Present and Future of Soft to Hard X-ray Free-electron Lasers

Zhentang Zhao
Shanghai Advanced Research Institute, Chinese Academy of Sciences

The X-ray free-electron lasers (X-ray FELs) have given us the first chance to explore the structures and dynamics of the atomic and molecular system at femtosecond time scales and angstrom space scales. At present, FELs hold the possibility to provide radiation pulses with perfect spatial coherence, high peak power at hundreds of GW level and pulse duration of sub-femtoseconds to hundreds of femtoseconds. The most exciting milestone in FEL history is the operation of the first hard X-ray FEL facility – LCLS in 2009. Motived by the success of LCLS, several X-ray FEL facilities have been built worldwide. In Japan, SACLA achieved lasing at wavelengths as short as 0.06nm in 2011. In Italy, Fermi@Elettra became the first seeded FEL covering a wavelength range between 100nm to 4nm in 2014. In South Korea, the PAL-XFEL produced a 0.1nm FEL pulse with less than 20fs time jitter at the end of 2016. European XFEL delivered first laser and started operation in 2017. The hard X-ray branch of Swiss FEL started user operations early in 2019. The SXFEL in China is now under commission and will soon be opened to users. In addition, a lot of new proposals and upgrade plans, like SHINE, LCLS-II, FLASH-II, have showed the vigorous side of the FEL technology. For the foreseeable future, X-ray FELs will raise the peak power to the TW level and reduce the pulse duration to the attosecond level. Combining these enhanced properties with features like broad-bandwidth, well-defined polarization, high-repetition rate and fully coherence, X-ray FELs will continue helping extend our knowledge of the ultrafast and ultrasmall world.