# Optical measurements of mmWaves near resonant structures via Rydberg atomic interface

Lately, the scientists researching radio frequencies have been focusing on the study of extremely high frequencies. It is clear to see why: next generations of wireless communication need faster and faster data transfer, which higher radio frequencies are required for. The current 5G technology already uses frequencies 20 times higher than the ones that our standard WiFi runs on. The plans for 6G and 7G technologies include even higher ones. When we increase the frequency of radio wave, its length decreases, and it happens that for extremely high frequencies the waves have a few millimetres, which is why they are called mmWaves.

The problem with the mmWaves is that they are difficult to measure precisely. Because they have extremely high frequencies, they oscillate very quickly and we need very fast equipment to even register them. What is more, because for a mmWave a lot may change at a distance of a few millimetres, all of the circuits and antennas have to be very carefully and precisely manufactured. It all comes down to very high costs of all the equipment, and it is viable to look for alternative technologies.

One of promising emerging technologies are Rydberg atoms – atoms enlarged and specially prepared with lasers. They can be very sensitive to radio frequencies, in particular even mmWaves, and because they are placed in a glass cell, the detectors based on them contain no metal – this is a very different situation than when standard metallic antennas are used. The Rydberg atoms are so sensitive that using them we can observe effects that can be explained only by the laws of quantum physics.

In this project we want to study how detectors based on Rydberg atoms behave when they are placed near a resonant structure made for mmWaves, such as an antenna or a resonant cavity. In particular cavities seem to be very interesting – they can trap the mmWaves inside and the Rydberg detector placed there may register such a trapped wave. It is promising that due to the exceptional sensitivity, we may count even single photons trapped in a cavity.