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Using light to control electrons to create new light.

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Intense Gaussian light can create an electron-hole pair in a semiconductor (or dielectric) and guide the relative electron-hole trajectory. Before dephasing, in semiconductors (and some dielectrics), the electron and hole have a significant chance of re-encountering each other where they can re-combine, creating a sub-cycle optical burst of coherent, short-wavelength radiation. Repeated over many cycles, we produce high harmonic radiation stretching into the VUV. We use in-situ measurement to confirm that the process I have just described is valid (and very similar to what occurs in gases). One notable distinction is that the absorption length of VUV light in solids is very short, thereby weakening the influence of phase matching. However, I will show that phase matching still plays a role [1]. What I have described above happens locally, everywhere across the beam profile, but by using vector beams, light control over electrons and holes can also be at the whole beam level, especially when combined with coherent control (using a beam and its second harmonic). I will show that we can drive directed currents even with relatively low intensity light. Surprisingly, all we need is two pathway interference to drive currents with 360 degree control pixel-by-pixel with only the relative phase between a circularly polarized beam and linear polarized second harmonic as a variable. One important application is to generate THz solenoidal magnetic field transients. I will show that we create ring currents in GaAs with an associated magnetic field [2]. We predict very large ring currents and very large magnetic field transients in breakdown gases [3]. [1] A. Korobenko, et al., *Opt Express.* **27**, 32630 (2019). [2] S. Sederberg, F. Kong, F. Hufnagel, E. Karimi, C. Zhang, P. B. Corkum, unpublished results. [3] S. Sederberg, F. Kong, P. B. Corkum, unpublished results.