Use of various seeding light sources for seeding FELs

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The Self-Amplified Spontanenous Emission (SASE) mode is currently employed for short wavelength Free Electron Lasers (FELs) because of lack of mirrors in the whole spectral range. SASE presents a limited temporal coherence, conveying « spikes » in the temporal and spectral distributions, because the emission starts with noise. For single pass sources, the injection of an external laser source tuned on the fundamental wave of the undulator (seeding) can improve the temporal coherence in relation to SASE, reduce the gain length and limit the intensity fluctuations. Using conventional lasers limits the wavelength of the seed to the UV (frequency doubled or tripled laser) and does not permit in principle to reach very short FEL wavelength, requiring up-frequency conversion. Coherent sources at short wavelength can also be considered as seeds. High order Harmonics generated in Gas (HHG) produced by focusing an intense laser in a gas (jet or cell) provide nowadays sources with transverse and longitudinal coherence down to a few nm in trains of attosecond pulses in a femtosecond envelop. They have been successfully employed to seed Free Electron Lasers at short wavelength. Indeed, seeding has been recently performed with High order Harmonic in Gas (HHG) seed on SCSS Test Accelerator in Japan at 160 nm in the frame of a French Japanese collaboration. Studies on the seed level were carried out. A further step has been achieved with the 60 nm HHG seeding. HHG seeding has also been conducted at SPARC and is under test at S-FLASH. Tuneability is here provided thanks to the tuneability of the generating laser coupled to stepping from one harmonic to the other. A more easily tuneable seeding source can also be considered, such as the radiation recently demonstrated with the kagome hollow-core photonic crystal fiber filled with noble gas. The emission of a resonant dispersive wave in the DUV spectral region process accompanies the soliton-effect self-compression of the pump pulse down to a few optical cycles. Pulses are diffraction-limited, of tens of femtosecond duration and provide energies larger than 50 nJ and fs-duration with a continuously tunability from below 200 nm to above 300 nm. One could also consider high order harmonics generated in solid targets. Short wavelength seed can also be combined to various up-frequency conversions scheme employed in Free Electron Lasers.