

National Radio Astronomy Observatory  
 Charlottesville, Virginia

To: D. S. Heeschen *25 Meter Millimeter Wave Telescope*  
*Memo #74*

From: B. E. Turner

Subject: On the Coefficients of Absorption of Atmospheric Water Vapor at Millimeter Wavelengths

The purpose of this memo is to show that there is no significant disagreement between the conclusions reached by Ulich (25-meter project memo #64) and reached by myself (Original Chapter VI, "Sites", Original 25-meter Proposal) on the question of water vapor absorption, contrary to recent statements made.

I expressed the absorption in terms of attenuation, in the form

$$A(\text{dB}) = a + b(\nu) W_v \text{ (mm)}$$

whereas Ulich expresses these effects in terms of transmission

$$= \exp \left\{ - \left[ \alpha(\nu) \cdot e^{-h/h_0} + \beta(\nu) \cdot W_v \text{ (mm)} \right] \right\}$$

At the frequencies of concern here,  $\nu \gg 230$  GHz, the value of  $\alpha(\nu) \approx 0$  and we shall ignore it. Then the two formulations are related by

$$= e^{-\beta(\nu)W_v} = e^{-A(\text{dB})/4.343} = a' e^{-b(\nu)W_v/4.343}$$

By arguments which are given in the original 25-meter proposal, which involve a number of experimental determinations, I used the values

$$a = 0.21$$

$$b = 0.165 \quad \text{at 230 GHz}$$

$$= 0.952 \quad \text{at 345 GHz}$$

Thus my constant  $a'$  has the value  $a' = e^{-0.21/4.343} = 0.953$  and my equivalent coefficient  $\beta(\nu) = b(\nu)/4.343$  is compared with Ulich's values below:

	(230 GHz)	(345 GHz)
BLU	0.067	0.20
BET	0.038	0.22

The agreement is excellent at 345 GHz, while I actually estimate a smaller absorption at 230 GHz than does Ulich, contrary to the statements made by Mark

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Gordon in his letter summarizing the Site search, and in various implied statements in Wade's site report. My constant  $a' = 0.953$  which is unity in Ulich's formulation, is indeed an over-estimate of the effects of absorption by  $O_2$ ; although the reduction in  $\tau$  due to my use of this constant is insignificant (<5%) I agree that the proper value should be closer to unity at 230 GHz.

If Ulich's value for  $\beta$  at 230 GHz is more reliable than mine, as I suspect it is, then it tends to argue in favor, rather than against, a site with low values of  $W_v$ . However, for the sites being actively considered, the differences in  $\tau$  using Ulich's and my values at 230 GHz are not very significant. At 345 GHz the differences are negligible.