Nonlinear quantum optics with Rydberg atoms in an optical cavity

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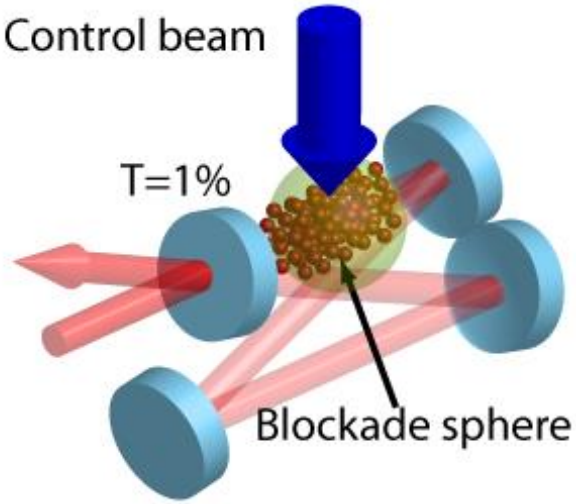

Online poster presentation, Cold Atom Online Meeting, France

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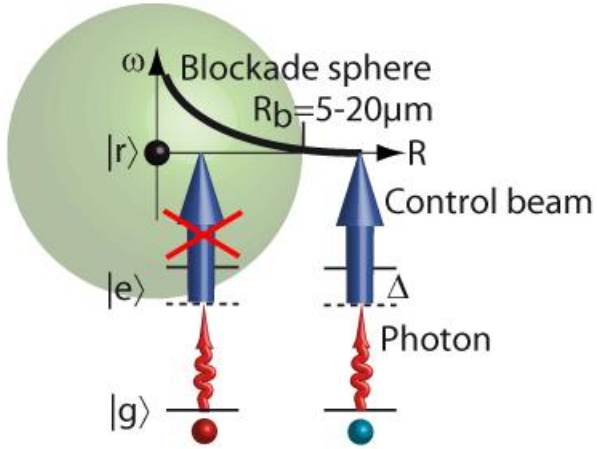
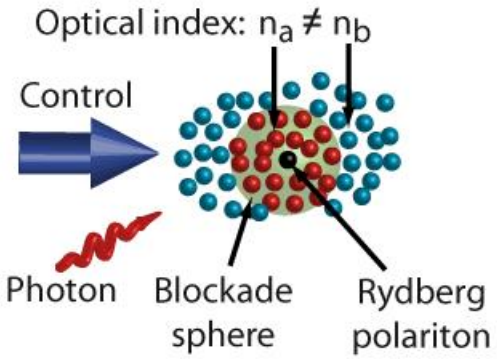
Principle : Towards efficient photon-photon interactions

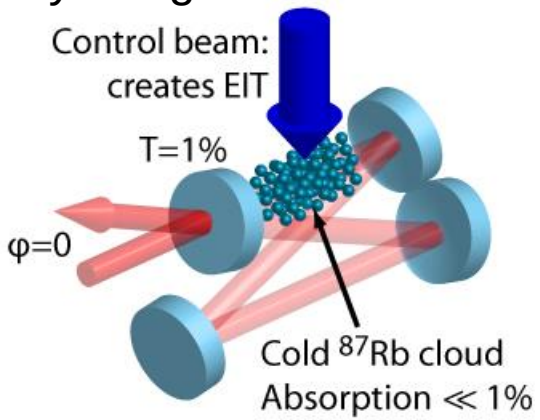
Rydberg EIT + Cavity → Efficient and deterministic photon-photon interactions



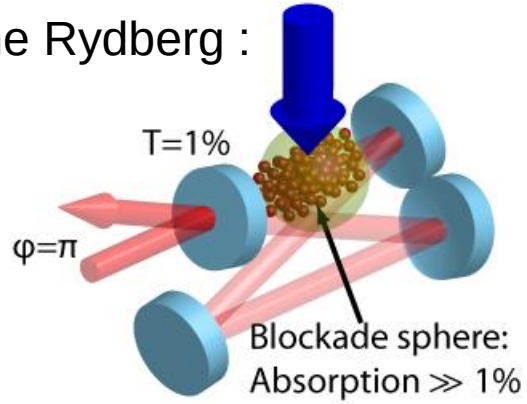


Collective effect produces a highly nonlinear response

No Rydberg :



