Electromagnetically induced transparency (EIT) is a quantum interference outcome that appears in three-level atomic architectures and initiates a sharp-edged transparency window within a wide absorption spectrum. In such systems the enhanced transmission is related to extreme dispersion. Consequently, the EIT effect enables a very small group velocity or even absolutely stops the light. In contrast to the EIT effect in atomic arrangements, the plasmonic metamaterial analogue of EIT, also termed plasmon-induced transparency (PIT) metamaterial, has attracted tremendous interest in a whole range of applications, including optical sensors, modulators, slow light (SL) and fast light (FL) devices and optical switching. The PIT effect results from the destructive interference between bright and dark plasmon modes, and can be regulated by tailoring the geometrical parameters of metasurfaces. Indeed, structured plasmonic meta-devices offer the design flexibility to be size scaled for operation across the electromagnetic spectrum and are extremely attractive for generating PIT, SL and FL behaviors via coupling of bright and dark subwavelength resonators.

In the framework of this project we intend to establish an interdisciplinary research team to simulate, characterize and optimize the tunable properties of the PIT, SL and FL effects occurring in hybrid terahertz metamaterials. In our approach, active stimuli-responsive materials (i.e. liquid crystals (LCs), vanadium dioxide (VO_2), and molybdenum disulfide (MoS_2)) will be integrated with metallic resonating meta-pixels to achieve a series of tunable and ultrafast hybrid terahertz metamaterials. The active switching of such hybrid system is thus attributable to the voltage, temperature, and photosensitivity of LCs/VO_2/MoS_2 contained in the metamaterial cavity. This makes it possible to achieve even picosecond switching times. Importantly, the strategy presented here allows continuous tunability of the plasmonic properties, in contrast to most reported methods to date, which usually allow only switching between the on and off states. Furthermore, the methodology proposed within the project allows for ultrafast and low-power electro-optical switching of plasmonic resonance. Such hybrid and active metamaterials open up the avenues for designing micro-sized active circuitry with switching, modulation, and “slowing down and speeding up terahertz waves” capabilities.

These hybrid and active metamaterials can provide a platform for construction of multifunctional structured photonic devices, e.g. bio-chemical sensors, absorbers, filters, nonlinear switches, whose properties can be actively modulated, and as a consequence, they are impossible to achieve employing currently used counterparts.

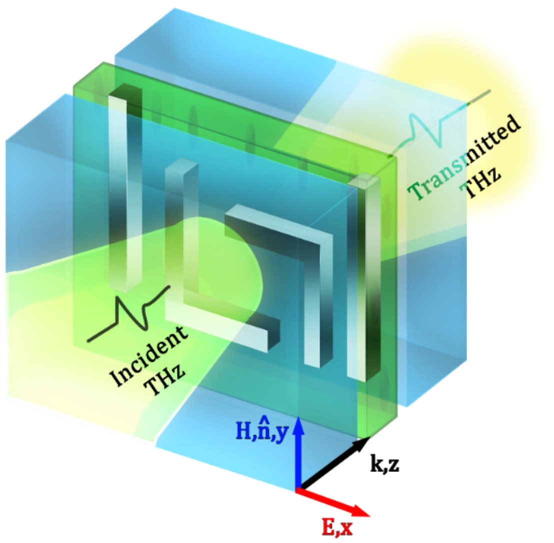

Fig. 1. Scheme of the single unit cell of PIT-based hybrid terahertz metamaterial. Blue color indicates dielectric substrates, silver color – metasurface unit cell, and green color – stimuli-responsive material (LC, VO_2 or MoS_2).