On-chip microwave spectroscopy: a toolset for the route towards topological superconductivity

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Narrow gap semiconductors, such as InAs and InSb have become the most studied platform of topological superconductivity and Majorana zero modes (MZMs) due to their strong spin-orbit coupling, large Landé g-factor and the possibility of inducing superconductivity with highly transparent Ohmic contacts to bulk superconductors.
We utilize a superconducting tunnel junction as an *on-chip* microwave generator to investigate the essential building blocks of prospective topological quantum bits. By exploiting the AC Josephson effect, we map the excitations of nanowire Josephson junctions up to $200\,\mu\text{eV} \approx 90\,\text{GHz}$ bounded by the superconducting gap of the generator. With this technique, we show the presence of gate-tunable Andreev bound states in a ballistic semiconductor channel for the first time, and demonstrate how an external magnetic field influences the spectrum in the presence of strong spin-orbit coupling, relevant for Majorana bound states. In addition, we demonstrate that the microwave generator has a profound influence on the poisoning dynamics of Cooper-pair transistors made of InAs nanowires with an epitaxial aluminium shell.