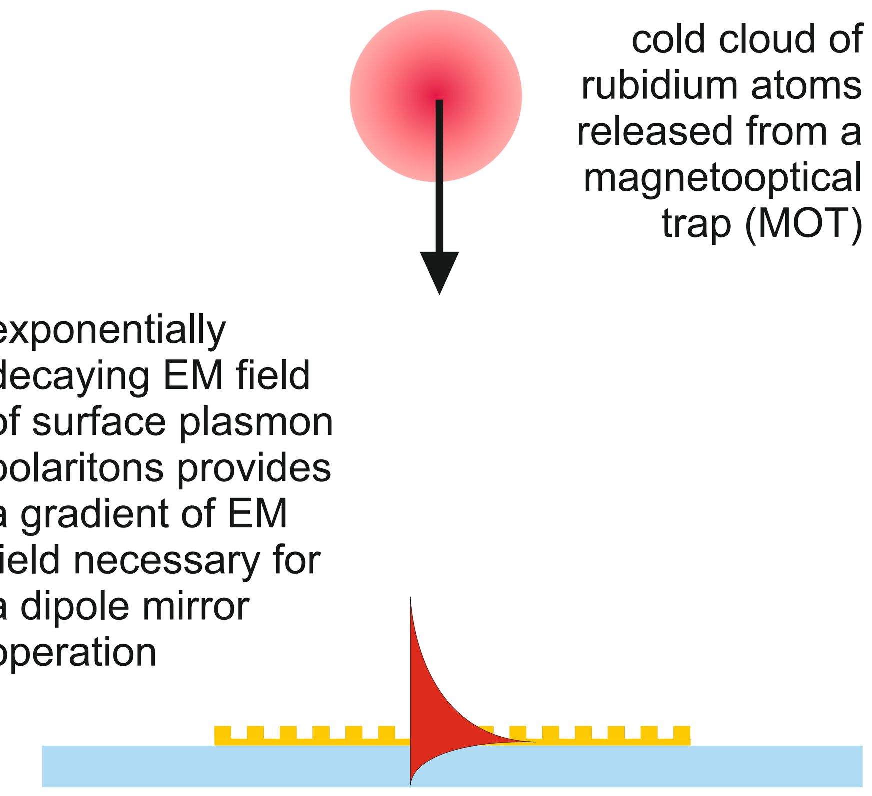
for gold and λ_0=780 nm: L~30 μm, λ~760 nm