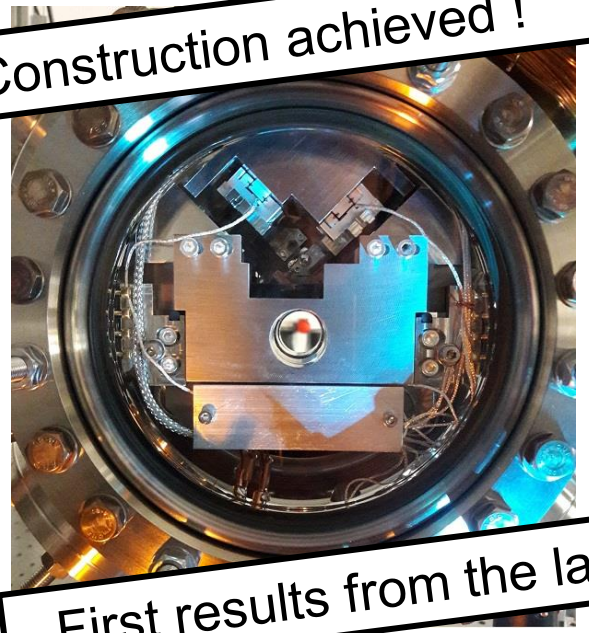
One Rydberg :



Enhance the nonlinearity
Induce a conditional π phase shift

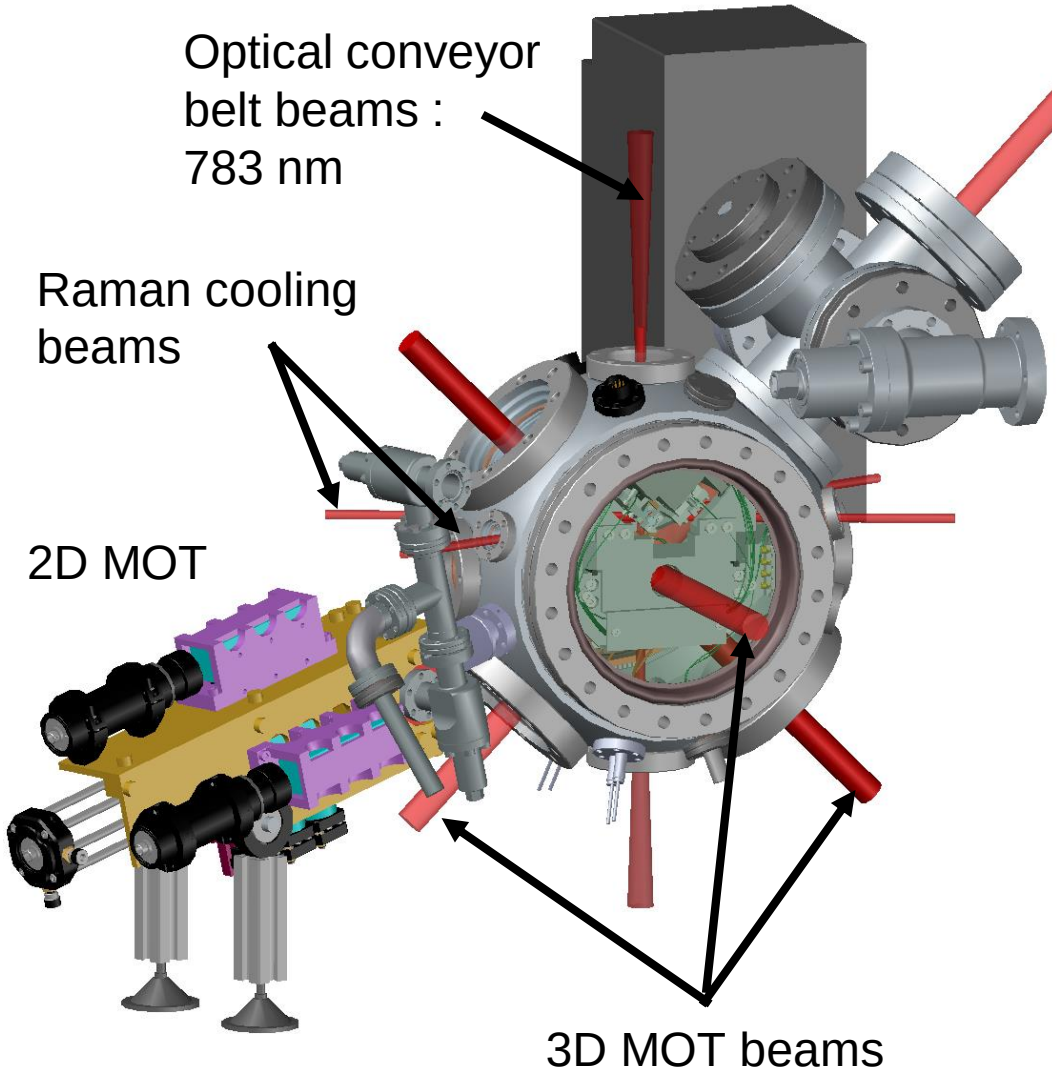
Outlook :
- Flying Schrödinger's cat states
- Two-photon control-Z gate
- Strongly interacting quantum fluid of photons

Construction achieved !

