In situ evidence of radiation trapping limiting Rb polarization in common continuous-flow SEOP setups

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Introduction

- Radiation trapping is a source of Rb depolarization which occurs when Rb absorbs unpolarized photons from radiative processes due to optical pumping[1,2] (Fig. 1)
- Radiation trapping is proportional to the optical pumping rate and therefore should be highest at combinations of high pump powers and low Rb densities[3]
- Common models assume that radiation trapping is quenched by N_2 buffer gas used in SEOP[4,5]
  - 100's torr for continuous-flow SEOP
  - 1000's torr for stopped-flow SEOP

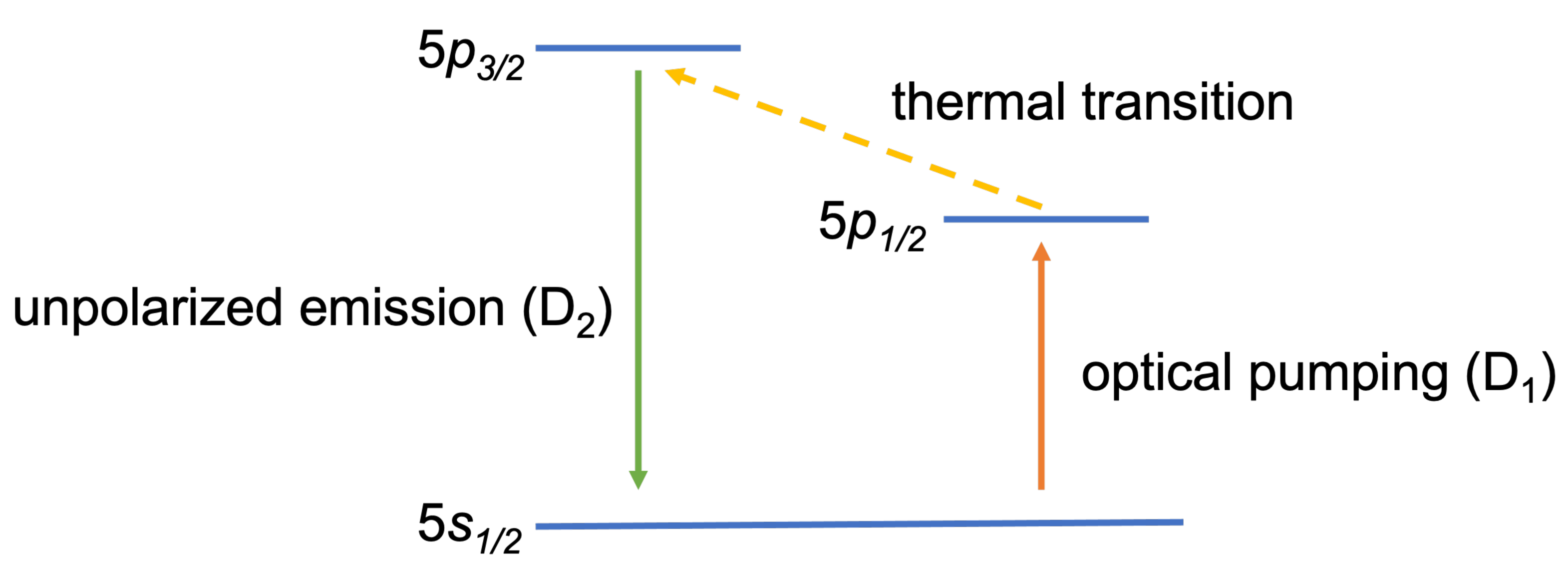

Figure 1 Example of radiation trapping. The $5p_{3/2}$ state is thermally accessible to excited atoms in the $5p_{1/2}$ state. By monitoring emission at the D_2 one can get a measure of the relative prevalence of radiation trapping.

Methods

- Small optical cell (5 cm x 10 cm) containing several atm of 1/10/89 of Xe/N_2/He
- Absorption spectroscopy was used to measure the Rb density
- Field cycling was used to measure the Rb polarization[6,7]
- Optical spectroscopy was used to monitor D_2 emission during SEOP

Results and Discussion

- Radiation trapping is still present despite N_2 buffer levels used for continuous-flow SEOP (Fig. 2)
- The relative prevalence of radiation trapping seems to track Rb polarization (Fig. 3)
- At low Rb densities additional pump power does not increase Rb polarization (Fig. 3 – see Rb polarization values at 22 W and 39 W for the lowest Rb densities)
- Behavior implies a depolarization mechanism that is proportional to the optical pumping rate – radiation trapping

