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## Perspective on FEL based WM

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In this paper, we will discuss how recent advances in the performance of the FELs allowed non-linear experiments at sub-optical wavelengths. In particular Second Harmonic Generation (SHG) [1] and Transient Grating (TG) [2] experiments have finally demonstrated the high potential of VUV/soft X-ray wave mixing techniques. TG experiments at sub-optical wavelength are relevant for the study of nanoscale dynamics in disordered systems as well as in semiconductors. Exciting phonon modes with nanometer wavelength would allow shedding light on a plethora of scientific open problems ranging from the thermal anomalies in glasses to understanding nanoscale thermal transport [3]. Wave mixing in the soft X-ray could be used as well to investigate drug/target intermolecular vibrational dynamics [4], or to measure natural circular dichroism signals [5].

[1] R. K. Lam, et al., Phys. Rev. Lett. vol. 120, pp. 023901 January 2018.

[2] F. Bencivenga et al., Adv. In Phys., vol. 63, pp. 327, May 2015.

[3] F. Bencivenga et al., Science Adv. vol. 5, pp. 5805, July 2019.

[4] R. Mincigrucci et al., submitted

[5] C. Masciovecchio et al., in preparation

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