SEVENTH FRAMEWORK PROGRAMME

ICT-2007.8.1 Nano-scale ICT devices and systems

Nano-Optics for Molecules on Chips

CHIMONO

LENS

Imperial College London

TU WIEN

Fritz-Haber-Institut der Max-Planck-Gesellschaft

Universität Bonn

Johannes Gutenberg-Universität Mainz

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Goal:

Control of cold molecules in single quantum states realized by means of integrated electric, magnetic, radio frequency, micro wave and optical fields

Strategies:

1 Electrostatic deceleration of molecular beams

1 Association of precooled atomic samples

2 Long term storage in integrated magnetic microtraps

3 Detection and addressing via integrated nano-optical elements

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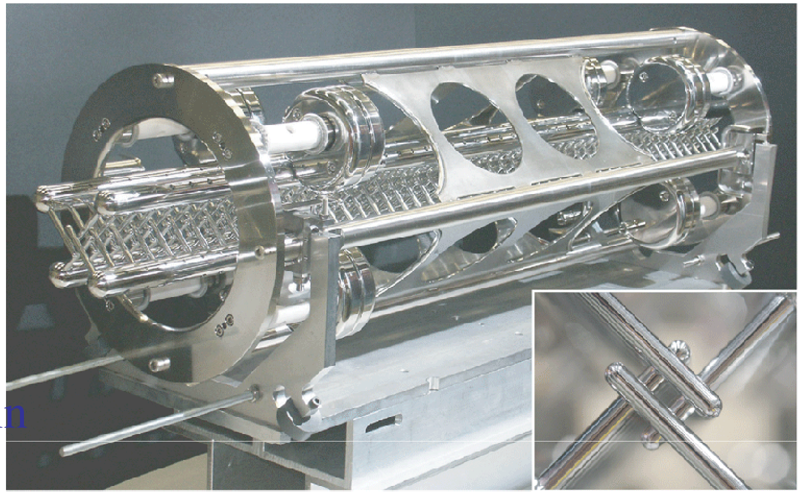
Design of microstructured Stark decelerator on a chip capable of:

- decelerating polar molecules directly from a pulsed supersonic nozzle beam to standstill
- maintaining three dimensionally confined bunches during deceleration
- guiding and keeping the bunches of molecules in traps above a chip



Realization on glass or silicon

- Fabrication of various designs in collaboration with TUW and JOGU MAINZ
- Development and manufacture of waveform generator producing harmonic potentials from about 3 MHz down to DC up to 300 V peak to peak
- Test and characterization of the chip via TOF and PMT using metastable CO molecules in proof of principle experiment

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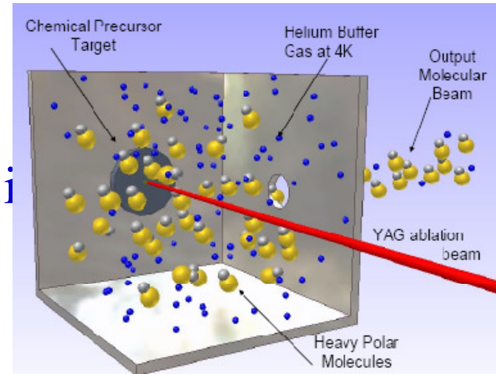
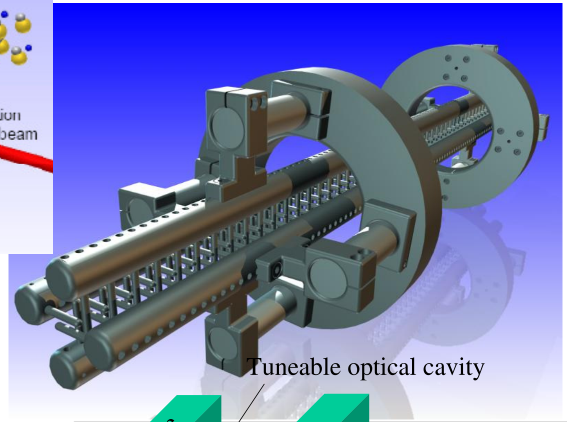
Task 1: Formation of cold molecules i
single quantum states

