Electrical control of spin transport in yttrium iron garnet thin films

Pure spin currents, i.e. the flow of angular momentum without an accompanying charge current represents a new paradigm in the field of spintronics. Most importantly, pure spin currents can be transported by fermions, i.e. by electrons, in electrical conductors as well as by bosons, i.e. by quantized magnetic excitations, in magnetically ordered insulators. Interestingly, heterostructures consisting of spin-orbit coupled metals with magnetically ordered insulators allow investigating pure spin current transport in both regimes and their interconversion at the interface. I will present our recent experiments on the control of magnon spin currents via a DC charge current injected pure spin current. In the first part, I will discuss our approach to generate pure spin currents in metallic ferromagnetic thin films deposited on yttrium iron garnet (YIG) via the anomalous spin Hall effect. Utilizing an equivalent spin current circuit model, our experiments allow quantifying the efficiency of the charge to spin current conversion process in the ferromagnetic material. Our results suggest that ferromagnetic metals are also good candidates for efficient charge to spin current conversion. In the second part, we utilize three electrically isolated platinum (Pt) electrodes deposited on an ultrathin YIG film. Employing all-electrical injection and detection mechanisms, we provide evidence for efficient spin transport manipulation by a DC charge current in these devices. I will further discuss the origin of the observed non-linear effects and threshold behavior in the framework of magnon Bose-Einstein condensation induced by a DC charge current. Above a critical DC current, the magnon density is sufficient to form a magnon condensate and eventually trigger auto-oscillations of the magnetization. In this regime, our diffusive magnon transport experiments indicate a zero-resistance state below the injector strip.