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The Population Densities of Argon Metastable Levels
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Introduction
Over the past few decades, the interest in low temperature, non-equilibrium plasmas used for plasma processing has been increasing. It has been shown that low temperature, high-density plasma sources generated using radio frequency powers can help us understand the most attractive properties for plasma etching and cleaning plasma.

Even though these discharges are widely used, their fundamental properties are still being explored. Therefore, developing models and experiments to improve understanding, performance, and control of these processing plasmas is much needed. Most of the time it is necessary to apply non-intrusive, spectroscopic techniques. In this study, the optical emission spectroscopy (OES) method is used to obtain the main properties of argon plasma. OES is useful only when detecting species that are excited energy levels higher than ground metastable states.

Experimental Setup
Radio Frequency Argon Plasma
Detection system driven by Raspberry Pi computer
RF Frequency – 13.56 MHz
Pressures: 15 – 50 mTorr
Power: 15 – 100 W
Pressure 30 mTorr
Power 50 W

Results
Spatial distributions of population densities of resonant states 1s₄ and 1s₅

2pₓ - Population density at 738nm and 706nm
2pᵧ - Population density at 800nm and 763nm

Metastable and Resonant Levels
Selection rules: Δσ = 0,½
Metastable levels: 1s₄ and 1s₅
Correction for the reabsorption:
Φ - Between 0.75 – 0.8
Φ = γ₁/γ₂A₁A₂N₁
Escape factor: pₓ = 2 – e⁻紧接着 / kₓ
Absorption coefficient k (Doppler broadened line):

Conclusion
In this experiment, the optical emission spectroscopy (OES) is useful only when detecting species that are higher than the ground and metastable levels.

To calculate the metastable levels, we can use the fact that the population densities depend on the spectral line intensity and photon emission rate (photon flux). We can take the ratio of two sets of spectral lines from photons emitted from two different level upper energy levels to the same two lower energy levels, we'll have a system of two equations with two unknowns. This system has a unique solution and can be solved numerically. We were able to calculate the spatial distributions of population densities of resonant 1s₄ state and metastable 1s₅ state using the two 2pₓ lines at 738 nm and 706 nm and the two 2pᵧ lines at 800 nm and 763 nm.

References and Acknowledgement
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