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A Potential New Light Source for Nuclear Fusion

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Abstract

Lasers typically emit light of one or two, well-defined, frequencies (or ‘colours’). However, numerous applications arise if such light can be converted into a broad, multi-frequency (e.g. ‘multi-colour’) comb of laser beams. Applications range from meteorology, sensing and measurements to those potentially in the domain of the emerging research field of attosecond science. We report on detailed investigations of a novel self-organisational effect that can convert laser light into an extremely broad comb of multi-colour beams. The importance of this new effect is that it spontaneously gives rise to an extreme enhancement of the output comb bandwidth, and that constituent frequencies may self-synchronize.

The bandwidth generated may extend across the entire visible spectrum, resulting in white light laser output. But, the breadth of new frequencies actually extends well beyond this – into the invisible infra-red and ultra-violet regions of the electromagnetic spectrum. The synchronization of so many frequencies can result in attosecond pulses. During the last decade, there have been several reports of contexts [1-3] where efficient broadband frequency comb generation may be possible. We will demonstrate distinctiveness with regard to these known contexts, and summarise results from an exhaustive exploration of this new effect. Moreover, we will compare modelling results with two new analytical models, developed to lend insight into the underlying physics involved.

A specific potential application of our results arises in the area of Inertial Confinement Fusion (ICF), where high gain targets require collisional absorption to be the dominant process in the laser-target coupling. Experiments have shown that reducing the coherence of the incident light can suppress laser-driven plasma instabilities [4,5]. However, a simple increase in the bandwidth of the incident light can also increase thresholds and lower growth rates for such instabilities [6-8]. Thus, instability-free transmission of high energy light can be attained by dividing this energy into very many, separate frequency channels. However, absorption of the energy of this comb of multi-colour beams at the fusion target can remain relatively unaffected by such frequency division. This approach, as an alternative to or in combination with the use of incoherent sources, has therefore been suggested for ICF [9,10].

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