Spectral line shape analysis gives the information of the internal structure of investigated molecule as well as interaction with surrounding molecules. Spectroscopic laboratories data obtained under controlled conditions, are collected in widely available databases, like HITRAN, GEISA or ExoMol. They are needful in many fields basing on molecular spectroscopy, e.g. to study Earth's atmosphere in terms of concentration of pollutants or greenhouse gases, to study the atmospheres of other planets, also the exoplanets, formation and evolution of stars, but also in the industry to monitor the production process or for breath analysis in medicine. The development of measurement techniques and numerical methods as well as new applications require increasingly higher precision and accuracy of the spectral line-shape parameters. Required uncertainty of the spectral line-shape parameters has to be of the order of tenths of a percent. Obtaining such accuracy for the laboratory reference data requires measurement techniques with a high signal-to-noise ratio as well as taking into account a number of physical effects during the radiation molecules interaction, as well as interactions with other gas molecules - so-called collisional effects that affect the shape and position of individual spectral lines. This requirement for the accuracy of the reconstruction of molecular spectra made the new spectroscopic databases expand the spectral lines description beyond the Voigt profile. In 2014, the HTP model was recommended as a new standard for the description of the spectral line shapes, which allows achieving a sub-percent accuracy.

Cavity ring-down spectroscopy (CRDS) is currently one of the most sensitive and widely recognized methods for trace gas detection and precise measurements of weak absorption spectra. It relies on the measurement of absorption by a gas sample in the optical cavity (resonator). The main elements of the optical cavity are very high reflectivity mirrors. After entering the cavity the light reflects many times between these mirrors, it results in a very long optical path equal to several kilometers, which allows to observe even very weak absorption, impossible to measure by other methods. High accuracy and precision of the frequency axis of the recorded spectra is possible due to the link of a CDR spectrometer with an optical frequency comb. Direct link to the optical frequency comb (OFC) allows for the determination of the optical frequencies with extremely high accuracy by direct measuring of the absolute frequencies.

CRDS is being developed at the Institute of Physics of Nicolaus Copernicus University (KL FAMO laboratory) for about 10 years. Previous experiments have been conducted in the visible range (around 689 nm: oxygen B band) and in the infrared (1.5 μm: spectra of CO, H_2 and D_2). The investigation described in this project will be performed in the spectral range of about 1.22-1.32 μm, where it was not yet conducted. The measurement system in the new spectral range in combination with the data analysis using advanced line shape functions will provide more accurate reference data on intensities, transition frequencies and line shape parameters of molecular oxygen in this spectral range and comparison with theoretical data.