Post-Compression Temporal Contrast Improvement for Femtosecond Lasers via Ionization Plasma Gratings

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Advances in high-power laser design require the development of optical materials that can withstand extremely high light intensities and energy fluxes. High-intensity laser-plasma interactions also require lasers that can deliver pulses with extremely good temporal contrast to avoid target disruption prior to the arrival of the peak laser intensity. The current primary solution for improving temporal contrast after compression in high-power beamlines is the plasma mirror, which combines the high reflectivity of an overdense plasma surface with the low reflectivity of anti-reflection coated glass, providing a two or three order-of-magnitude improvement of contrast. Here we describe how an ionization plasma grating [1], an optic which can be used for high-power pulse compression [3] and focusing [4] well above the damage threshold of solid materials, also improves the temporal contrast of femtosecond laser pulses. We demonstrate with third-order autocorrelation measurements that an ionization grating can be used to clean the temporal contrast of a 30-fs laser pulse by more than five orders-of-magnitude, with a turn-on time shorter than 500 fs. Since ionization gratings rely on gas targets, continuous operation at 10 Hz is far easier than solid-based plasma mirrors. By combining these features with diffraction efficiencies above 50% [4], plasma gratings could offer an efficient and effective method for cleaning the temporal contrast of high-power high-repetition-rate ultrafast laser pulses.

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[3] M.R. Edwards et al., *Phys. Rev. Appl.* **18** 024026 (2022).

[4] M.R. Edwards et al., *Optica,* **10** 12, 1587-1594 (2023).