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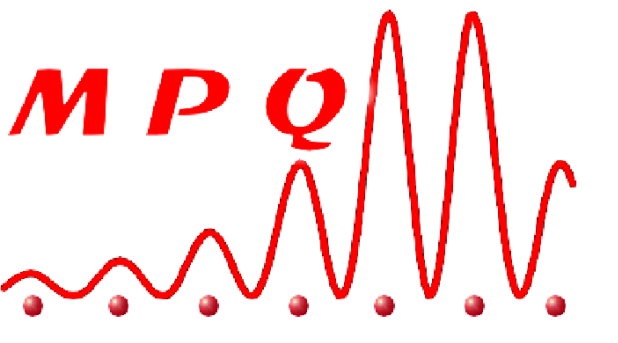


# Sympathetic cooling of ${}^9\text{Be}^+$ by ${}^{88}\text{Sr}^+$ Doppler cooled ions in large Coulomb crystals: an experimental study

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J. Heinrich<sup>2</sup>, T. Louvradoux<sup>2</sup>, J.-P. Karr<sup>2</sup>, L. Hilico<sup>2</sup>, and L. Guidoni<sup>1</sup>

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## Motivation

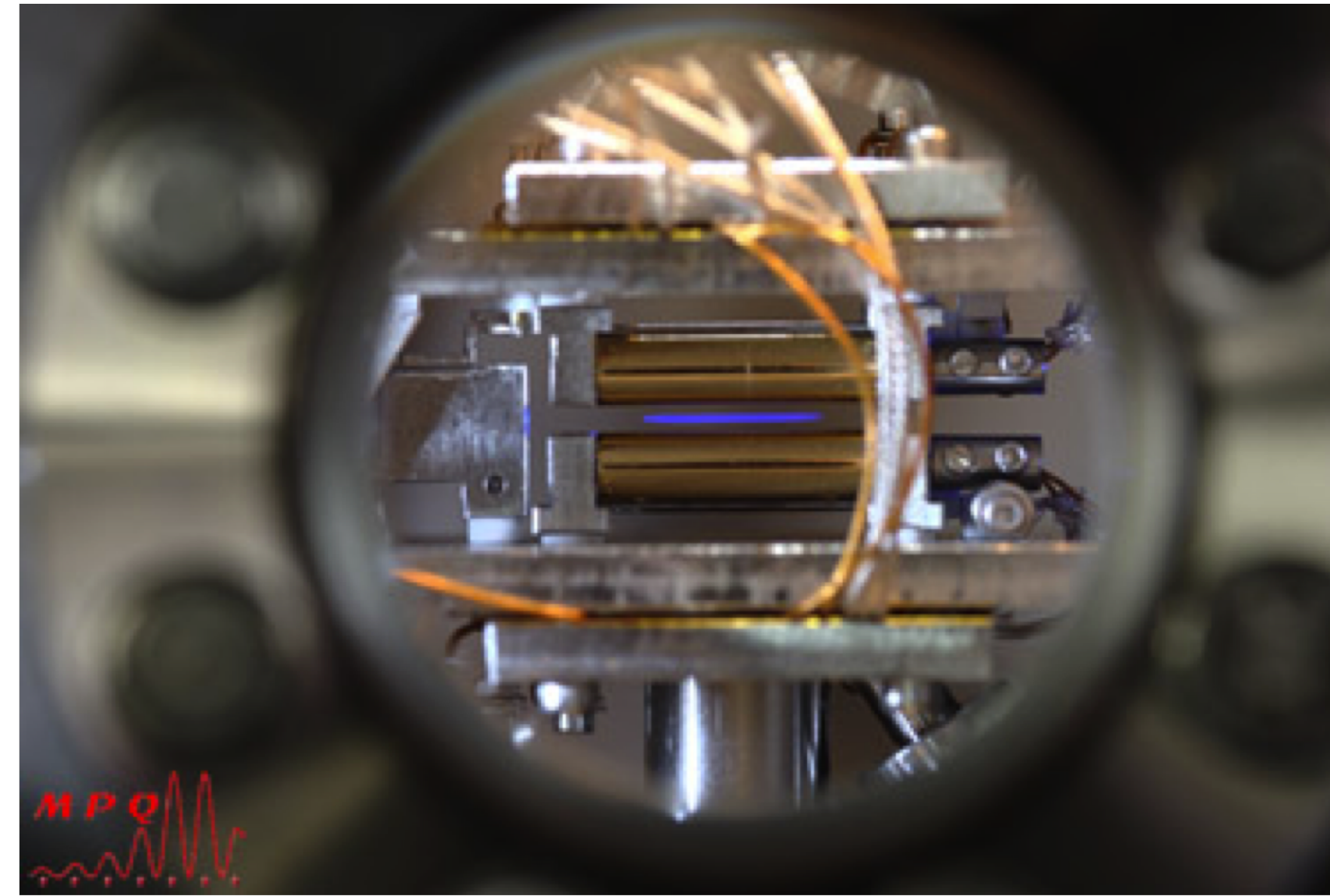
sympathetic cooling of light species by heavy coolants

