High-Performance Custom Laser Shutters

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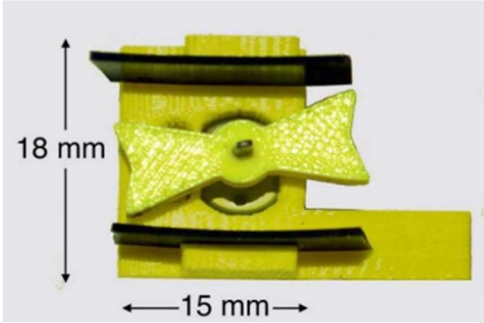
Mechanical optical shutters are an essential component in quantum optics experiments, due to their unique combination of perfect transmission when opened and perfect optical attenuation when closed.



This project aims to surpass the performance achieved by the 3D-printed optical shutter introduced in [1].

This advantage often outweighs the shutters' much slower response speed as compared to alternative technologies for blocking and unblocking light, such as electro-optical, acousto-optical, and MEMS-based modulators. Commercial solutions for mechanical optical shutters are typically large, slow, expensive, and/or noisy. In a previous project [1], we demonstrated a simple and compact 3D-printed optical shutter with 1 ms response time and a volume footprint below 5 cm^3. The CAD files for producing this shutter design were shared in an open-source manner to maximize utilization by other laboratories. Since then, we have identified several improvements to both the mechanical and optical aspect of the shutter design, including:

- Fabricating the shutter body out of metal to improve thermal dissipation properties.
- Fabricating the shutter blade out of metal or carbon fiber to increase laser power handling and shutter switching speed.
- Using high-torque and increasingly compact DC motors developed for drone applications.
- Using a digitally controlled circuit to increase shutter speed and reduce mechanical noise.
- Simplifying the customization of the shutter for high speed or high laser power applications by introducing a semi-standard library of shutter blade designs.

In this project, the student will realize the above goals by designing and building a new optical shutter and driver system. The student will quantitatively test the shutter's speed, repeatability, reliability, and low level of mechanical and electrical noise to confirm its suitability for usage in a state-of-the-art quantum optics laboratory. The student will also investigate the fundamental and technical limitations to optical shutter performance at different laser beam sizes and powers.

[1] Zhang, G. H., Braverman, B., Kawasaki, A., & Vuletić, V. (2015). Note: Fast compact laser shutter using a direct current motor and three-dimensional printing. *Review of Scientific Instruments*, *86*(12). https://doi.org/10.1063/1.4937614