KrF Laser Drivers for Inertial Fusion Energy

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The Electra laser facility at the Naval Research Laboratory (NRL) is developing the science and technology for a repetitively pulsed, electron beam pumped, krypton fluoride (KrF) laser for inertial fusion energy (IFE). KrF lasers are ideally suited for IFE due to their established uniform beam quality, short lasing wavelength (248 nm), and pulsed power architecture that scales to large systems. The technologies developed on Electra must meet the fusion energy requisites for repetition rate, efficiency, durability and cost. Although Electra is approximately 1-2% of the energy of a power plant size laser beam line, it is large enough that the components that are developed are directly scalable to a full-sized IFE facility. Specifically, the KrF laser design includes: a durable, efficient, and cost effective pulsed power system; a durable, uniform cathode (electron beam source); a long life, e-beam transparent pressure foil structure; a gas recirculator to cool and quiet the laser gas between shots; and long life, fluorine resistant optical windows and coatings.

The Electra laser is pumped with two V = 500 kV, I = 110 kA, t = 140ns (FWHM) electron beams. The beams are injected into a laser cavity volume that measures 30x30x100 cm^3 with the laser aperture along the long axis. To date, Electra has produced an output energy of 700 J per pulse at a repetition rate of 1 Hz and 625 J per pulse at 5 Hz, with efficiencies that scale to > 7%, which is within the IFE requirement. The laser performance has been modeled with the "ORESTES" KrF physics code developed at NRL. Recent experiments show long-lived pressure foils can be achieved by periodically deflecting the laser gas to cool the foils. This paper discusses an overview of the objectives of Electra KrF laser program; a background of the physics and technology of KrF lasers; the most recent advances in laser performance, KrF physics modeling, system efficiency, cathode development, and foil lifetime; and the technical challenges that still need to be addressed.

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