HEterodyne Receiver for OST (HERO)

Martina C. Wiedner[*1], Andrey Baryshev[2], Victor Belitsky[3], Yan Delorme1, Vincent Desmaris[3], Anna Di Giorgio[4], Brian Ellison[5], Juan-Daniel Gallego[6], Maryvonne Gerin[1], Paul Goldsmith[11], Christophe Goldstein[7], Frank Helmich[8], Fabrice Herpin[9], Jean-Michel Huet[10], Willem Jellema[8,2], Jean-Michel Krieg[1], Philippe Laporte[10], André Laurens[7], Imran Mehdi[11], Gary Melnick[12], Benjamin Quertier[9], René Plume[13], Christophe Risacher[14], Russel Shipman[8], OST STDT and NASA Goddard Engineering Team[15],

[1] *LERMA, Observatoire de Paris, ENS, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, avenue de l'Observatoire, 75014 Paris, France*
[2] *Kapteyn Astronomical Institute, University of Groningen, P.O. Box 800, 9700 AV, Groningen, NL*
[3] *Group for Advanced Receiver Development, Chalmers University of Technology, Gothenburg, SE 41296,*
[4] *Istituto Fisica Spazio Interplanetario INAF, via Fosso del Cavaliere 100, 00133 Roma, Italy*
[5] *Rutherford Appleton Laboratory, Space Department, Harwell Campus, Didcot, OX11 0QX, UK*
[6] *Observatorio de Yebes, CDT-IGN, Apdo. 148, Guadalajara 19080, Spain*
[7] *CNES, 18 Avenue Edouard Belin, 31400 Toulouse, France*
[8] *SRON Netherlands Institute for Space Research, Landleven 12, 9747 AD Groningen, The Netherlands & Kapteyn Astronomical Institute, University of Groningen, Groningen, The Netherlands*
[9] *Laboratoire d'Astrophysique de Bordeaux, Pessac, 33615, France*
[10] *GEPI, Observatoire de Paris, PSL Research University, CNRS, Paris,75014, France*
[11] *JPL, California Institute of Technology, 4800 Oak Grove Drive, Pasadena CA 91109, USA*
[12] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA, 02138, USA*
[13] *University of Calgary, T2N1N4, Canada*
[14] *Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121, Bonn, Germany*
[15] *NASA Goddard Space Flight Center, 8800 Greenbelt Rd., Greenbelt, MD 20771, USA*
[*]Contact: martina.wiedner@obspm.fr

Abstract— The Origins Space Telescope (OST) is one of the four science and technology definition (STDT) studies selected by NASA Headquarters for the 2020 Astronomy and Astrophysics Decadal survey. OST is designed to a) Chart the Rise of Metals, Dust, and the First Galaxies, b) Unveil the Growth of Black Holes and Galaxies Over Cosmic Time, c) Trace the Signatures of Life and the Ingredients of Habitable worlds, and d) Study the Solar System in Context. To enable these studies OST is equipped with five instruments including the HEterodyne Receiver for OST (HERO).

HERO is based upon proven heterodyne receiver technology and encompasses the frequency range of 0.468 to 4.752 THz with up to 128 pixels per band. The major design challenges were to accommodate the large number of receiver components and minimize power dissipation at 4K and the overall payload power consumption.

HERO's optical system is designed to be compact and light-weight. A two-axis Offner Relay configuration within the optics allows the selection of the individual frequency bands and the internal hot and cold calibration loads. The Offner relay also allows pointing agility and fast scanning of the beam on the sky without moving the whole heavy satellite.

The mixers are divided into six frequency bands each having two polarizations, five bands for the frequency range from 0.47 to 2.7 THz and the sixth from 4.54 to 4.75 THz. For easy packaging and compactness on the sky, the mixer arrays are in square geometries. The lowest two frequency bands have 2x16 SIS mixers, the upper four bands 2x64 HEB. All mixers posses 8 GHz IF bandwidth and have state-of-the-art noise temperature.

The local oscillators for HERO are critical as they need to be tunable over a wide RF band and must provide sufficient power to 'pump' up to 2x64 pixels. Amplifier multiplier chains provide the LO for all bands, including that at 4.7 THz. The LO is divided in waveguide to the appropriate number of pixels. Subsequent optical transport and alignment of the LO signal from the space bus to the mixers located approximately 8m away poses an additional engineering difficulty and requires a path length compensation system and tip-tilt mirrors. These compensate for any vibrations or relative changes between the position of the space bus and the mixers.

Low power dissipation, low noise cryogenic SiGe amplifiers amplify the signal at 4K and 20K, and are followed by compact CMOS amplifiers in the warm space bus. The signal then passes into 128 (+2) extremely low power (1W/ 8GHz) digital spectrometers built either using CMOS ASIC technology or FPGAs.

The instrument control is located in 3 subunits and is fully redundant, while most other components are internally redundant.

An international team of experts has designed HERO and the OST STDT team and NASA engineering team for OST have substantially supported the concept. HERO builds on the successful Herschel/HIFI mission payload heritage, but exploits latest technical developments and very considerably extends HIFI in terms of sensitivity, and spectral and spatial coverage.