- precision molecular spectroscopy  
J. C. J. Koelemeij et al., Phys. Rev. Lett. **98**, 173002 (2007).  
J. Biesheuvel et al., Nature Comm., **7**, 10385 (2016)

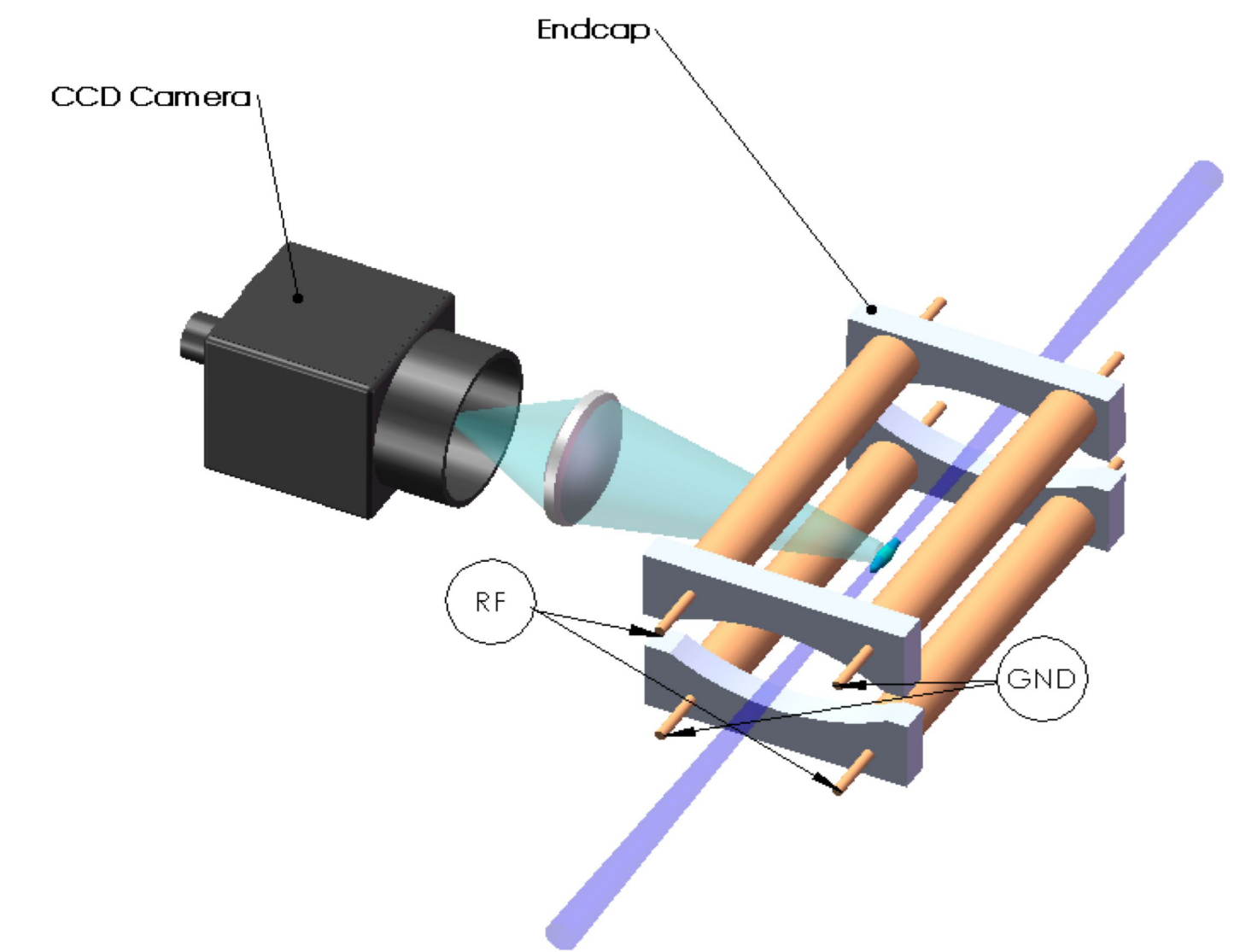
- multicharged ions  
L. Schmoeger et al., Science, **347**, 1233 (2015)

- GBAR experiment  
P. Perez and Y. Sacquin, Classical and Quantum Gravity, **29**, 18 (2012)

- experiments test for molecular dynamics simulations  
N. Sillitoe et al., arXiv:1705.03347 [physics.comp-ph]