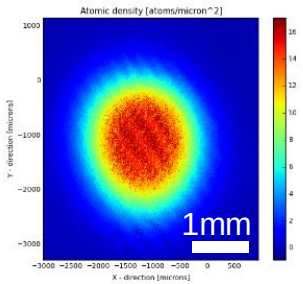


First results from the lab !

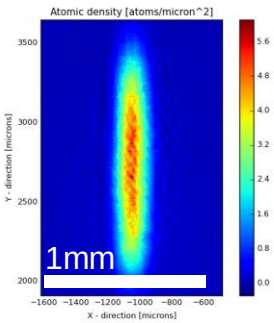
Experimental setup : producing a small cold atom cloud in cavity



2D MOT → 3D MOT → Optical conveyor belt



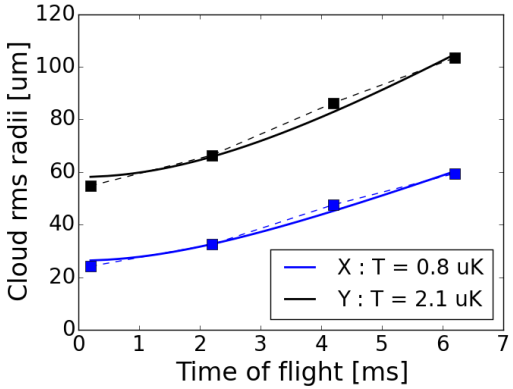
80 M atoms in 100 ms



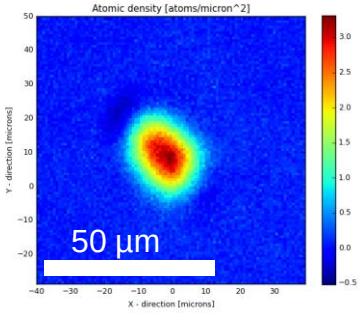
Transport of 1 M atoms over 33 mm in 10 ms