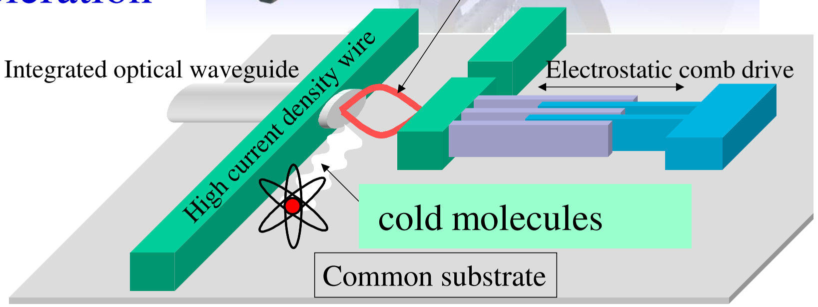


Cryogenic buffer-gas source



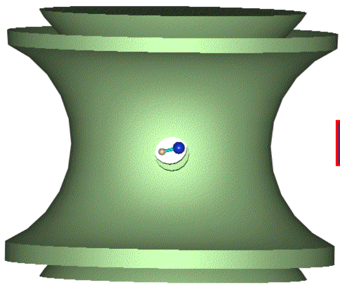
Electrostatic deceleration

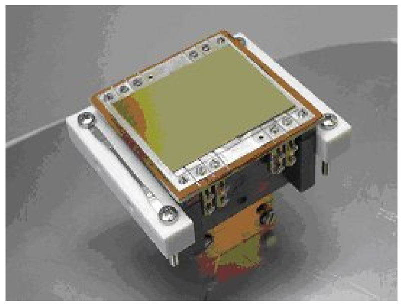
Task 2: Detection of single molecules



Integrated cavity-based
single-molecule detectors

Task 3: Long term storage of single
molecules and ensembles





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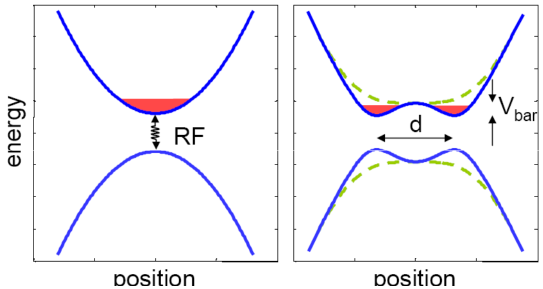
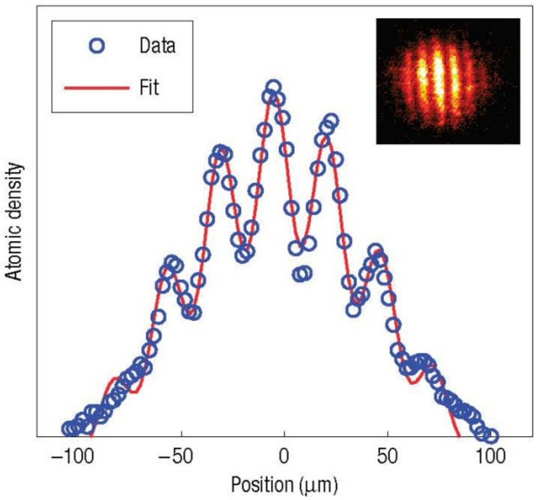
Present core expertise of the group is based on:

Double well matter wave interferometer

bý adiabatic RF potenials

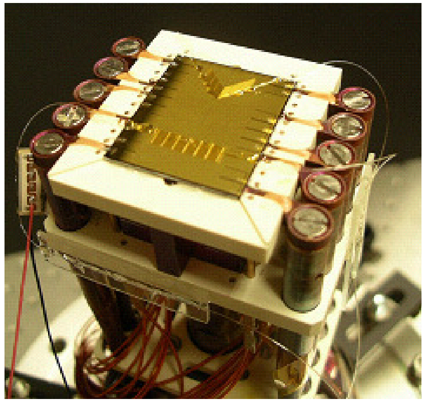




interference of two BECs

Micro-optics on the AtomChip

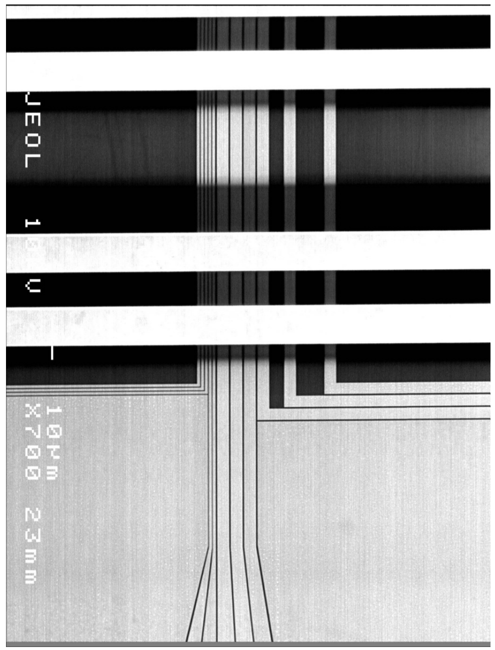
for detection and preparation of quantum states



fluorescence fiber detector

AtomChip fabrication

- **double layer structure**
- **semiconductor structure**
- **access to superconducting technology**



AtomChip with double layer structure

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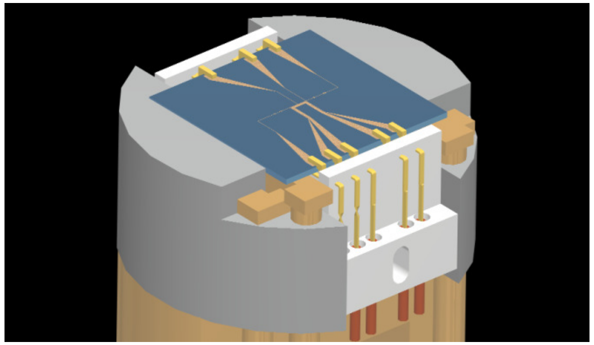
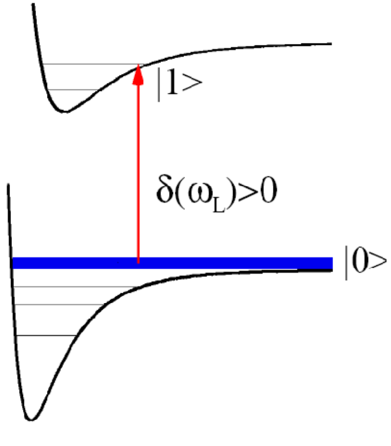
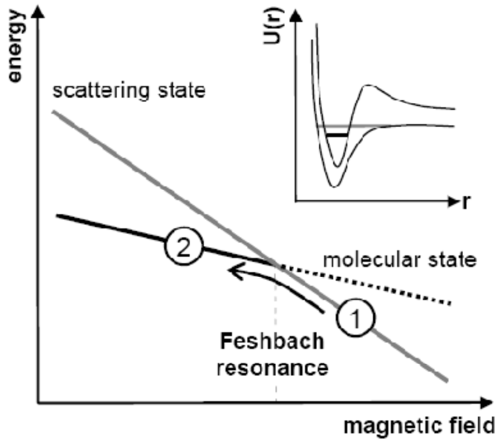


•Implement an atom chip based degenerate mixture of Rubidium and Potassium.

•Investigate different routes (photoassotiation and/or Feshbach resonances) to polar Rb-K ground state molecules (with Imperial).





•Investigate the possibility to use the very strong RF and MW near fields to assist in molecular formation and transfer to the ground state (with TUW).

