

ISS 10: Nano Plasmonic (A, HL)

Plasmons are collective motions of electrons in different environments being exhibited by surface states and nanoparticles on a condensed matter substrate as well as in free nanoparticles, clusters, and fullerenes. Even a single atom displays the collective motion of its surrounding electrons in the form of electron correlation satellite excitations. This intersectional subject of overlapping interest between condensed matter and atomic, molecular, and optical physics should be presented in this session.

Time: Friday 10:30–13:00

Location: BAR 205

Invited Talk ISS 10.1 Fri 10:30 BAR 205
Plasmon Driven Higher Harmonics Generation — IN-YONG PARK, SEUNGCHUL KIM, JOON-HEE CHOI, and ●SEUNG-WOO KIM — Ultrafast optics for ultraprecision research group, KAIST, Daejeon, Republic of Korea

Plasmonic resonance enables field enhancement of a low-intensity fs pulse, permitting high harmonic generation without an additional amplifier. This new concept of generating ultrafast higher harmonic pulse was previously demonstrated using Au bow-tie antennas. The resulting intensity enhancement factor reached ~ 20 dB and successfully produced up to the 21st harmonic. Notwithstanding the high enhancement factor, the 2-dimensional configuration of the bow-tie nanostructure was found sensitive to thermal damages preventing practical usage. To cope with the problem, a 3-dimensional solid nanostructure is newly proposed and tested in this investigation. The newly designed nanostructure takes the shape of an ellipsoidal tapered waveguide fabricated in a cantilever micro-structure. The tapered waveguide functions as a plasmonic device that induces field enhancement by exploiting surface-plasmon polaritons being created as a femtosecond pulse propagates through. In comparison to bow-tie nano-antennas, the use of surface plasmon polaritons offers a much larger volume of enhanced laser field due to counter-propagating surface plasmon modes within the waveguide in response to the incident femtosecond pulse. The intensity of incident NIR pulses is enhanced by a factor of ~ 350 , being strong enough to produce EUV harmonics up to the 43rd order directly from a modest input intensity of 10^{12} Wcm $^{-2}$ in interaction with Xe gas.

Invited Talk ISS 10.2 Fri 11:00 BAR 205
Structure and Dynamics of Free Nanoparticles: From Charging to Time-Resolved Photoemission — ●ECKART RÜHL — Physikalisches Chemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin

Nanoscope systems prepared from nanoparticles as unique building blocks have the advantage that their properties depend critically on the single nanoscopic units and their assembly on substrates. Single nanoparticles show often size and composition dependent optical, electronic, structural, and dynamical properties. This includes quantum size effects, which are efficiently modified by the internal structure of the nanoparticles and their surroundings. Recent progress in chemical syntheses of structured nanoparticles as well as properties of single nanoparticles is presented. This includes controlled preparation of dimers or small aggregates of nanoparticles. Single, free nanoparticles without any contact to other particles or substrates are either prepared in traps or focused nanoparticle beams. These approaches allow us to study the intrinsic size- and composition dependent properties of isolated nanoscopic matter and their photon-induced dynamics. Results from a variety of different experimental approaches making use of synchrotron radiation and ultra-short laser pulses are presented. These provide specific information on the electronic structure, plasmonic excitations, the location of the emitted electrons in nanoparticles, the dynamics of electron emission and cation formation, as well as the dynamics of collective electronic excitations in the femtosecond time domain.

Invited Talk ISS 10.3 Fri 11:30 BAR 205
Terahertz Nano Plasmonics — ●DAI-SIK KIM — Center for Sub-wavelength Optics, Department of Physics and Astronomy, Seoul National University, Seoul, Korea

In this talk, we will focus on how terahertz electromagnetic waves, with wavelengths in the millimeter scale, can funnel through nano slits and nano slot antennas. The field enhancement is enormous, three orders of magnitudes, which can be used for nonlinear processes and ultrasensitive probing of underlying structures. Optics in extreme subwavelength regime resembles electro-statics involving capacitors, in contrast to the electromagnetic waves in free space.

Invited Talk ISS 10.4 Fri 12:00 BAR 205
Coulomb complexes: Electron emission from clusters in strong FEL pulses — ●ULF SAALMANN — MPI for the Physics of Complex Systems

The response of atomic clusters to short intense pulses at extreme-ultraviolet (XUV) and X-ray wavelengths—as available from short-wavelength free-electron laser (FEL) sources like FLASH in Hamburg/Germany, the SCSS in Japan or LCLS in Stanford/California—is studied theoretically. Due to the high photon flux the clusters become multiply charged by massive electron emission. We devise a model, which we call Coulomb complexes [1], in order to investigate the emission process. It turns out that the electron spectra strongly depend on the ionization rate. For low rates the electron release occurs sequentially and our model allows for an analytical description of the plateau-like electron spectra [1]. At high rates a dense nanoplasma is formed and ionization occurs through energy-exchanging collisions resulting in exponential electron spectra [2]. Both mechanisms can be understood in terms of our model containing only very few parameters available from experiments.

[1] Gnodtke, Saalman, Rost, New J. Phys. in press (2011).

[2] Bostedt et al., New J. Phys. **12**, 083004 (2010).

Invited Talk ISS 10.5 Fri 12:30 BAR 205
Appearance of Surface and Volume Plasmons in Fullerenes — ●SANJA KORICA¹, AXEL REINKÖSTER¹, MARKUS BRAUNE¹, JENS VIEFHAUS¹, DANIEL ROLLES¹, G. FRONZONI², D. TOFFOLI², M. STENER², P. DECLEVA², O. AL-DOSSARY³, BURKHARD LANGER⁴, and UWE BECKER^{1,3} — ¹Fritz-Haber-Institut der MPG, Berlin — ²Università di Trieste, Italy — ³King Saud University, Riyadh, Saudi-Arabia — ⁴Freie Universität Berlin

Since the discovery of the C₆₀ molecule in 1985 many studies have been performed to investigate its fundamental properties. These properties are mainly driven by its unique molecular structure like its spherical shell. One of the important characteristics of this molecule is the collective response of its valence electron cloud to electromagnetic radiation. This collective behavior gives rise to the occurrence of the giant dipole resonance a surface plasmon in the absorption spectrum centered around 20 eV, which has been analyzed theoretically by various authors. In addition, our photoionization cross-section measurements reveal a resonance near 40 eV, a volume plasmon analogous to observations made for C₆₀ ions. Time-dependent density functional calculations confirm the collective nature of this feature as corresponding plasmon excitation. A third excitation of this kind is predicted but not experimentally confirmed. Concerning photoelectron emission, plasmonic excitations are characterized by a particular intensity behavior near threshold. They follow the threshold behavior law predicted for the first time by Thomas Derrah. Our measurements of the C₆₀ plasmon excitations above the C 1s ionization threshold confirm this law very well and are in unexpectedly good agreement with the corresponding behavior of K-shell satellite excitations in atoms such as neon.