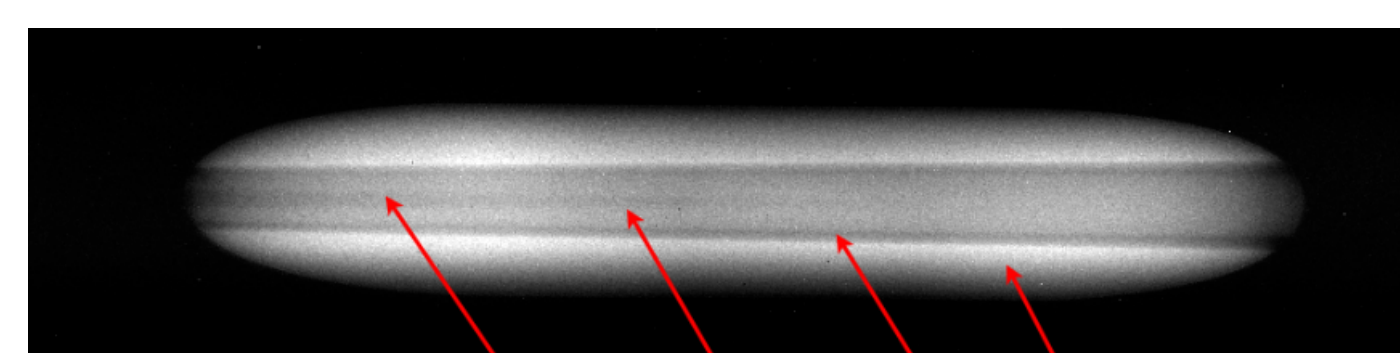
## Trap features



- inner radius  $R = 3.4$  mm
- length  $Z_1 = 30$  mm
- radio-frequency 7.6 MHz
- amplitudes  $V_{RF}$  50 - 800 V

- axial motional frequency ( ${}^{88}\text{Sr}^+$ ): 10 - 30 kHz
- typical stability parameter ( ${}^{88}\text{Sr}^+$ )  $q < 0.005$

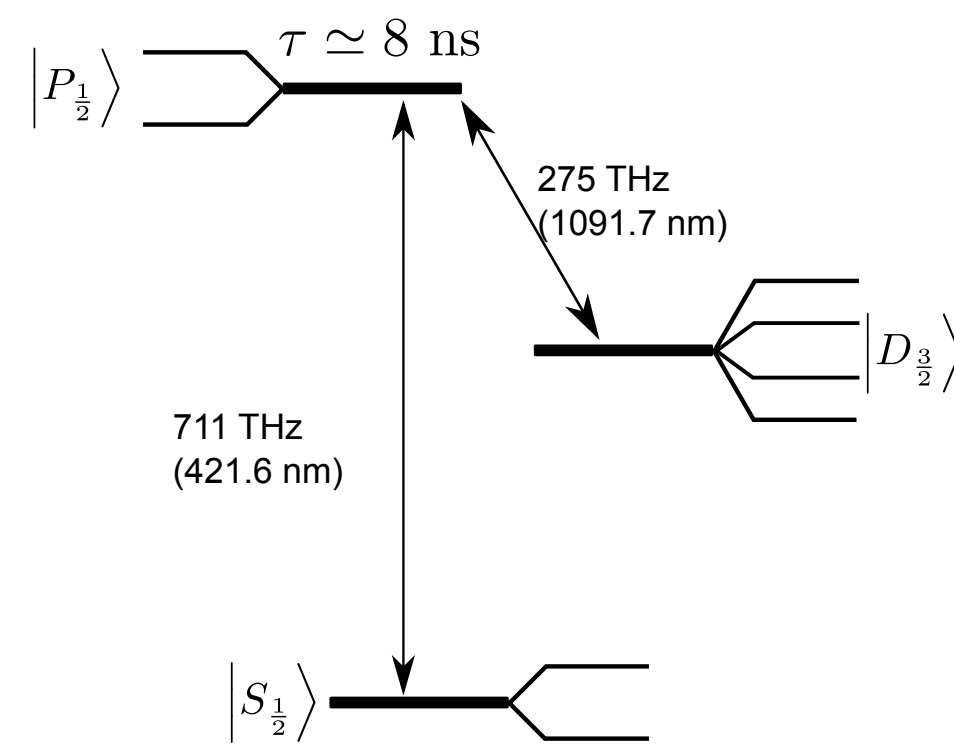
## Sympathetic cooling of $\text{Sr}^+$ isotopes



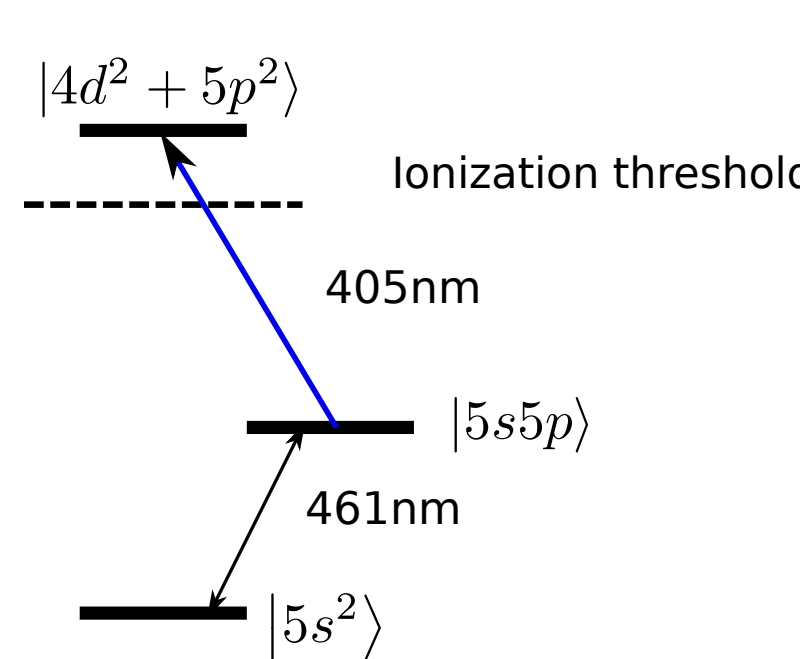
${}^{84}\text{Sr}^+$  0,56%  
 ${}^{86}\text{Sr}^+$  9,86%  
 ${}^{87}\text{Sr}^+$  7%  
 ${}^{88}\text{Sr}^+$  82,58%

