BRE-RAM: A Ground Based mm-Wave Ozone Radiometer at Bremen / Germany

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Instrumental Outline

The BRE-RAM (Bremen Radiometer for Atmospheric Measurement) is currently under construction at the Institute of Environmental Physics, University of Bremen. The goal of this projekt is to construct a radiometer at low cost and with the usibility at relatively humid sites. Therefore it is built for ground based measurments of the mainly pressure broadened thermally induced rotational emission line of ozone at 110.836 GHz. From the line-shape stratopheric ozone profiles over Bremen (53°04'N, 8°48'E) can be retrieved. The vertical resolution will be approximately 10 km for the altitude range of 20 - 55 km.

The detailed outline of the radiometer is shown in figure 1. The beam guiding to the antenna is realized by optics based on Gaussian beam technics, using components like mirrors and wire grids. Special features of the optics are a single-sideband-filter (SSB) surppressing the image sideband and a path length modulator (PLM) minimizing baseline effects in the spectra. After passing the horn-antenna the incoming radiation is down converted to 8 GHz by an uncooled Schottky diode mixer. The first intermediate frequency (IF) stage consists of an isolator, two low noises amplifiers and a bandpass filter. A second down conversion stage to a frequency of 995 MHz including again two amplifiers, a bandpass filter and an isolator provides the input signal for the acusto-optical-spetrometer (AOS). The bandwith of the AOS is 600 MHz and the frequency resolution is approx. 1.5 MHz. The whole radiometer is computer controlled and operates in the total power mode using a cold and a hot calibration-load, which are realized by a dewar filled with liquid nitrogen (77 K) and a mm-wave-absorber at ambient temperature (295 K). The system-noise-temperature of the radiometer is 2970 K in the single-sideband-mode.

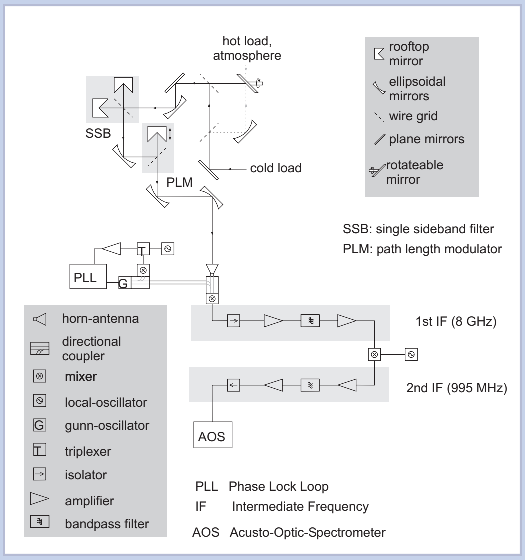

Figure 1: Schematics of the BRE-RAM. In the top part the quasi-optics and the calibration units, in the center the antenna, the Schottky diode mixer and the first local oscillator controlled by a PLL-electronic are shown. The lower section contains the amplifier chain with two intermediate frequency stages and the spectrometer.

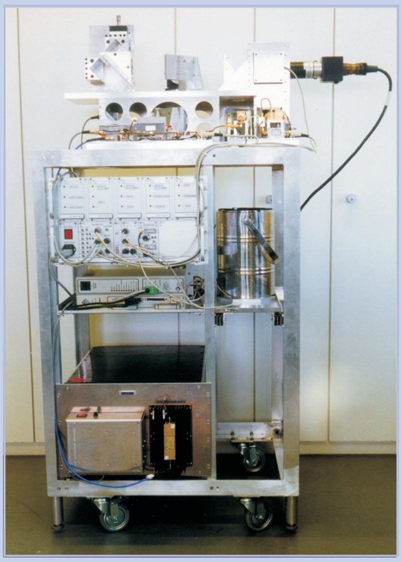

Figure 2: Photo of the BRE-RAM. On the top of the rack the quasi-optics and in front of that the mixer and the two intermediate frequency stages are mounted. In the center the control electronics and the dewar for the cold load are installed. The lower section of the rack holds the acusto-optical-spectrometer.

Conditions for mm-Wave-Measurements at Bremen

Seasonal ozone changes over Bremen measured by the TOMS-instrument are shown in figure 3. A typical annual variation with high ozone values in winter and low values in summer is evident. In wintertime changes of total ozone by approx. 200 DU in a few days are common and mainly caused by atmospheric dynamics.

Ground based radiometry is limited by tropospheric water vapor. As shown in figure 5 weather conditions in Bremen are known to be rather humid. The average water vapor column in the atmosphere is approx. 27 mm. Globally gridded data of water vapor profiles from the DAO GEOS1 Multiyear Assimilated Datasets of the Data Assimilation Office, NASA, which are based on measurements, were used for radiative transfer calculations at 110.8 GHz. They produce a typical seasonal cycle in zenith-opacities over Bremen. We expect that measurments by BRE-RAM will be possible at opacities better than 0.35 Neper corresponding to a transmission of 50% at a typical elevation angle of 30°. Measurements by the BRE-RAM may be limited in summer.

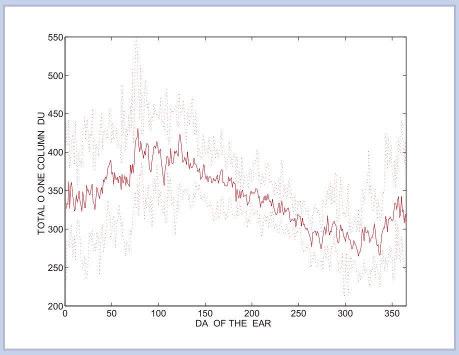

Figure 3: Total ozone columns over Bremen based on TOMS-data. The blue line represents the average of ozone columns in the eighties, the dotted lines daily maxima and minima during the years.

In order to illustrate the expected spectra measured by BRE-RAM we have carried out radiative transfer calculations with a N2-O2-H2O-O3 model atmosphere and measured profiles of water vapor, ozone, temperature and pressure. In figure 5 a wide range of calculated brigthness temperature mainly due to the variable influence of water vapor is shown. The 110.836 GHz emission line of ozone is situated on the wing of a very strong oxygen line at 118 GHz which causes an increased slope at higher frequency. The contribution of nitrogen is nearly constant over the frequency range and the seasons.

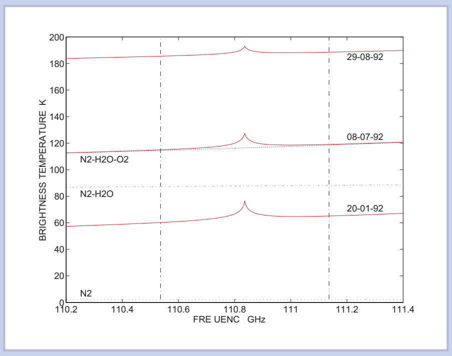

Figure 5: Radiative transfer calculations of the 110.836 GHz ozone emission line using a standard midlatitude ozone profile and tropospheric water vapor content over Bremen based on global gridded data from the Data Assimilation Office, NASA. January 20, July 8 and August 29, 1992 are typical examples of low, middle and high water vapor content. The influence of nitogen, oxygen and water vapor on the spectra is illustrated in the spectrum of July 8.

Figure 4: Calculated atmospheric zenith-opacities at 110.8 GHz based on water vapor profiles over Bremen obtained from the Data Assimilation Office, NASA. At opacities less then 0.35 Neper we expect good observations by BRE-RAM. The solid line represents monthly averages of water vapor columns.