creation of SPPs on a grating

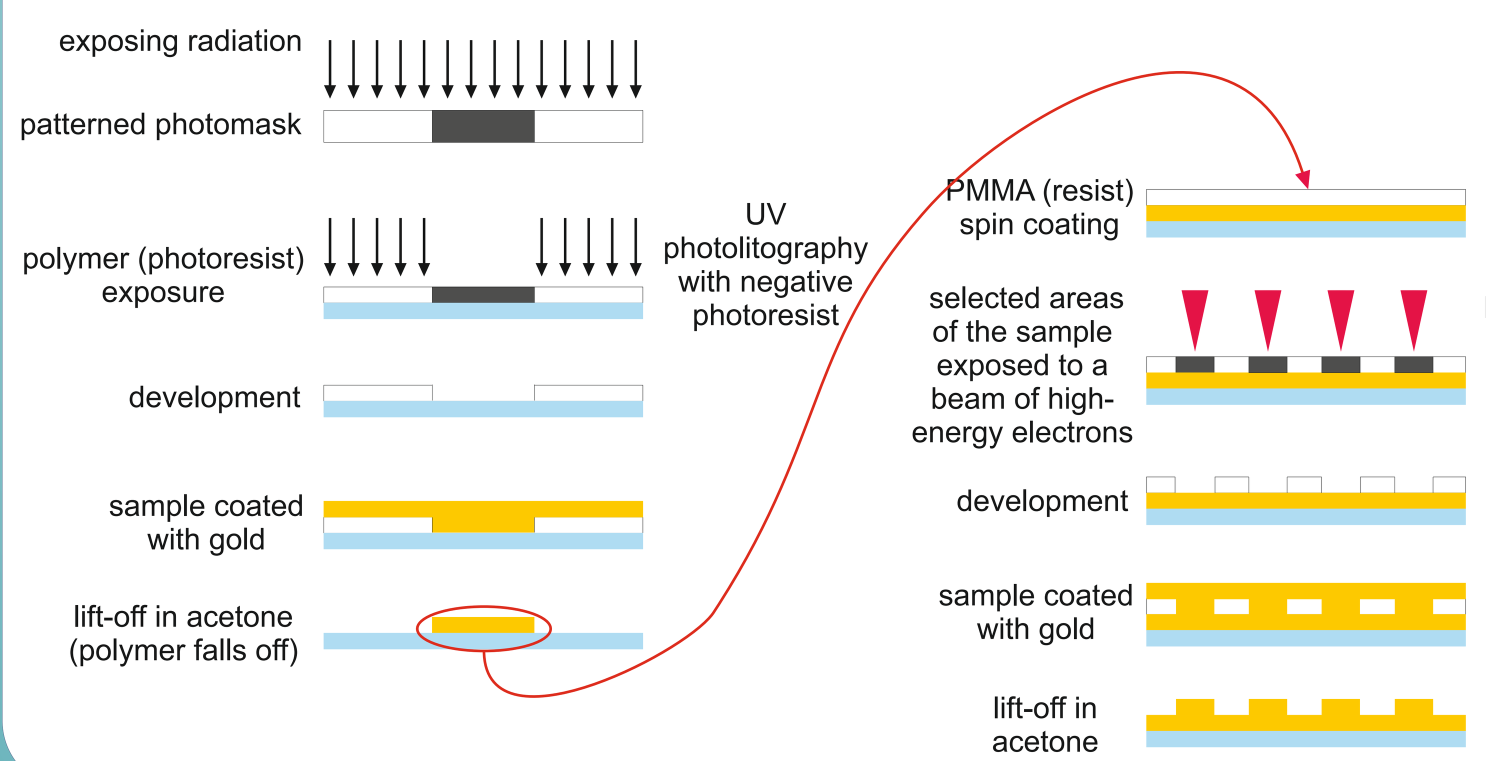


$$k_x = k_0 \sin\theta \pm n \frac{2\pi}{d}$$

SPPs and cold atoms

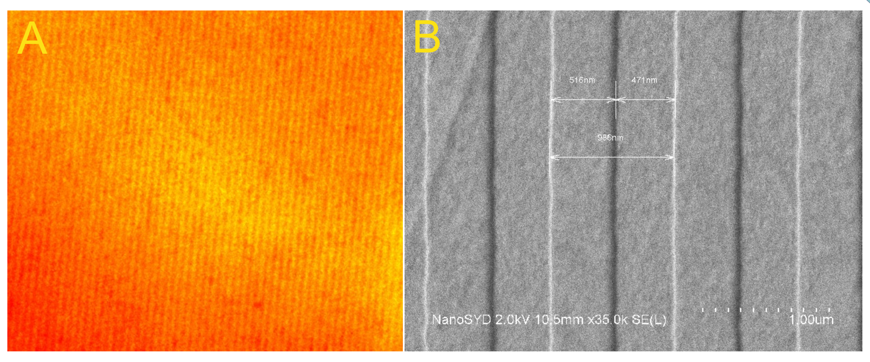


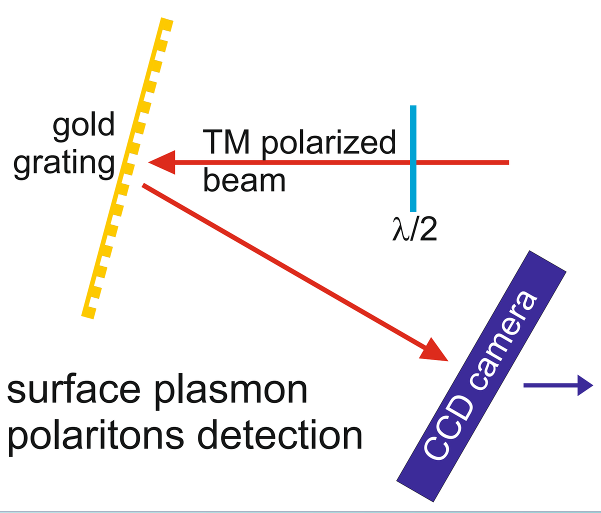
fabrication of gratings



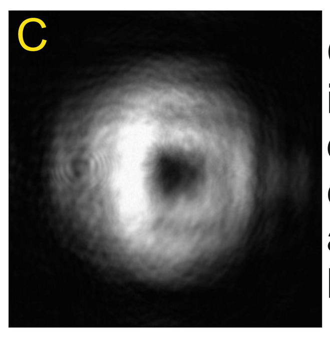
scanning electron microscope

grating seen under an optical microscope (A) and in SEM (B)



