Broadband Ultra-Compact High-Power Array Local Oscillator Sources for High-Spectral Resolution Submillimeter-Wave Receivers

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Star formation is the single most important process determining the chemical and physical evolution of galaxies. It is the fundamental process that makes life possible in the Universe. However, we still know very little about what initiates and regulates it. Despite the tremendous success of the Heterodyne Instrument for the Far Infrared (HIFI) on board the Herschel Space Observatory and other instruments, rapid mapping speed high-spectral resolution velocity resolved array heterodyne cameras are needed to investigate the transition from the diffuse ISM to dense molecular clouds from which stars form, to evaluate feedback processes, and to enable surveys of a wide range of regions of massive star formation on scales ranging from local regions in the Milky Way to nearby galaxies. Most of the key tracers of star forming regions such as ionized carbon, oxygen and nitrogen lie on the terahertz range between 1.4 THz and 4.7 THz.

The main limitation to achieve large-pixel count terahertz array cameras had been the lack of broadband terahertz local oscillator (LO) sources delivering enough power to drive array receivers. These LO sources need to be broadband to allow observation of multiple species, high-power to enable large-pixel count arrays, and ultra-compact to achieve the necessary pixel spacing to efficiently map star forming regions. The dc power consumption needs to be extremely low in order to make it possible to build large pixel count terahertz array receivers suitable to fly in balloon borne or space borne missions within the typical power constrains of these missions. Room-temperature operation to avoid the need for cryogenic cooling is also a must to keep the power consumption low. Moreover, individual pixel power control is required to maximize the instrument sensitivity and to avoid single point failures. Schottky diode based frequency multiplied LO chains have been the preferred technology so far for sources in the terahertz range and are currently the only technology that meets these requirements. The new generation of frequency multiplied LO sources recently demonstrated by our group exhibit one order of magnitude improvement in output power in the terahertz region. Record output powers of 550 mW in the 200 GHz range and 0.7 mW in the 1.6 THz range have been measured. Recently, we also successfully flew the first multi-pixel sources beyond 1 THz as part of NASA's Stratospheric Terahertz Observatory: A 4-pixel 1.46 THz source (~50 µW output power/pixel) and a 4-pixel 1.9 THz source (~30-40 µW output power/pixel). We recently demonstrated an ultra-compact 16-pixel 1.9 THz–2.06 THz source with a dc power consumption of ~2.6 W/pixel (ten times lower than the previous state-of-the-art). Here, we will discuss these latest developments together with the progress to demonstrate the first broadband room-temperature source at 4.7 THz (for [OI] detection). This work enables large pixel count terahertz array receivers.

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.