## Experimental setup

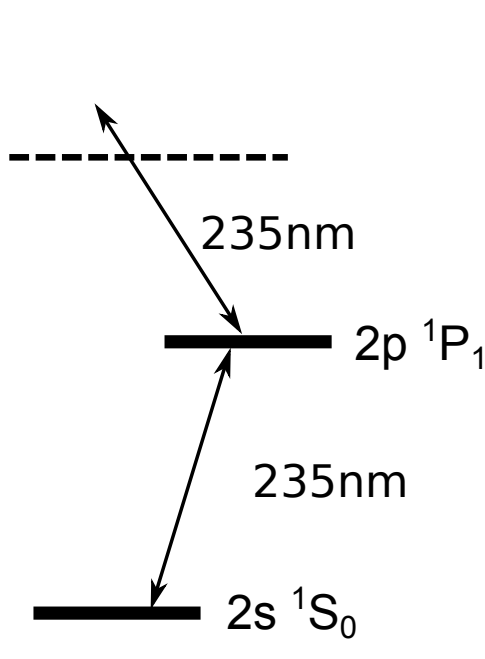
### Doppler cooling of $\text{Sr}^+$



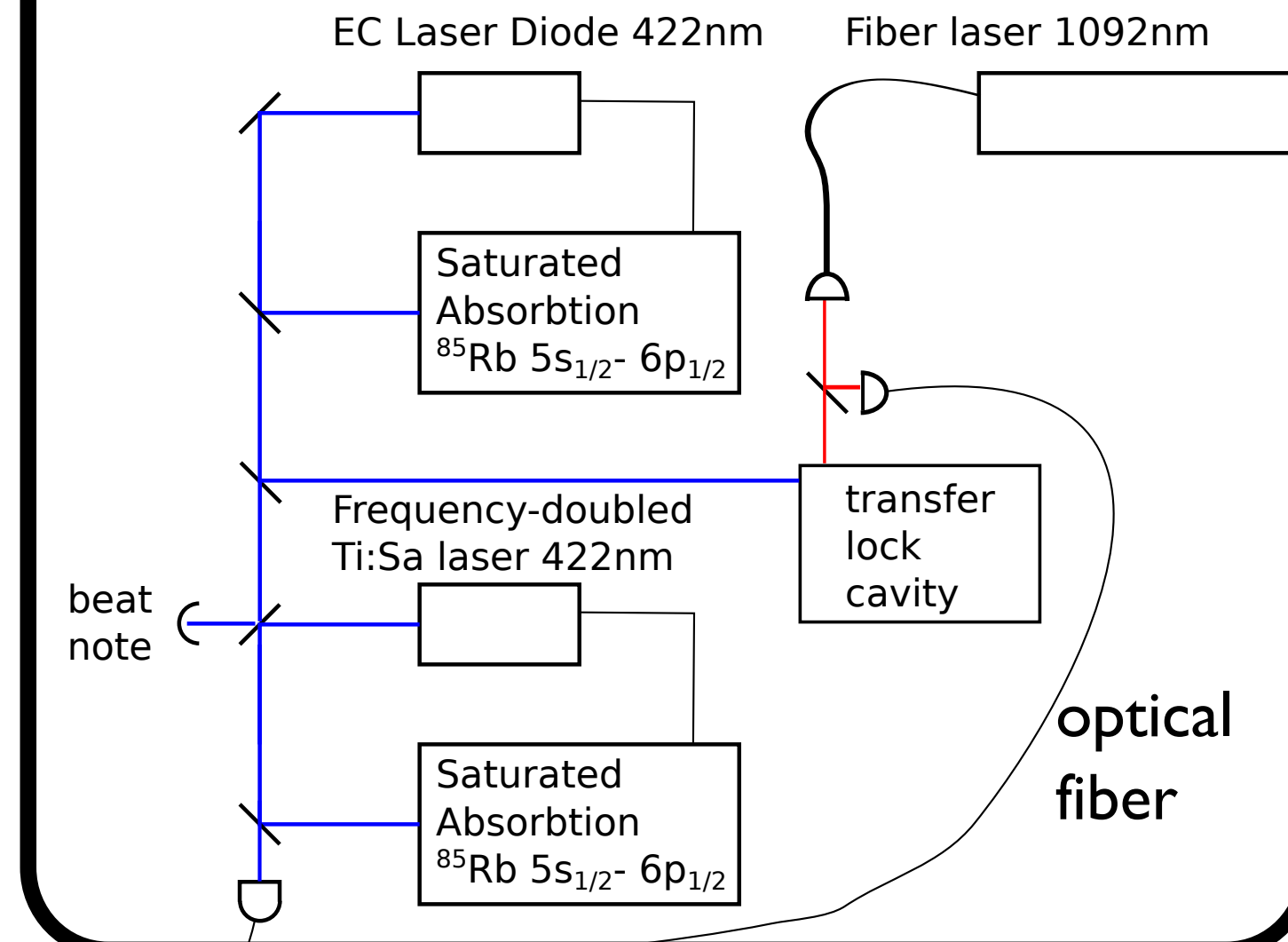
