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Attosecond nonlinear optics

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Attosecond pulse generation was realized through high harmonic generation and has made it possible to observe attosecond phenomena [1]. Another interesting application of attosecond pulses is nonlinear optics in the XUV and soft x-ray region However, the pulse energy of attosecond pulses available so far is not intense enough to cause nonlinear optical phenomena. In this work, intense attosecond pulses were nonadiabatically generated by using 8-fs blue laser pulses. We present the observation of the above-threshold ionization (ATI) of rare gases by XUV pulses . [2] and demonstrate the autocorrelation measurement of isolated attosecond pulses. 8-fs blue laser pulses were generated by broadband frequency doubling (BFD) of Ti:sapphire laser pulses (photon energy 1.55 eV). BFD enables us to shorten the pulse duration with high efficiency. The blue laser induces relatively larger nonlinear dipole moment. At the same time, high harmonic pulses rises rapidly nonadiabatically and the field ionization shuts off the harmonic generation, producing intense isolated attosecond pulses. The ninth harmonic pulses of the blue laser (photon energy 27.9 eV) were generated by focusing the blue laser pulses into Ar gas and were characterized by the autocorrelation technique, in which the two-photon ATI process in helium atoms was used. The ATI process was confirmed by observing photoelectrons ejected from helium atoms, recorded as a function of the relative delay time of two high harmonic pulses to form an autocorrelation trace. The shortest pulse duration was 950 as with pulse energy of 2 nJ [3]. References .[1] E. Goulielmakis et al., Science 305, 1267 (2004)., [2] N. Miyamoto, M. Kamei, D. Yoshitomi, T.Kanai,T,Sekikawa, T. Nakajima, and S. Watanabe, Phys. Rev. Lett. 93, 083903 (2004). [3] T. Sekikawa, A. Kosuge, T. Kanai, and S. Watanabe, Nature ,432,604 (2004).