Mg $L_{2,3}$ stimulated emission from MgO pumped by FERMI FEL pulses: a milestone toward a soft-x-ray solid-state laser

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Summary

We show evidence, both experimentally and theoretically, for stimulated emission of Mg $L_{2,3}$ from a MgO solid target pumped by extreme ultraviolet pulses delivered by the FERMI free electron laser (FEL) facility in Trieste (Italy). We observed in backward geometry two effects separately revealed in semiconductors [1] and metals [2]: the stimulated emission process is enhanced in a privileged direction and its intensity exhibits a material-dependent threshold characteristic of the spontaneous amplified emission regime [3]. Our results could represent a milestone for future soft-x-ray solid-state lasers.

Experiments and results

As shown in Fig. 1, we used 65 fs FEL pulses at 56.8 eV impinging normally a MgO solid sample with a maximum fluence of 10^{13} photons/pulse. The intensity of the Mg $L_{2,3}$ emission is measured as a function of the angle β and of the FEL pulse intensity. The angular distribution recorded at maximum FEL fluence peaks around 50° (Fig. 2). The intensity vs FEL intensity measured at β = 52°, presents first a slightly increasing plateau followed by a linear growth from $7x10^{12}$ photons/pulse (Fig. 3) being the threshold of a lasing process. The results (directionality, pumping threshold, …) are modelled by a set of rate and transport coupled equations, confirming that the Mg $L_{2,3}$ stimulated emission is generated in the regime of travelling-wave amplified spontaneous emission.

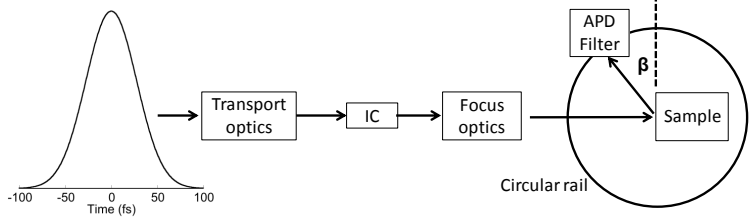

Figure 1: The MgO sample normal to the incident FEL beam; the emitted radiation is measured versus the detection angle β using an avalanche photo-diode.

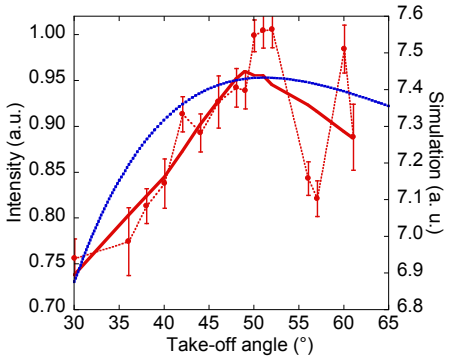

Figure 2: Angular distribution of the Mg $L_{2,3}$ emission generated in MgO upon the FEL irradiation at 56.8 eV: (points and thin dotted line) measurements from the APD detector; the error bars correspond to 3 statistical errors; (thick line) smoothed experimental curve; (thick dotted line) simulation.

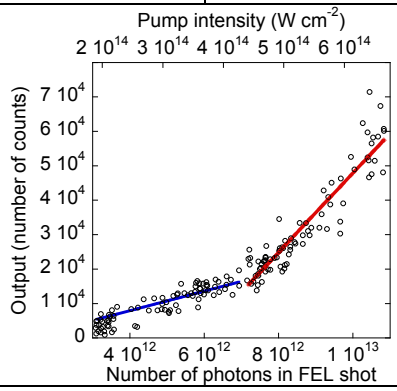

Figure 3: Number of detected Mg $L_{2,3}$ photons as a function of photons in a FEL shot and of the pump intensity: (points) experimental values; (blue solid line) region of the slightly increasing plateau; (red solid line) linear fit.

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References

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[2] H. Yoneda *et al.*, Nature **524**, 446 (2015)
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