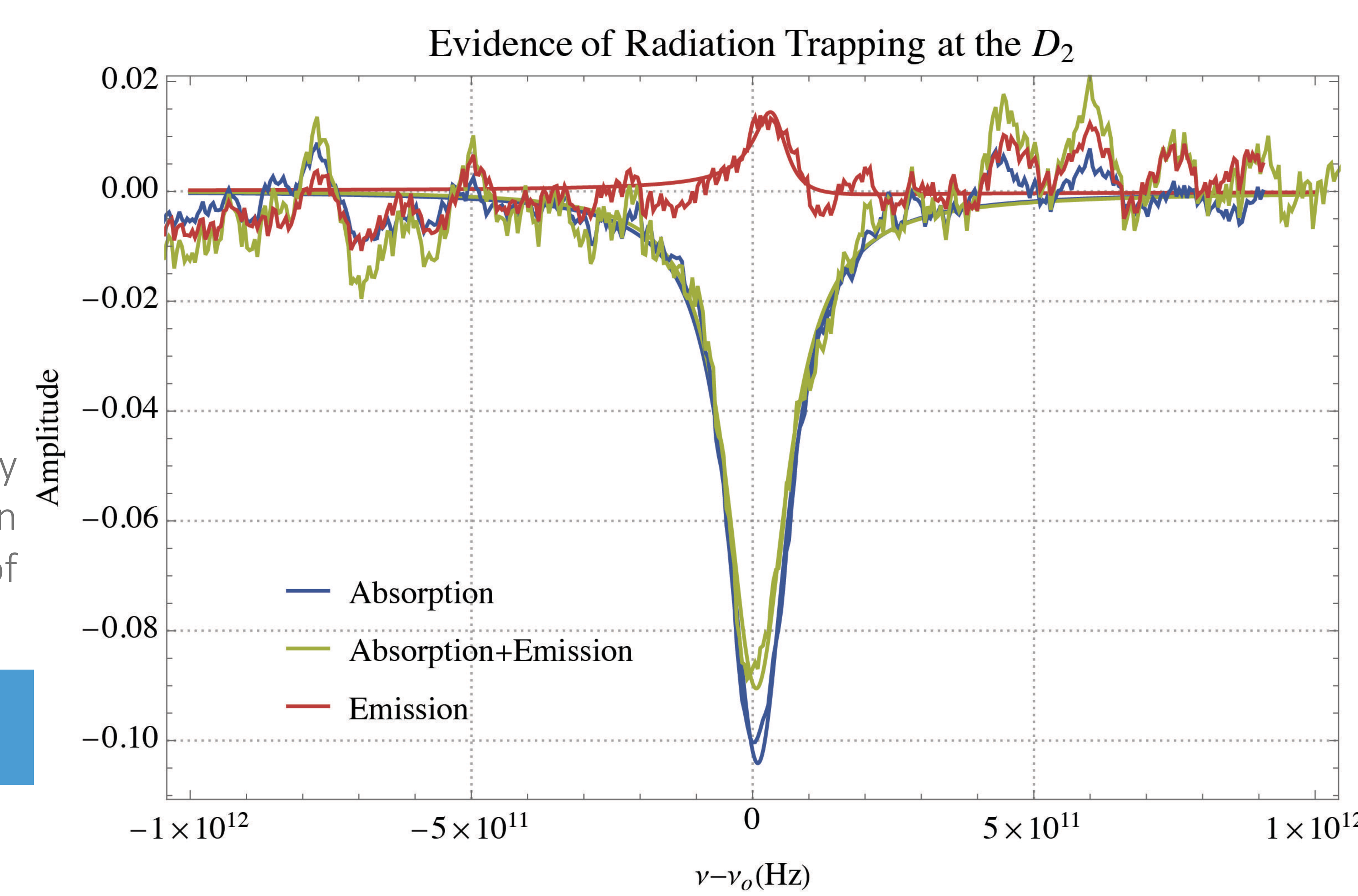

Figure 2 Example of in situ monitoring of the D_2 emission under optical pumping (red). The absorption line (blue) used to measure the Rb density is taken with the halogen lamp on, but with the pump laser off. To optimize the fitting, the absorption and emission data were added together (green) before fitting and integrating. The radiation trapping fraction was taken to be the area of the blue minus the green curve divided by the blue curve.

