High Power Infrared Super–Gaussian Beams: Generation, Propagation and Applications

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We present a CO_2 laser resonator that makes use of an intracavity diffractive mirror to generate a super–Gaussian beam as the output mode. We demonstrate the concept on a high average power TEA CO_2 laser, and consider the propagation of the output field from source to target, as well as various applications including paint stripping and laser propulsion.

There are many applications in which a laser beam with flat–top intensity profile would be ideal, as compared to a laser beam with a non–uniform energy distribution. One example is materials processing where uniform heating or material removal is desirable. Techniques exist to generate flat–top beams external to the cavity, but this is usually at the expense of energy, and almost always requires very precise input beam parameters.

In this paper we present the design of a CO_2 laser resonator that produces a super–Gaussian laser beam as the stable transverse mode. The resonator makes use of an intra-cavity diffractive mirror and a flat output coupler, generating the desired intensity profile at the output coupler with a flat wavefront. We consider the modal build–up in such a resonator using a Fox–Li analysis and include the impact of the gain medium on the potential energy extraction of the mode. We show that such a resonator mode has the ability to extract more energy from the cavity than a standard cavity single mode beam (e.g., Gaussian mode cavity). We demonstrate the design experimentally on a high average power TEA CO_2 laser for paint stripping applications, and highlight advantages of such a beam shape in applications such as laser propulsion.

One of the issues with super–Gaussian laser beams is that they change shape during propagation, complicating delivery to targets, and also impacting negatively on the propagation inside the laser cavity. We consider these issues in detail, and highlight the regimes in which such fields may be generated and propagated with minimal error.

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