### Photoionization of Sr



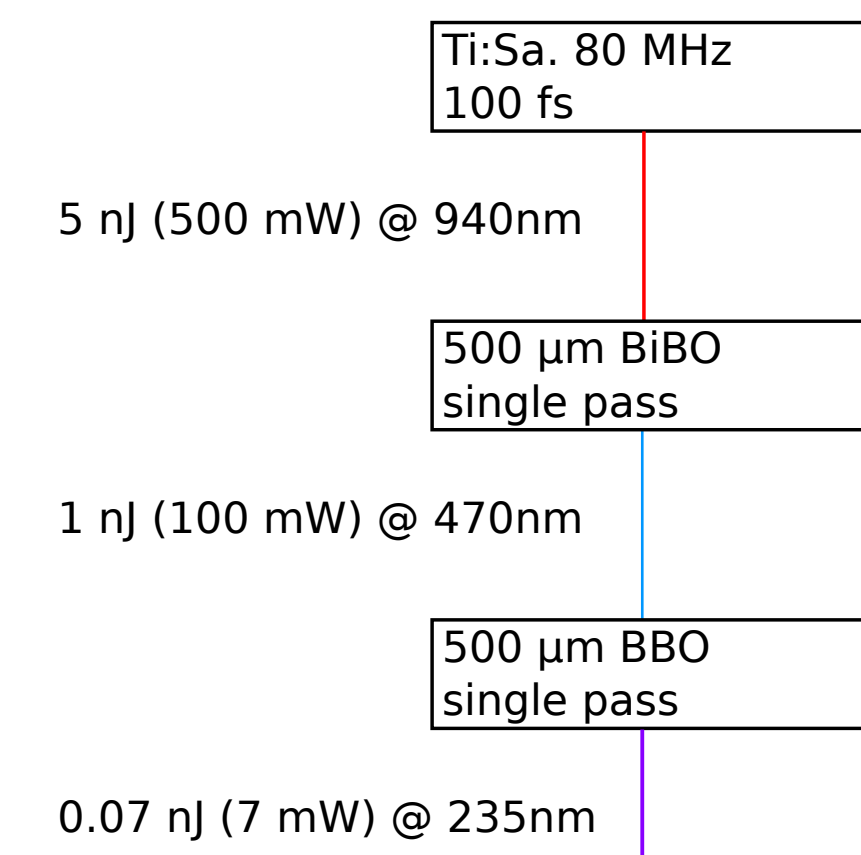
### Photoionization of Be



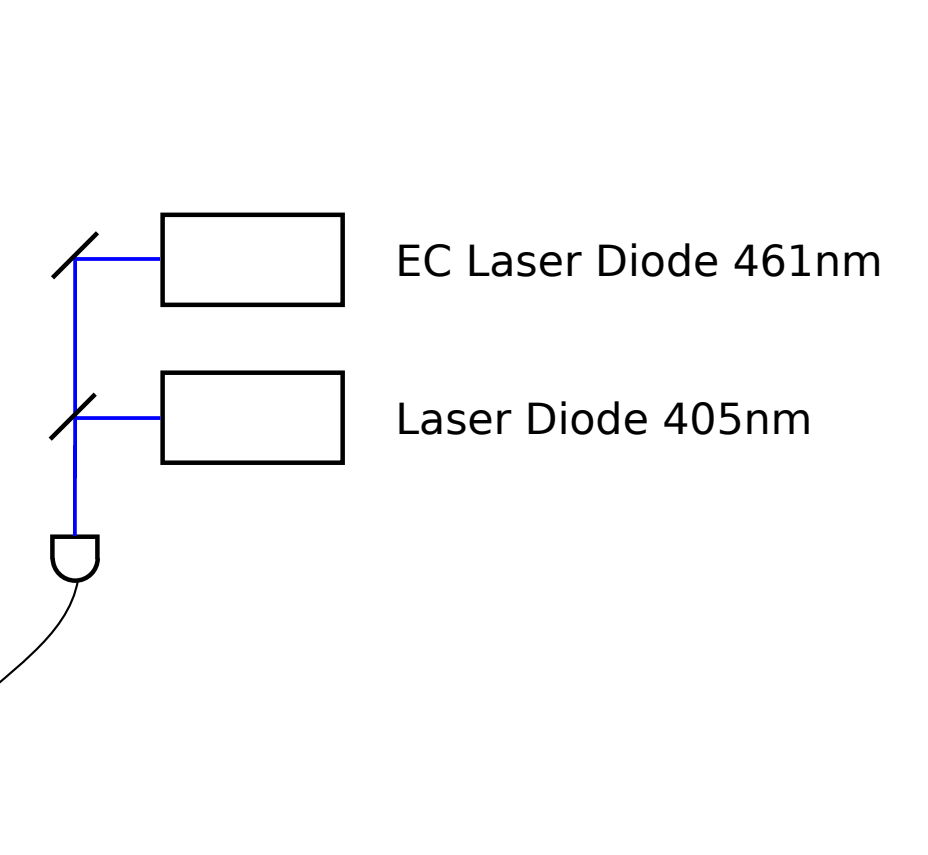
### $\text{Sr}^+$ cooling lasers and stabilization