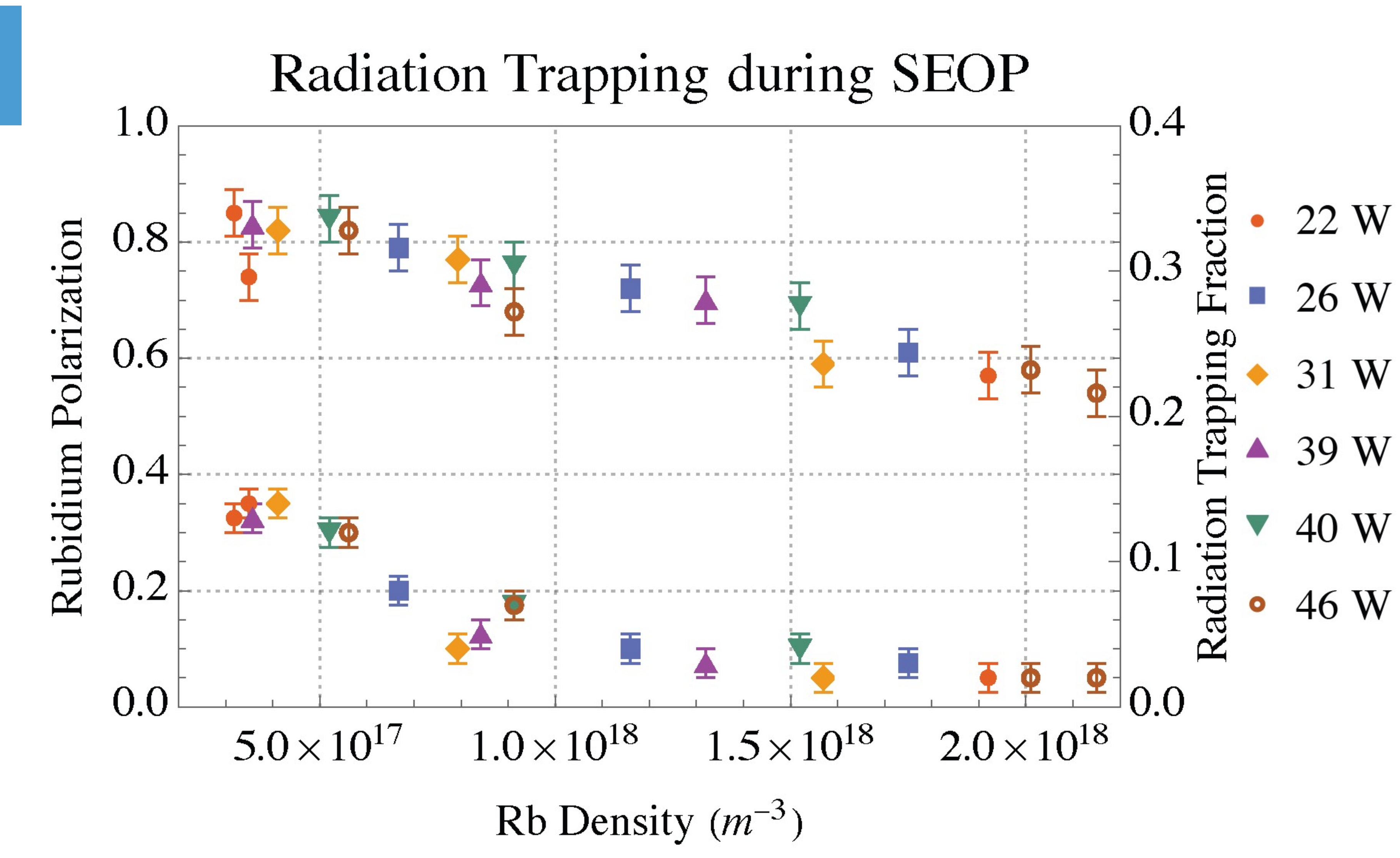

Figure 3 The Rb polarization (upper data points) and fraction of Rb atoms participating in radiation trapping (bottom data points) as a function of Rb density for laser powers ranging from 22 to 46 W. The fraction of atoms participating in radiation trapping is greater for lower densities, where the optical pumping rate will be the highest. As a function of density, the fraction of radiation trapping appears to track the Rb polarization.

Conclusions

- Radiation trapping is still an issue for continuous-flow SEOP as it limits the Rb polarization
- Higher Rb and ^{129}Xe polarization values might be obtained with higher percentages of N_2
- More investigations are needed for higher pump power with larger optical cells

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