



TRIPLE RESONANCE OF Rb FOR ATOMIC CLOCKS AND QUANTUM METROLOGY

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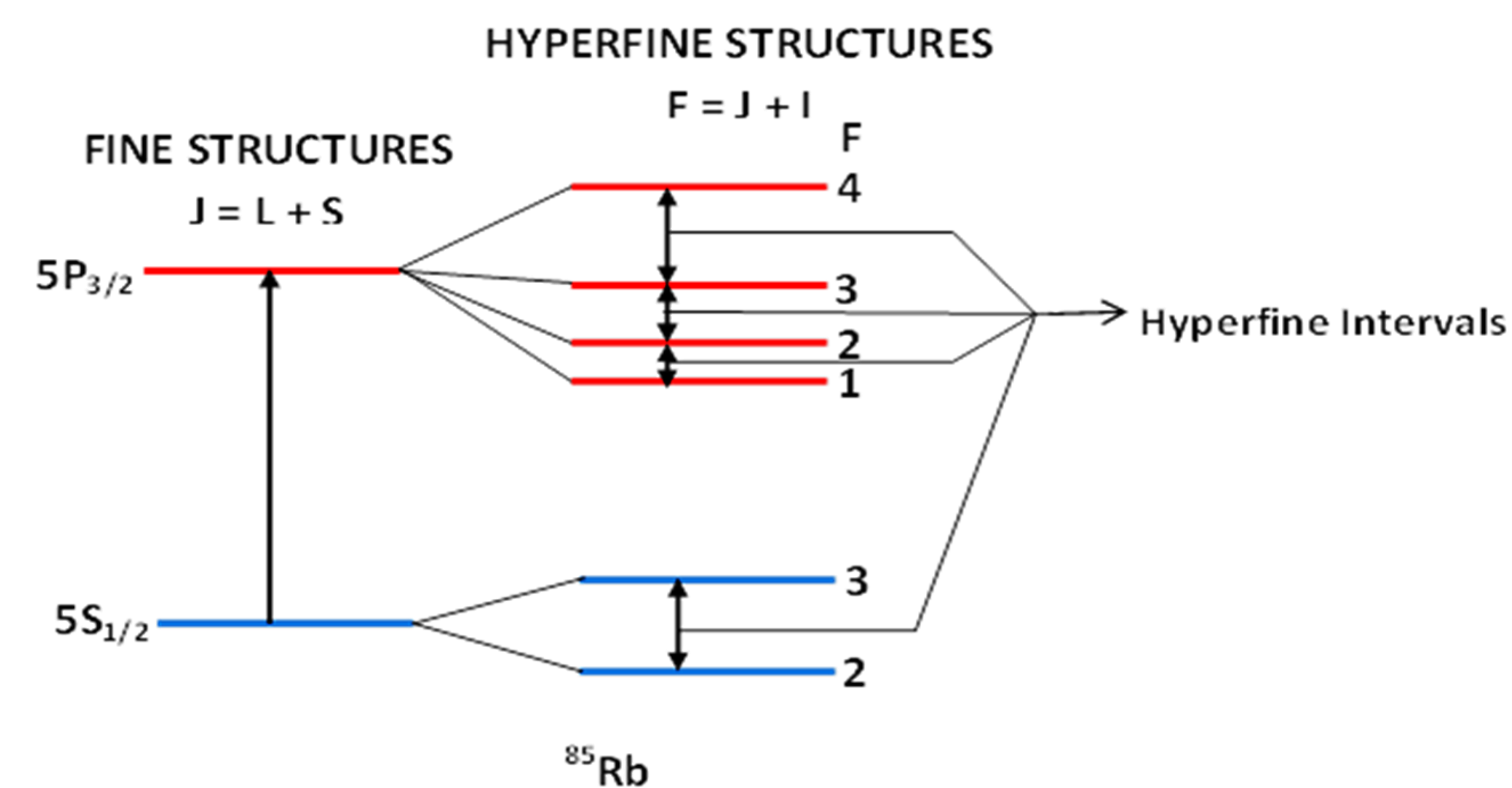
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ABSTRACT

Atoms leave unique "light fingerprints", recorded as spectral line profiles, which reveal their interactions with light. This study explores how loss of atoms to dark states decreases the contrast of the line profiles of rubidium atoms in double resonance spectroscopy. This decrease of contrast makes the closely spaced spectral lines appear merged, making precise measurements challenging. To overcome this, we present a theoretical framework demonstrating that triple resonance spectroscopy significantly improves spectral resolution by pumping the atoms from the dark state. These findings have implications for quantum measurements and atomic clock applications, with future work focusing on experimental validation.