→ Degenerate Raman sideband cooling → Crossed dipole trap

3D lattice with conveyor belt + blue detuned Raman beams => ~1µK

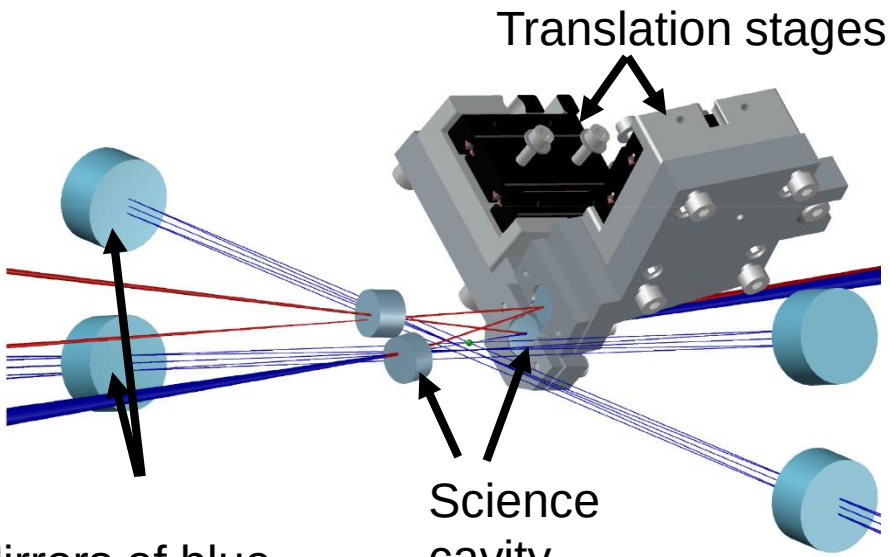


@ 1064 nm
cloud radius = 6um



Observing cavity Rydberg EIT

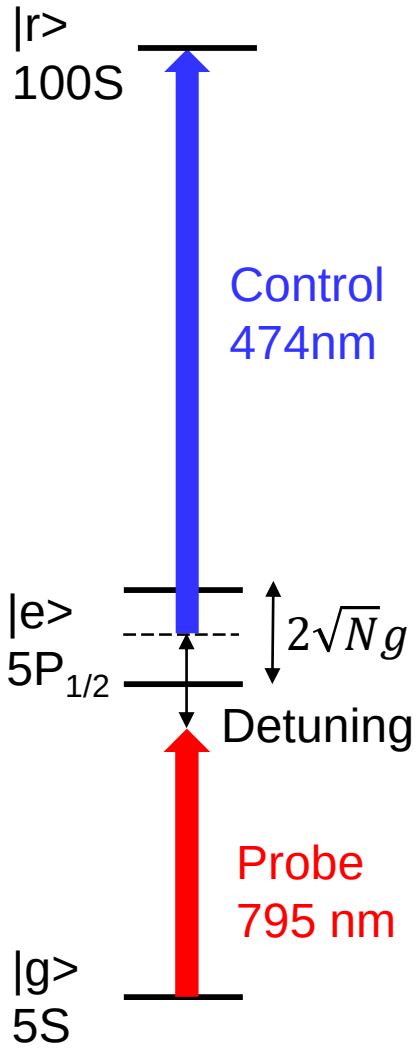
3 cavities in vacuum



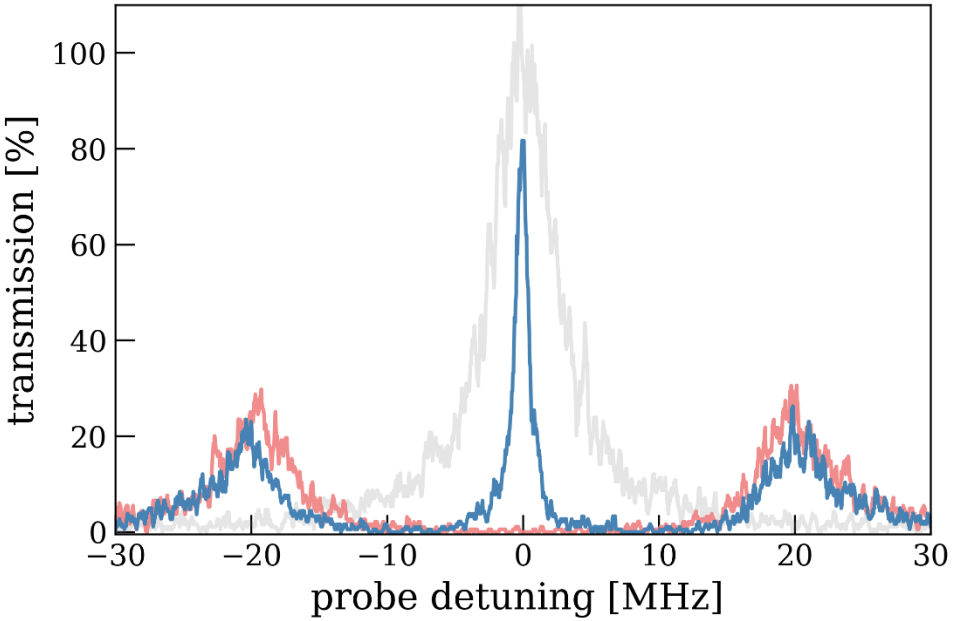
Enhance control laser power to allow higher-energy Rydberg states

Finesse at 795 nm : *F ≈ 700*
Input-output coupler : Transmission T ≈ *0.8* %

Atoms-cavity coupling and Cavity Rydberg EIT

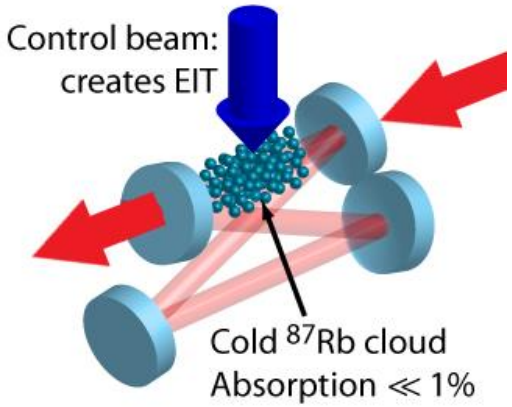


Probing cavity transmission :
- Empty cavity
- With atoms : Vacuum Rabi splitting
- With control beam : Rydberg EIT



