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A Photon Kinetic Description of Laser Bandwidth Mitigation of Laser Plasma Interactions

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In both direct drive and indirect drive laser fusion it is necessary to limit the level of stimulated scattering from laser plasma interactions to almost zero level. One way to accomplish this is to use broadband lasers. However, the inclusion of bandwidth or incoherence effects in theoretical models of laser driven parametric instabilities in plasmas is a long-standing problem. The difficulty resides in the lack of an appropriate theoretical framework where a statistical description of the radiation is natural. A generalized Wigner Moyal statistical theory of radiation, or generalized photon kinetics (GPK), formally equivalent to the full wave equation, is used to derive the general dispersion relation for Stimulated Raman Scattering (SRS) and Stimulated Brillouin Scattering (SBS) driven by a spatially stationary radiation field with arbitrary statistics. The theory is thus valid for all ranges of coherence of the pump field. In this dispersion relation, both three-wave processes and four wave processes are included, and for a plane-wave pump field the standard results are recovered. Analytical results, are derived for different regimes of SRS and SBS and wave number ranges, showing universal lowering of the growth rate with bandwidth. Laser bandwidths of around a percent can reduce the growth rates significantly to a level where the level of stimulated scattering is acceptable. Such photon statistical models can also be used to study other problems such as photon Landau damping and photon acceleration in plasmas.