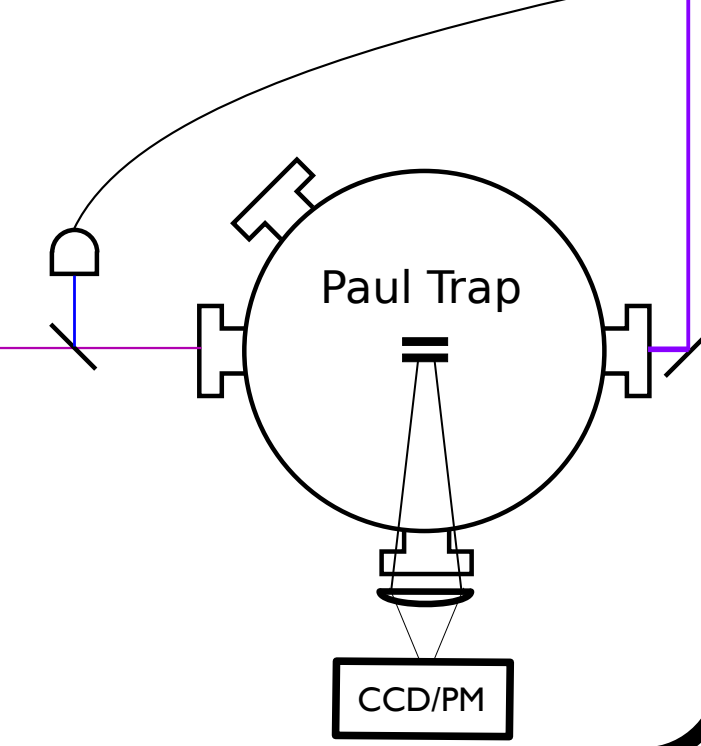
### ${}^9\text{Be}$ photo-ionization



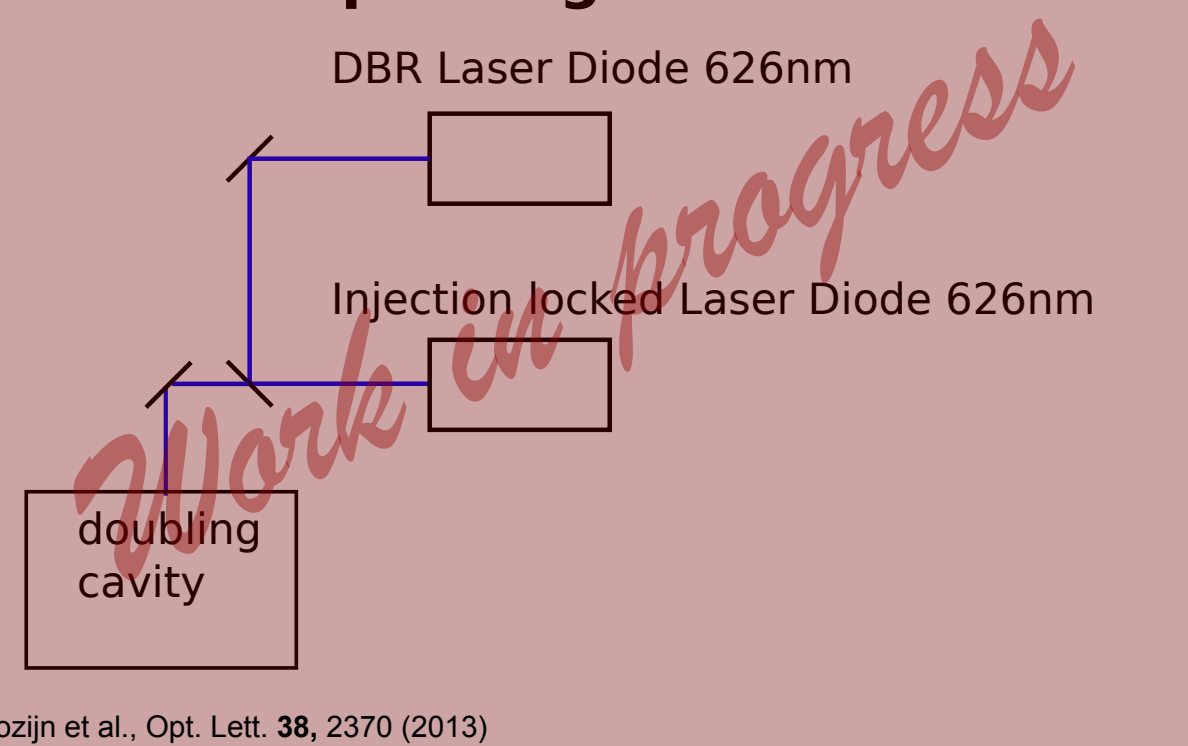
### ${}^{88}\text{Sr}$ photo-ionization



### Vacuum chamber

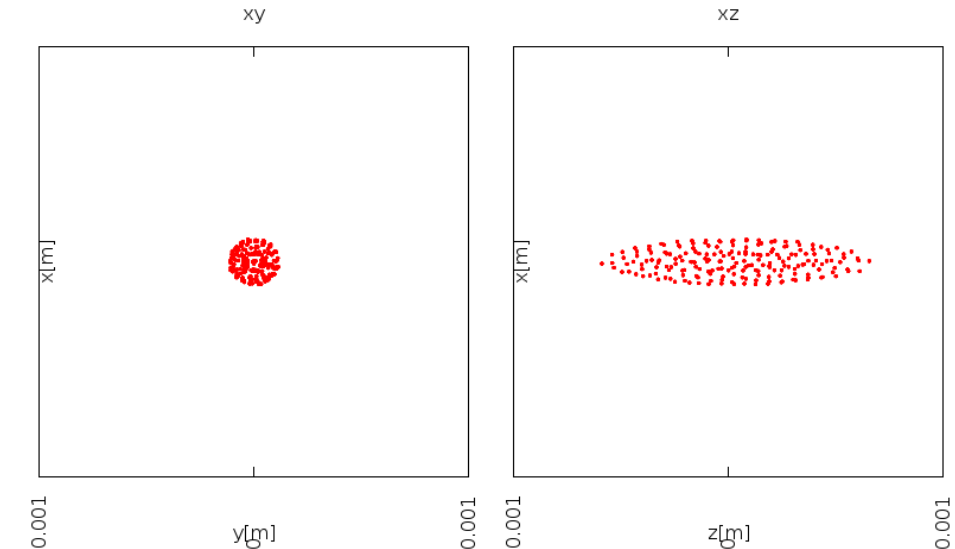