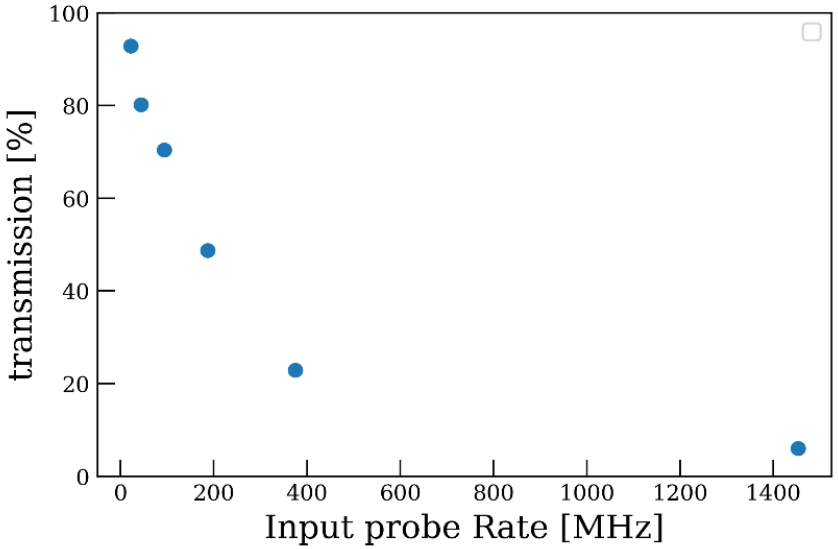
Observing the nonlinearity

No Rydberg :

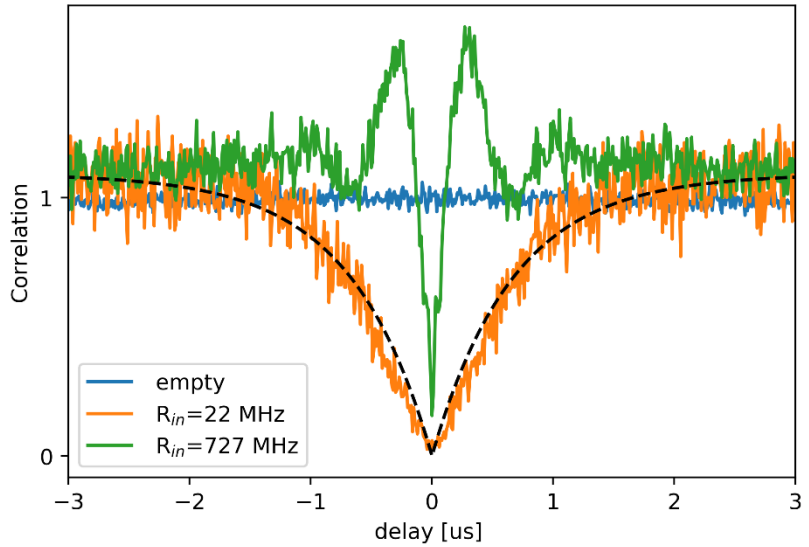


=> High Transmission

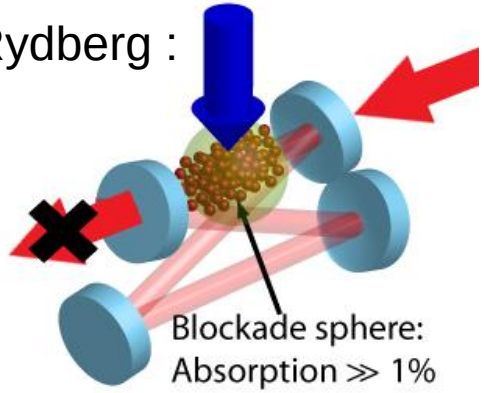
Saturation of transmission



Sub-Poissonian light

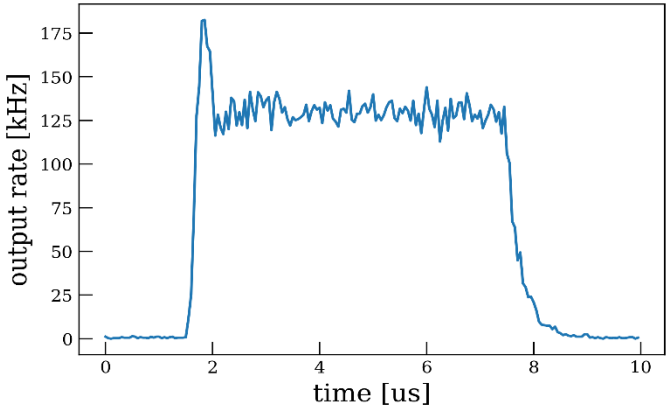


One Rydberg :



=> Transmission is blocked

Rabi oscillations



Nonlinearity at the single photon level