CONDOR
1.4 THz Hetrodyne Receiver for APEX and for GREAT on SOFIA

F. BIELAU, M. EMPRECHTINGER, U. U. GRAF, C. E. HONINGH, K. JACOBS, K. RETTENBACHER, G. SCHMIDT, J. STUTZKI, N. H. VOLGENAU, M.C. WIEDNER[1]

Universität zu Köln, I. Physikalisches Institut, Zülpicher Straße 77, 50937 Köln, Germany
[1]Contact: wiedner@ph1.uni-koeln.de

CONDOR (CO N^+ Deuterium Observations Receiver) is a heterodyne receiver covering the frequency band 1250 - 1530 GHz with an IF of about 1 GHz bandwidth (214 kms^{-1} at 1.4 THz), which will be increased up to 4 GHz. CONDOR is designed to be used on different telescopes. It will make observations at the Atacama Pathfinder Experiment (APEX) in Chile, and it will be incorporated into the German REceiver for Astronomy at Terahertz frequencies (GREAT) at the Stratospheric Observatory For Infrared Astronomy (SOFIA).
As in any other heterodyne receiver, the astronomical signal and the local oscillator (LO) signal are mixed, and the resulting Intermediate Frequency (IF) is read out spectroscopically. The critical components of CONDOR are the LO, whose power needs to be sufficient and stable, and the mixer, which must have as little noise as possible. The LO is manufactured by Radiometer Physics (Germany) and consists of a Gunn-Oscillator at about 125 GHz followed by a tripler and a quadrupler. The output power varies between 0.5 and 2 μW over the receiver band. To insure frequency stability, the Gunn is locked with a commercial Phase Lock Loop (PLL) with $\sim$55 dB carrier-to-noise ratio (C/N) at 10 kHz, necessary to give sufficient C/N after the $\times$12 multiplication for THz applications. For efficient coupling of the astronomical signal and the LO signal, we use a Martin-Puplett interferometer. Furthermore, we are focusing on waveguide based mixers to optimise the coupling of the beam with the telescope. To achieve a low receiver temperature, the main effort is directed toward developing phonon-cooled NbTiN Hot Electron Bolometer (HEB) mixers. The HEB mixer is produced in-house and needs to be cooled down to $\sim$4 K. Therefore, we use a closed cycle dewar at APEX and a liquid He dewar on SOFIA. The current IF signal at 1.5 GHz is amplified and upconverted to 5-6 GHz and then fed into the spectrometer of the telescope. The IF bandwidth will be increased to up to 4 GHz with the next generation of HEB mixers to allow extragalactic observations. The first results of the entire system show a noise temperature of about 2000-2500 K over the 1-1.8 GHz IF. The IF is currently limited by our isolator. Further tests of the system (total power and spectroscopic Allan variances, losses in the optics and Martin-Puplett interferometer, measurements of the receiver temperature over the IF band and as a function of LO power) are underway. After testing and optimising the receiver in the lab, we intend to make the first astronomical observations in 2005/06 at APEX. Observations at SOFIA are scheduled for 2006 or 2007.
CONDOR will be one of very few astronomical THz instruments. Its particular strength lies in its high spatial (APEX: 4.5", SOFIA: 20") and spectral (up to 45 kHz) resolutions. Our astronomical goals for CONDOR focus on observations of the high-J transitions of CO at 1267 GHz (11$\rightarrow$10), 1382 GHz (12$\rightarrow$11) and 1496 GHz (13$\rightarrow$12), the N^+ line at 1461 GHz, and the H_2D^+ line at 1370 GHz. Observations of high-J transitions allow us to probe hot molecular gas ($\sim$500K) and (with the help of mid- or low-J transitions) to determine its physical, chemical and dynamical properties. The high spectral and spatial resolutions of CONDOR in these lines will allow us to map the density and velocity structure of high mass star forming regions, thus constraining models of high mass star formation. Observations of the N^+ transition at 205 μm are intended to investigate the warm interstellar medium (WIM). In contrast to the C^+ line, the N^+ line only traces regions where hydrogen is ionised and/or diffuse, such as HII regions and the WIM. A comparison with the distribution of molecular gas (as traced by CO) and atomic gas (as traced by H) will give important clues to the origin of the WIM. Another exciting research area is an investigation of the chemistry in molecular clouds using the H_2D^+ line at 1370 GHz. This is the transition to the ground state of para-H_2D^+ ($1_{01} \rightarrow 0_{00}$). Recently, there have been many new detections of deuterated molecules and ions. At low temperatures ($\leq$ 20 K), theory predicts that all these deuterated molecules form via reactions with H_2D^+. Furthermore, H_2D^+ might be one of the very few tracers of cold dense cloud cores, as most other tracers freeze out. (See also poster by Emprechtinger et al. in this meeting.)