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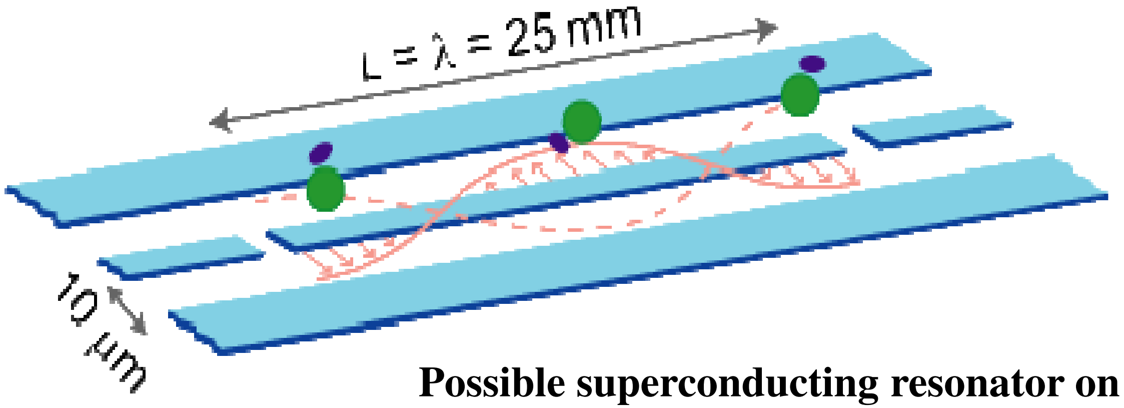
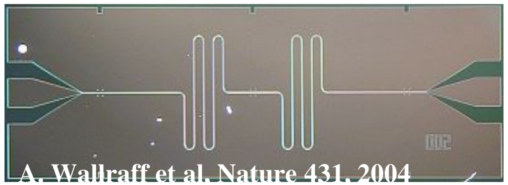
Quantum interface between cold atoms or molecules and solid state quantum systems:

A new experiment will be set up to combine a ultra cold source of atoms (^{87}Rb) or molecules. One of the first tasks will be to establish an apparatus that should allow us to create a sizeable BEC atom chip, as close to a cryogenic surface where a superconducting device can be mounted. Starting from a 4K experiment, the design should allow us to reach the interesting temperature domain of superconducting devices, below 1K. Superconducting microwave resonators will allow quality factors $>10^5$ and low noise operation.



Possible superconducting resonator on the atom chip in order to couple microwaves to corresponding molecule transitions



Existing superconducting devices

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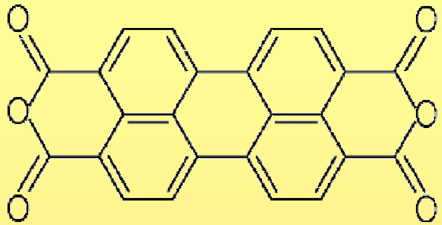
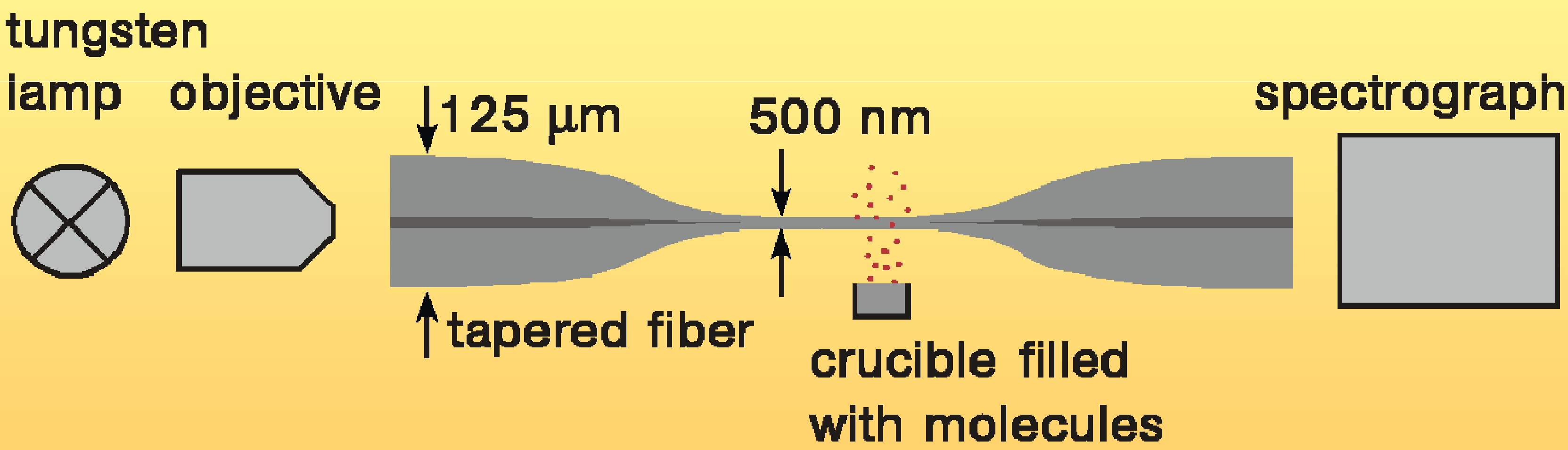
Spectroscopy of Thin Molecular Films

