Laser drivers for inertial fusion reactors

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During the past few years, the e-beam pumped rare gas halide (RGH) lasers such as KrF and XeCl have been shown to be efficient (5–10%), short wavelength (250–350 nm) lasers which are volumetrically scalable (10–20 J/l) when operated with pump pulsed durations $\tau p > 100$ nsec. However, the presence of nonsaturating losses in the gain medium limits the laser output intensity to values in the range of 5–20 MW/cm^2. To utilize RGH lasers for short pulse inertial fusion applications ($\tau_l \sim 10$ nsec), some method of pulse compression of the RGH laser output waveform must be implemented. Angle-coded multiplexing, backward wave Raman pulse compression, and "hybrid" combinations of these techniques have been developed and will be reviewed. The LLL e-beam pumped KrF laser system testbed RAPIER has been used to demonstrate efficient Raman pulse compression (e.g. compression ratio of 5 with an efficiency $> 70\%$) and angle-coded multiplexing (compression ratio of 3 for 20 nsec pulses). Implications of these results for large laser systems in terms of energy scaling, optical complexity and cost will be discussed. Finally, the performance of a V: MgF_2 MJ-class energy-storage laser system will be projected as a means of contrasting the benefits and issues associated with energy storage and non-storage laser systems.

用于惯性聚变反应堆的激光驱动装置

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在过去几年中，已经证明电子束泵浦的稀有气体卤化物（RGH）激光器，例如KrF和XeCl，是高效率（5～10%）的短波长（250～350毫微米）激光器。当泵浦脉冲持续时间 τ_p 大于100毫微秒时，它们可以按比例放大（10～20焦耳/立升）。但是，增益介质中存在的非饱和损耗将激光输出强度限制在5～20兆瓦/厘米^{2}范围内。要将RGH激光器应用于短脉冲惯性聚变（$\tau_l \sim 10$ 毫微秒），必须提供压缩脉冲RGH激光输出波形的某种方法。本文评述了角度编码多路传输，反向波喇曼脉冲压缩和这些技术的"混用"。已应用了劳伦斯·利佛莫尔实验室的电子束泵浦KrF激光系统试验台RAPIER证实了高效率喇曼脉冲压缩（例如，压缩比为5，效率大于70%）和角度编码多路传输（对于20毫微秒脉冲压缩比为3）。还讨论了这些结果对大规模激光系统在能量定标、光学复杂性和价格方面的含义。最后，作为比较储能与非储能激光系统的优点和问题的手段，设计了V: MgF_2 兆焦耳级储能激光系统的性能。