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PATHWAY TO A LOWER COST HIGH-REPETITION IFE IGNITION FACILITY*

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We have identified a faster and lower cost path to develop the science and technology for fusion energy based on a new class of pellet designs. A power plant based on laser fusion will require pellet energy gains of about 100 to overcome inefficiencies in the laser and power generation. For directly-driven targets this requires energies of at least one MegaJoule. However, many of the key science and engineering tasks could be accomplished with ignition and lesser gains. If one increases the pellet implosion velocity from the nominal 300 km/sec in high gain designs to about 500 km/sec, one can obtain ignition and moderate gains at substantially reduced laser energy. This higher velocity can be obtained by increasing the distance over which the pellet shell is accelerated. But this approach leads to thin large-diameter pellet shells and the implosion is likely to be disrupted by hydrodynamic instability. One can alternately obtain higher velocity by increasing the laser irradiance and thereby produce higher ablation pressure. This approach allows high-velocity implosion of relatively thick-shelled smaller-diameter targets that are much more resistant against hydrodynamic instability. The Krypton Fluoride (KrF) laser has substantial advantages towards implementing this approach. Its 248 nm deep-UV wavelength and very broad bandwidth suppress the laser-plasma instability that limits usable peak irradiance. The short laser wavelength also gives higher pressure and more efficient absorption. One-dimensional simulations using a KrF driver predict ignition at about 130 kJ and gains of about 15 at 250 kJ. This approach opens the opportunity for a relatively small high-repetition KrF-based laser fusion facility that would be useful for developing and testing fusion energy science and technologies.

We are examining our phased development of laser-fusion energy in light of this newly realized opportunity. The ongoing Phase I effort involves developing basic IFE technologies including high-repetition lasers; Phase II includes development of a full size driver module; and the new Phase III would involve building a reduced-scale high-repetition laser-fusion facility. The laser driver for this facility could be as small as 250 kJ and therefore be relatively low cost compared to the earlier MJ class concepts. This Fusion Science and Engineering Test Facility would develop target physics, chamber clearing, wall materials and target injection in a power-plant-like environment but with smaller size. It would produce a few tens of megawatts in 14 MeV neutrons that should be useful to test materials and blanket concepts for all approaches to fusion. We believe this program would provide the S&T experimental base for follow-on full-scale laser fusion power plants.

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