PTCDA



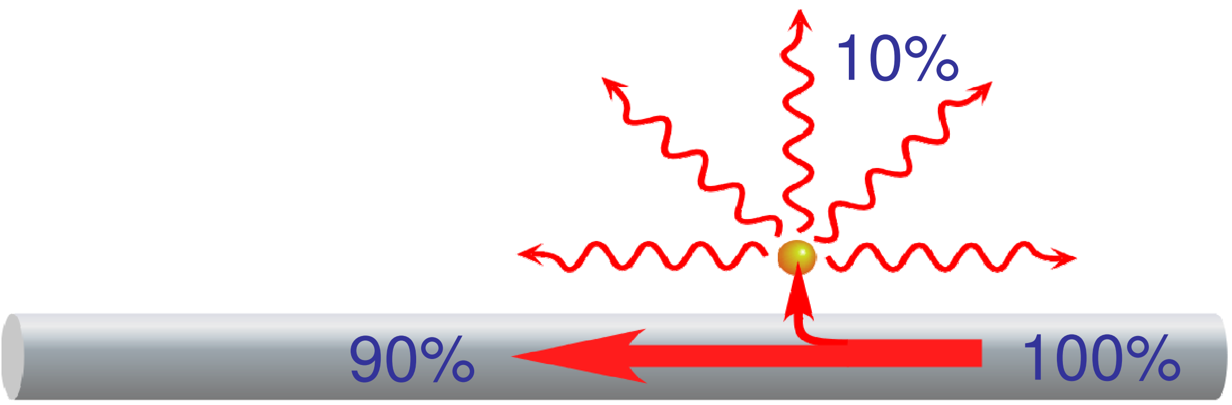


F. Warken *et al.*, Opt. Express **15**, 11952 (2007).

Sensitivity

- Spectroscopy of less than 1 % of a closed monolayer of molecules with excellent S/N.
  Realistic limit: 1–100 molecules at ambient conditions!

- Sensitivity much higher for laser cooled atoms or molecules at cryogenic temperatures:



G. Sagué *et al.*, Phys. Rev. Lett., in press (2007).

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Foreseen Outcome:

- ***Development of "MoleculeChip" the molecular analogue of "AtomChips" developed in FP6***

Long Term Goals:

1. *Ultimate precision/control of a single atom or molecule functionality, control of the connectivity and of addressability of a single atom/molecule. Control of state and conformation, where the conformation is connected to the function.*
2. *An appropriate technology to exchange energy, data and instructions within a single atom or molecule and between different atoms or molecules*
3. *Control and synthesis down to the sub-nano scale, constructing the system one-by-one from atomic and molecular building blocks*