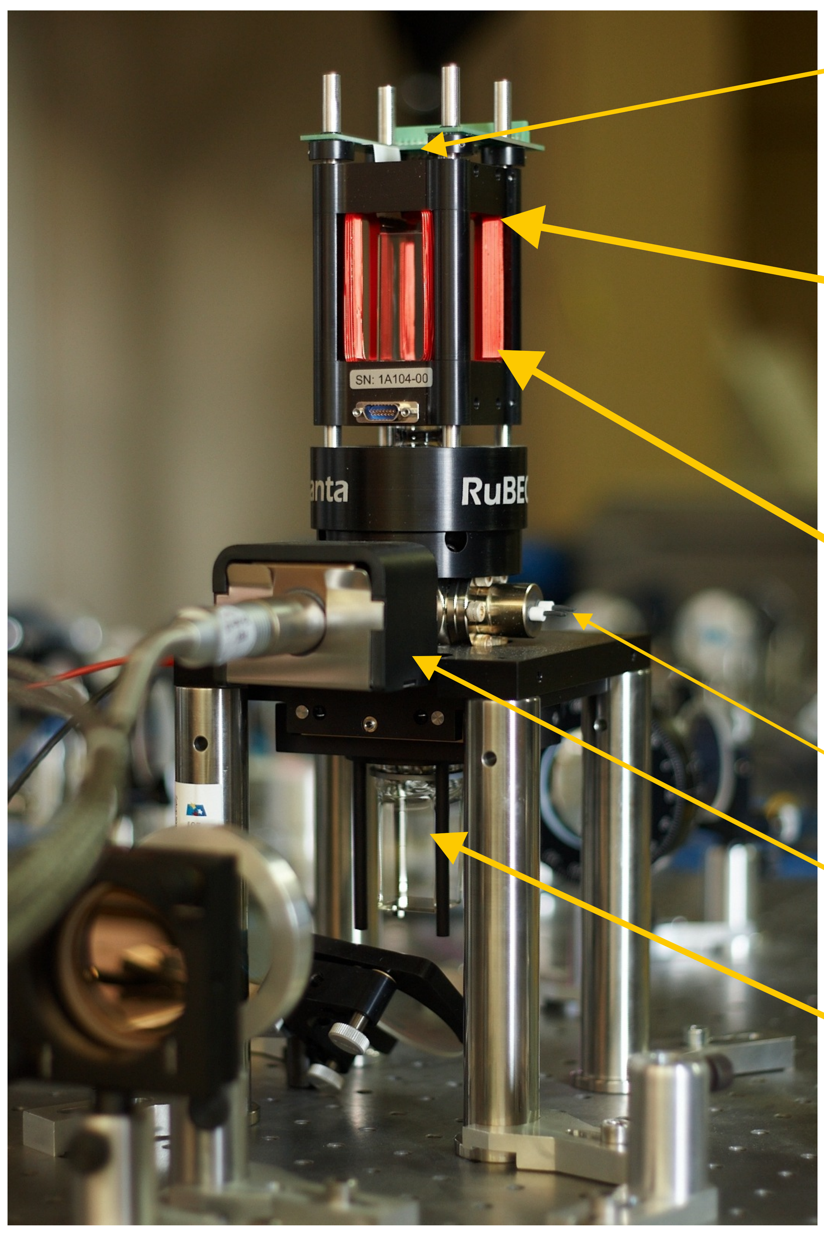


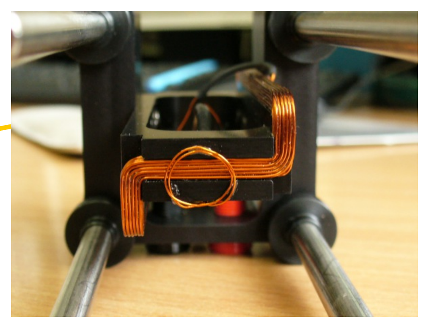
surface plasmon polaritons detection



C. decrease in intensity due to SPP coupling in a reflected beam

Towards chip-based Bose-Einstein condensation





external Z-wire (for external Ioffe-Prichard trap), radiofrequency coil (for evaporation cooling)

