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An Ultra-Stable Mid-Infrared Transit Spectrometer for the Detection of Bio-Signatures in the Atmospheres of Exoplanets

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The discovery of the Trappist-1 system, which consists of an ultra cool M-dwarf star orbited by 7 planets, 3 of which are located in the habitable zone, has demonstrated that these types of planetary systems are very common. The search for bio-signatures in the atmosphere of such planets will be a high-priority science goal of future space missions. The mid-IR band between 3 and 15 um is probably the best available band for this science, because the spectral lines of methane, ozone, and nitrous oxide can be found in this range. The coexistence of these constituents in a planet's atmosphere is considered a very strong indicator for the existence of life on the planet.
Mid-IR transit spectrometers on future space missions such as Origins Space Telescope (Origins) will aim at detecting these bio-signatures in exoplanets around M-dwarfs. However, current mid-IR detectors which are based on impurity band conduction (IBC) devices do not provide the required 5 ppm stability for a reliable detection of the aforementioned spectral lines.

Here we describe the development of an ultra-stable Mid-IR Array Spectrometer which includes a calibration system that, needed to achieve the required stability. The spectrometer uses Transition Edge Sensors (TES) which are very linear and stable. Furthermore, the required detector parameters (sensitivity, dynamic range) for space based mid-IR transit spectroscopy can be met with existing devices. The calibration system consists of a temperature controlled black body source which itself will be monitored in the visible (at 0.5um) by a photo diode. At this wavelength the precision of the load temperature measurement exceeds that of an in-band calibration. This scheme will allow for real time monitoring of the detector gain and offset at about one minute intervals and with that it is anticipated to provide the needed stability for the detection of bio-signatures by means of mid-IR transit spectroscopy on space missions such as Origins.

Less than 5 years of experience since completion of Ph.D

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