LINE PROFILE ANALYSIS

- **Line profile analysis:** is like decoding an atom's "light fingerprint" to reveal how it absorbs or emits light.
- Energy levels are split to **fine structures** due to the spin – orbit interaction.
- Fine structures are further split to **hyperfine structures** due to the electron – nucleus spin interaction.



- To analyze the line profiles and precisely measure the linewidths of ⁸⁵Rb, the hyperfine levels of the closely spaced weak transition have to be well resolved.

METHODOLOGY

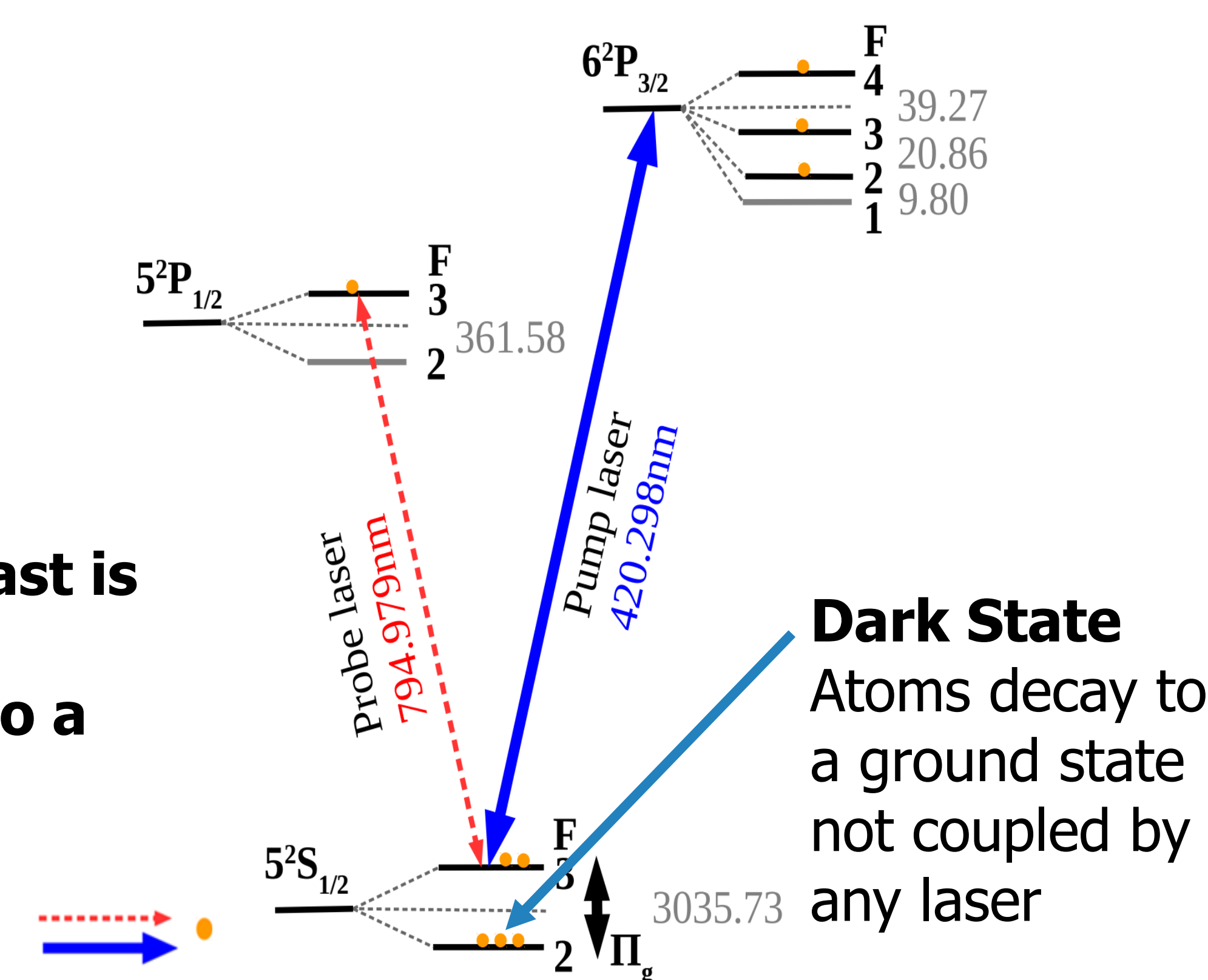
- To generate the line profiles several techniques have been used:

