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Two Decades of Progress in Understanding and Control of Laser Plasma Instabilities in Indirect Drive Inertial Fusion[1]

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Our understanding of laser-plasma interaction (LPI) physics has improved dramatically over the past two decades through advancements in experimental techniques, diagnostics, and theoretical and modeling approaches. We have progressed from single-beam experiments — ns pulses with ∼kJ energy incident on hundred-micron-scale target plasmas with ∼keV electron temperatures — to ones involving nearly 2 MJ energy in 192 beams onto multi-mm-scale plasmas with temperatures ∼4 keV. At the same time, we have also been able to use smaller-scale laser facilities to substantially improve our understanding of LPI physics and evaluate novel approaches to the their control. The need to interpret and understand these detailed LPI experimental results has inspired an evolution of theoretical models, from 1D fluids with linear plasma wave responses to individual beams via a three-wave interaction, to today's fully nonlinear, 2D and 3D fluid and kinetic simulations of systems whose LPI dynamics are dominated by wave-wave and wave-particle nonlinearity. These efforts have led to a change in paradigm for LPI research, ushering in an era of engineering LPI to accomplish specific objectives, from tuning capsule implosion symmetry to fixing nonlinear saturation of LPI processes at acceptable levels to enable the exploration of high energy density physics in novel plasma regimes. This talk will review the progress in the field from the vantage of the foundational LPI experimental results. The pedagogical framework of the simplest models of LPI will be employed, but attention will also be paid to settings where more sophisticated models are needed to understand the observations. Prospects for the application of our improved understanding for inertial fusion (both indirect- and direct-drive) and other applications will also be discussed.

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