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Research at DESY's VUV-FEL user facility FLASH

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FLASH is currently the only operating free electron laser providing lateral coherent radiation in the wavelength range from 13 to 48 nm in the fundamental in flashes of 10 femtoseconds duration. One obtains 10^{12} photons per flash, i.e. as many as we get today from the best storage ring facilities per second. The maximum peak pulse energy for 13 nm is 120 μJ , the peak power is larger than 4 GW, the average power goes up to 30 mW. The peak brilliance reaches 5×10^{29} . The intensity of the third harmonic at 4.6 nm (270 eV) is on the 0.5% level of the fundamental. Since August 2005 FLASH operates as a user facility and experiments have been performed successfully on atoms, highly charged ions and clusters. First photoelectron spectra have been taken, materials damage problems have been studied and first pump and probe experiments with an additional optical laser beam have been performed successfully. With respect to single particle imaging it was demonstrated that a fully interpretable diffraction pattern can be obtained by one flash of 25 femtoseconds duration before the sample heats up to about 60 000 K and evaporates. The experiments show the importance of the combination of extremely high peak brilliance with very high average brilliance for future experiments at X-ray free electron lasers.