Double Resonance Spectroscopy (Cascade V-System)

➤ Drawbacks

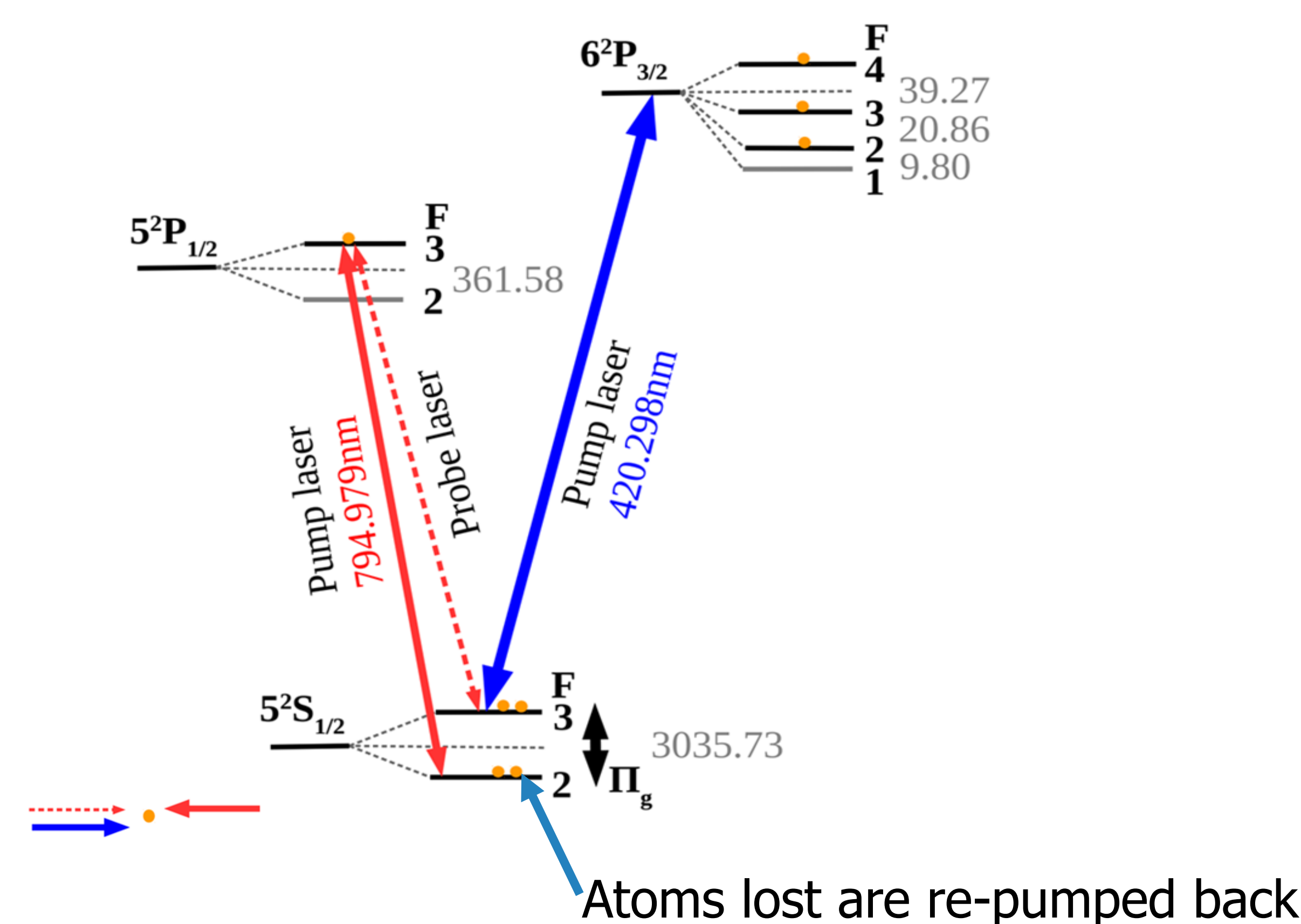
Line profile contrast is decreased by :