### $\text{Be}^+$ probing laser

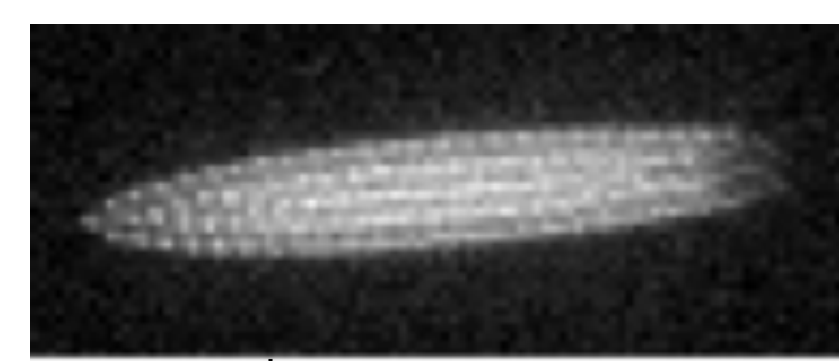


## Preliminary results

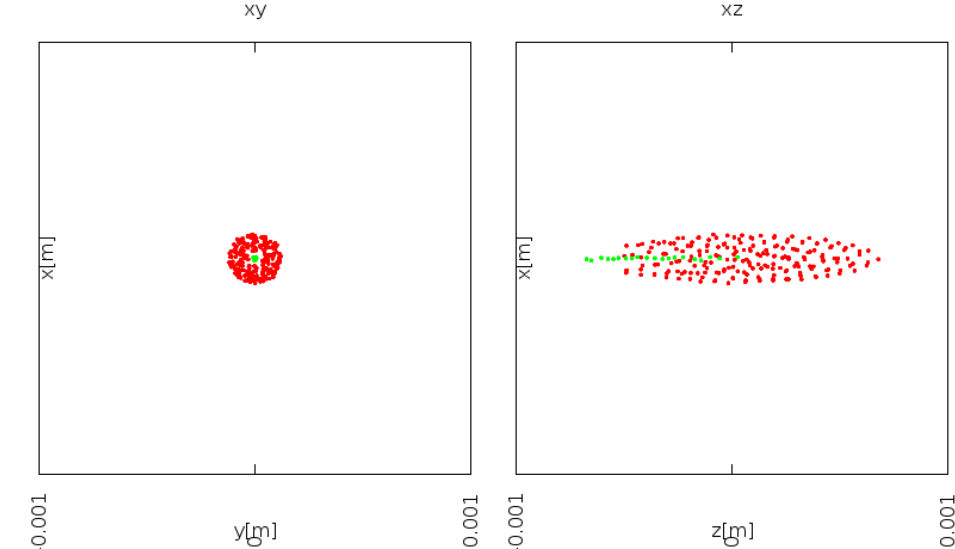
### numerical simulations of steady-state



