An Optical Design Concept for Future Heterodyne Instrumentation in Space

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***Abstract*— Existing ground- and space-based astronomical observatories like Herschel-HIFI, SOFIA and ALMA currently provide a wealth of high spectral resolution data in the far-infrared domain that are of key importance in modern astrophysics. Whereas the science goals of future space missions like JWST and SPICA can be targeted with highly sensitive direct detectors and medium spectral resolution spectrometers, a next generation space instrumentation will eventually require high resolution spectroscopy with $R \approx 10^7$ to 10^8 at far-infrared wavelengths probing the physical conditions and chemistry involved in for example star formation processes. Future heterodyne instrumentation requires in addition to enhanced spatial resolution and frequency extension into the 2-6 THz frequency range the application of heterodyne receiver arrays improving the overall mapping and observing efficiency.**

In this paper we present results of an optical design study into future heterodyne instrumentation for space. As a specific case we propose an instrument concept which can for example be applied to the Russian Millimetron mission. In addition to the required development of super-THz mixer, LO and low-dissipation IF amplifier technology overcoming thermal constraints related to the application of arrays, the optical design of a compact instrument accommodating multiple bands of heterodyne receiver arrays is considered as one of the main design challenges. We propose a highly flexible and modular system inspired by Herschel-HIFI enabling the operation of compact THz heterodyne arrays and offering dual-polarization and/or dual frequency observing capabilities. As future missions most likely feature a cooled telescope, with complementary direct detection instrumentation requiring low thermal backgrounds, special attention has been paid to the thermal architecture in relation to the Local Oscillator injection scheme.