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Physically based modeling of water vapor continuum: current problems and perspectives

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In addition to intense spectral lines, water vapor possesses a much weaker continuum absorption which varies slowly with wavelength and pervades the entire IR and microwave spectral region. The integrated contribution of the continuum to the atmospheric absorption is larger than the contributions from major greenhouse gases such as CO_2 and CH_4. Thus, proper modeling of the continuum is an important part of the Earth radiation budget calculations.

Discovered by Rubens and Aschkinass[1] and later by Hettner[2] as a low-frequency component of water vapor absorption in the atmospheric transparency window 8-14 μm, this phenomenon remained unexplained, until Elsasser[3] hypothesized that the continuum is an accumulated *far-wing* contribution of strong water vapor spectral lines from the neighbor bands. This hypothesis was generally accepted until the strong quadratic pressure dependence of the continuum absorption as well as the strong negative temperature dependence were detected. To explain the observations Viktorova and Zhevakin[4] and then Penner and Varanasi[5] and Varanasi *et al.*[6] suggested that the main contribution to the continuum could be caused by *water dimers*. Since then a long scientific discussion has been continuing between the adherents of the "monomer" (or "far-wings") and of the "dimer" nature of the water vapor continuum.

Characteristic spectral signatures of the dimer were found under vib-rotational bands of the H_2O monomer in the IR range by Ptashnik *et al.*[7], indicating the significance of the dimeric contribution to the continuum.

The breakthrough in understanding the continuum was the discovery of rotationally resolved water dimer spectrum in water vapor at close to atmospheric conditions by Tretyakov *et al.*[8,9,10] and its independent verification by observation of the envelope of the maximum of the dimer rotational spectrum by Odintsova *et al.*[11,12]. This left no doubt about the continuum nature in the mm-submm range. However, further study of the continuum within pure rotational and fundamental vibrational H_2O bands revealed that the dimer hypothesis alone is insufficient: more dimers than allowed by the second virial coefficient are required to explain the observed absorption and the far wings hypothesis was revisited[13]. Qualitative analysis of the continuum magnitude and supporting evaluations of its temperature dependence demonstrate that these two mechanisms complement each other and make a comparable contribution to the continuum.

Despite the significant progress in the understanding of the continuum, available information is still insufficient for constructing a comprehensive predictive, physically justified model. Our experimental and theoretical efforts in this direction are discussed in the lecture together with potential approaches to solving the problem.

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