1. Loss of atoms to a dark state.



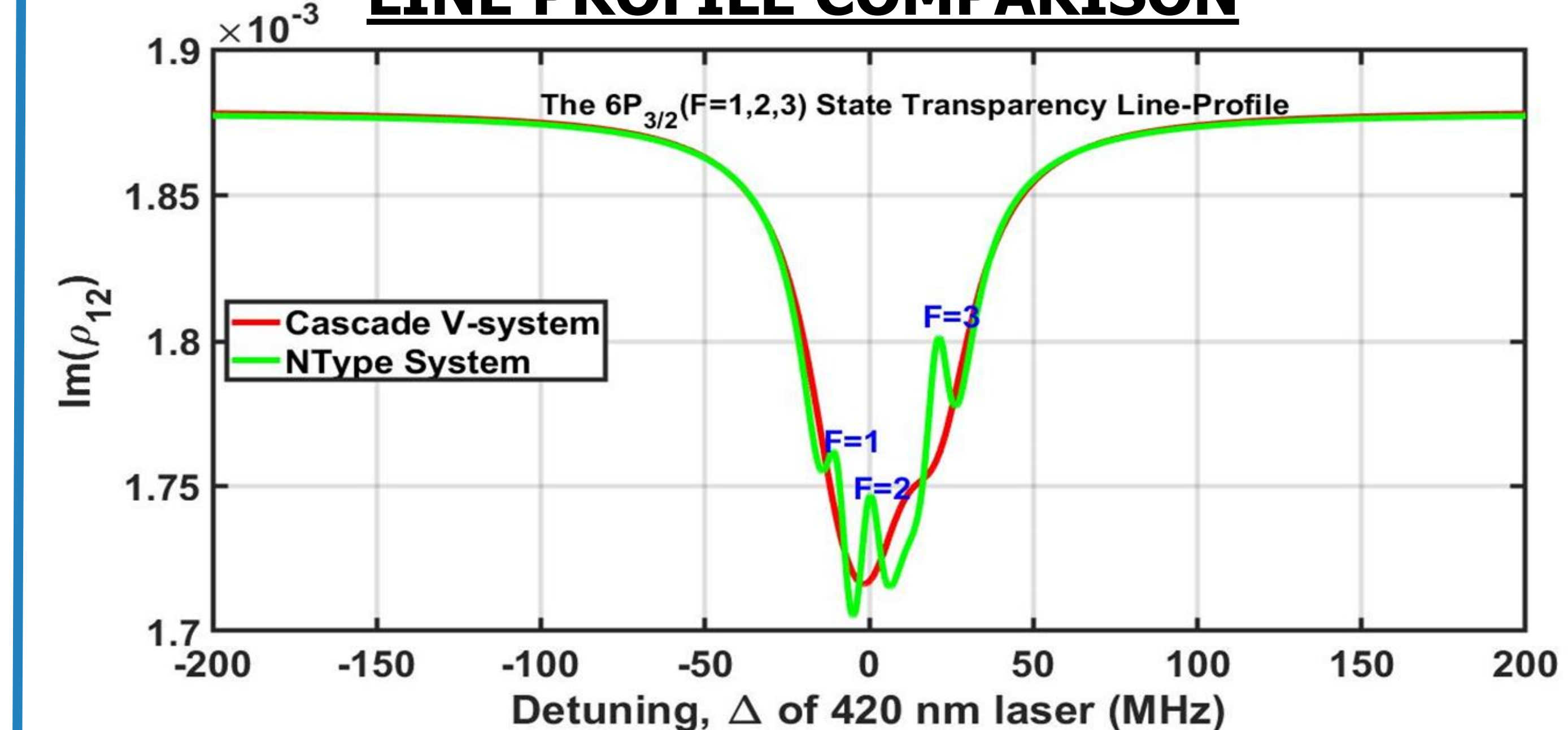
- To resolve the line profile using:

Triple Resonance Spectroscopy (N-Type System)



RESULTS

LINE PROFILE COMPARISON



Double Resonance (red line profile)

- Merged up (Not resolved)
- Linewidth: 24.8 – 30.5 MHz

Triple Resonance (green line profile)

- Well resolved
- Linewidth: 7.6 - 7.8 MHz

CONCLUSION

- ❑ The line profile contrast is reduced by loss of population to a dark state.
- ❑ Triple resonance resolves the line profile and precise measurements can be done enhancing precision in Atomic clocks and quantum metrology.

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