to achieve:
BEC containing ~ 10^4 atoms in the |F=2, m_F=2> ground state of ^{87}Rb

atom chip (chip Z-wire for Ioffe-Prichard trap, dimple trap and others)

non-evaporable getter

Varian ion pump MicroVac 2 l/s

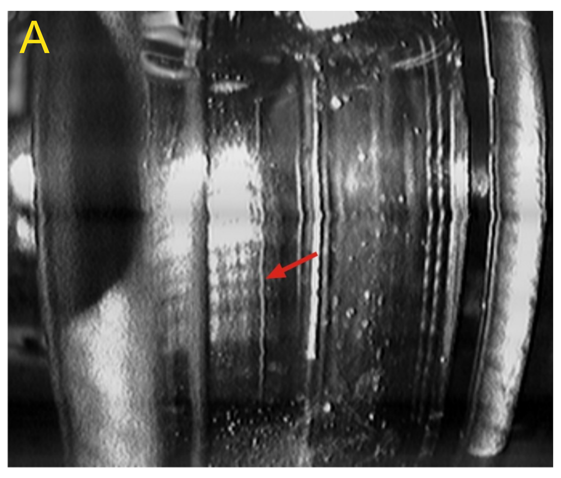
upper vacuum cell with atom chip, coils for upper magnetooptical trap and for bias magnetic fields

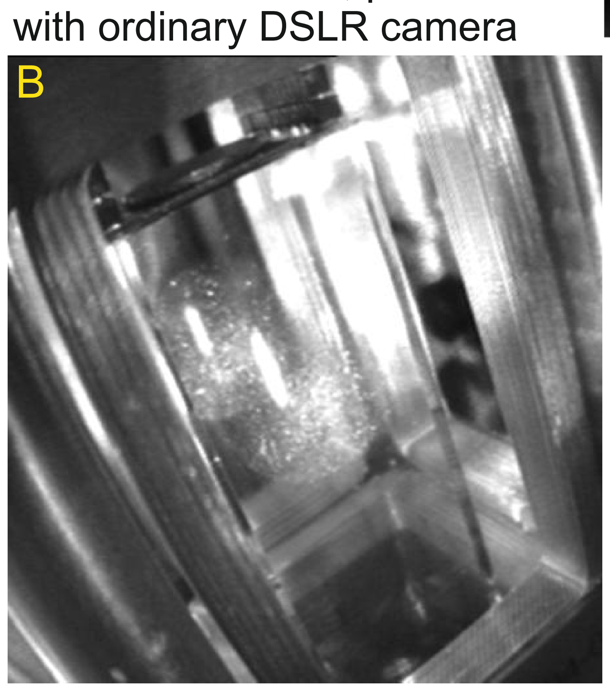
lower vacuum cell for 2D+ MOT with permanent magnets, rubidium dispenser, silicon disc with a 750 μm hole at the top of the cell

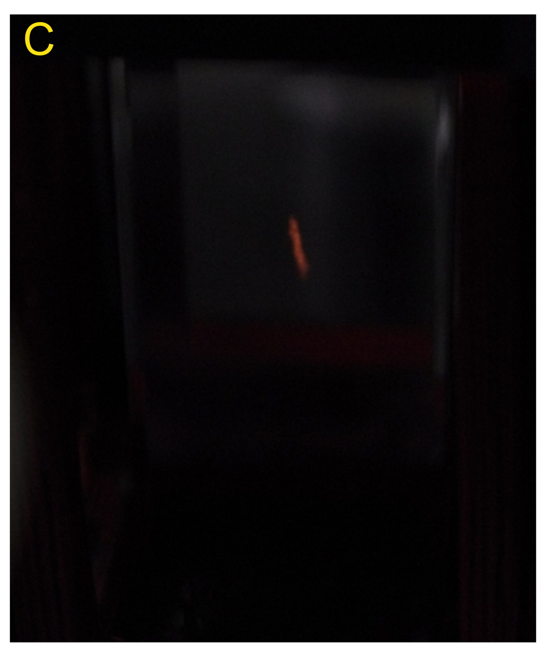
A. 2D+ MOT in the lower vacuum cell

B. MOT in the upper vacuum cell

C. The same as B, photo taken with ordinary DSLR camera







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