X-Ray Quantum Optics

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X-ray quantum optics has, so far, taken only a peripheral role in contemporary research. A few important phenomena are known from the literature, such as x-ray parametric down conversion [1, 2] and nuclear γ-ray superradiance [3, 4] The field is now poised to grow with the advent of novel coherent light sources, especially the x-ray free-electron laser (XFEL). Many ideas and concepts can be taken from the more mature field of conventional (near-visible) quantum optics, for example photon correlations and entanglement, squeezing, etc. There are, however, also important differences between the x-ray and near-visible cases. These are mainly due to the specics of photon-matter interactions, i.e., the role of inner-shell atomic energy levels, nuclear resonances, or large energy shifts in Compton scattering as photon energies approach that of the electron rest mass. For high-energy photons approaching 1 MeV, x-ray quantum optics also enters the domain of high-energy physics as pair creation can modify the vacuum. There will be brief introductions to the invited talks of the session, which will cover topics ranging from x-ray parametric down conversion to nuclear-resonant superradiance, electromagnetically induced transparency (EIT), and orbital angular momentum of photons. These will be followed by an overview of possible further experiments and applications, such as

- two-photon spectroscopy with linear intensity dependence using entangled photons [5] similar to a demonstration in the visible regime [6]
- inversionless lasing for free-electron and atomic-matter lasers
- control of timing and emission direction of nuclear γ-ray superradiance
- the Casimir force at sub-nm length scales
- photon correlations in scattering experiments at XFELs

Following the invited talks, there will be a general discussion about the relevance of x-ray quantum optics, similarities to and differences from conventional quantum optics, experimental programs to pursue, and specific equipment and facility needs.

References

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