Title: Lab demonstration of mid-infrared signal correlation for astronomical heterodyne interferometry

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Abstract

Context: Studying the formation of planets and protoplanetary disks around young stars requires the access to extreme angular resolutions which can only be achieved using interferometry with typically kilometric baseline mid-infrared instruments. Direct interferometry uses bulky mid-infrared free space delay lines to recombine the light from separate telescopes and to recover the astronomical object interferometric observables. Heterodyne interferometry, which is widely used in radio-interferometry, relies on a different approach and consists in detecting the heterodyne beating between the astronomical signal and a local oscillator (laser) at each telescope. The resulting heterodyne signals are radio-frequency signals can be either digitized or analogically processed to retrieve the interferometric observables.

Aims: We aim to demonstrate the interferometric recombination of two telescopes with a kilometric baseline in the N band using a heterodyne interferometry approach with photonic correlation. In the short term, we use a laboratory demonstration bench to test the different technological blocks that would be necessary for such a system and develop methods to operate a mid-infrared heterodyne interferometer.

Methods: For the heterodyne detection stage, we use commercial 1 GHz bandwidth infrared detectors and 10.6 um quantum cascade lasers to detect a wide-band infrared source. For the correlation stage, we use commercially available photonic components at 1.5 um telecom wavelength.

Results: We are able to measure the coherent flux of a wide-band source down to a few 100 fW (limited by our infrared detectors) and to retrieve the coherence envelop of an infrared source. We also demonstrate the ability to compensate free-space delay by fiber delay directly inside the photonic correlator.