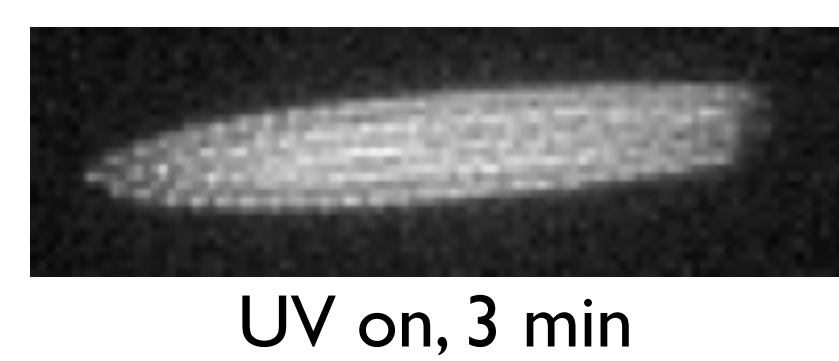
pure  $\text{Sr}^+$   $N=200$



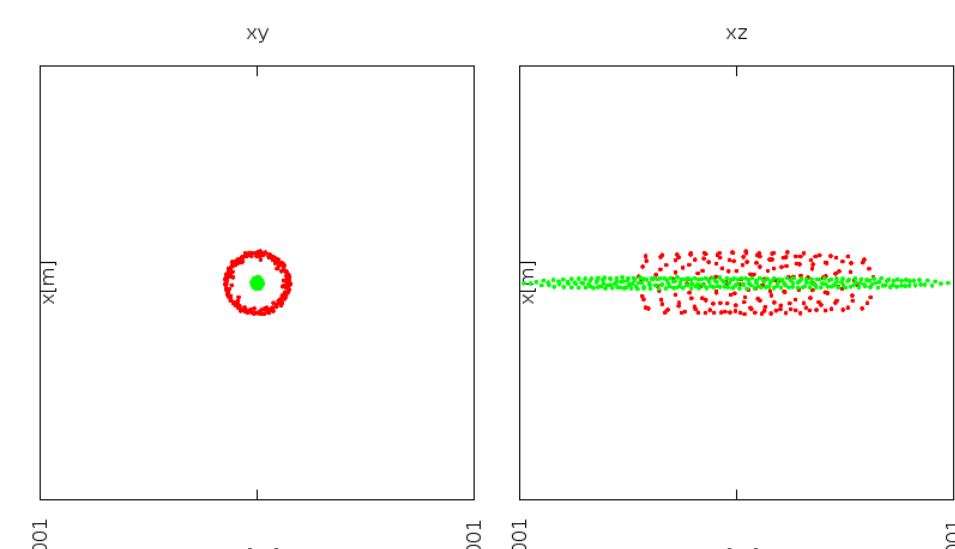
$\text{Sr}^+$  initial crystal



$N=200 \text{ Sr}^+ ; N=100 \text{ Be}^+$



UV on, 3 min



$N=200 \text{ Sr}^+ ; N=250 \text{ Be}^+$

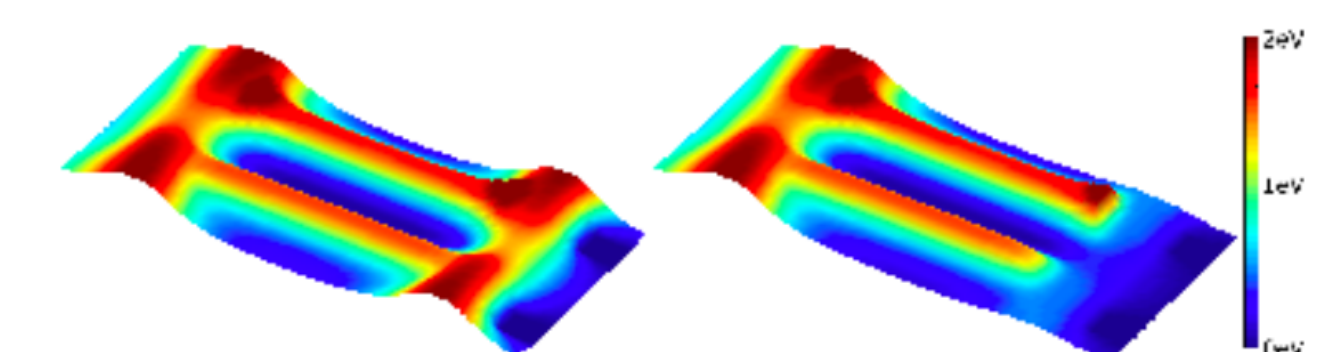


UV + Be oven on, 3 min

- qualitatively long ( $> 10$  s) cooling dynamics
- independent of loading order
- tickle confirmation of mass ratio

## Next steps

### ${}^{88}\text{Sr}^+$ isotope selection



probing  ${}^9\text{Be}^+$  for diagnostics

study of sympathetic cooling dynamics