Differential Microwave Hygrometer with Quasi-Spherical Resonators for Accurate Humidity Measurements on a Wide Range

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We have developed a differential microwave hygrometer (DMWH) for the measurement of the water vapor concentration in gases, in a wide dynamic range from some parts-per-million in volume (ppmv) to 1E5 ppmv. The DMWH measures the polarizability change in a moist gas in relation to the same gas devoid of humidity. The change is proportional to the shift of resonance frequencies in a microwave quasi-spherical resonator filled with the moist gas, in relation to another nearly identical resonator filled by the same dry gas. Differential measurement is used to remove any dependency of frequency shifts from gas pressure and temperature variations. In order to be able to measure low moisture content, pressure and temperature are controlled in both resonators. Temperature uniformity of both resonators is obtained using copper resonators and ensuring a strong thermal link between them. A temperature controlled vacuum enclosure is used to control the resonator's temperatures at the level of few millikelvin. A quasi-prolate spheroidal geometry is chosen for the inner surface of the resonator, in order to split the degenerate triplet for the TM11 and TE11 microwave modes of a perfect sphere. The frequency lock is based on a very robust and fast modified version of the Drever-Pound-Hall technique. The instrument is compared directly in terms of humidity using a reference chilled mirror hygrometer and shows a great sensitivity to moisture over the whole measured range. Due to its dependency only on frequency standards, the DMWH is a promising instrument for accurate humidity measurements on a large scale of moisture concentrations.