Complex permittivity of water at room temperature

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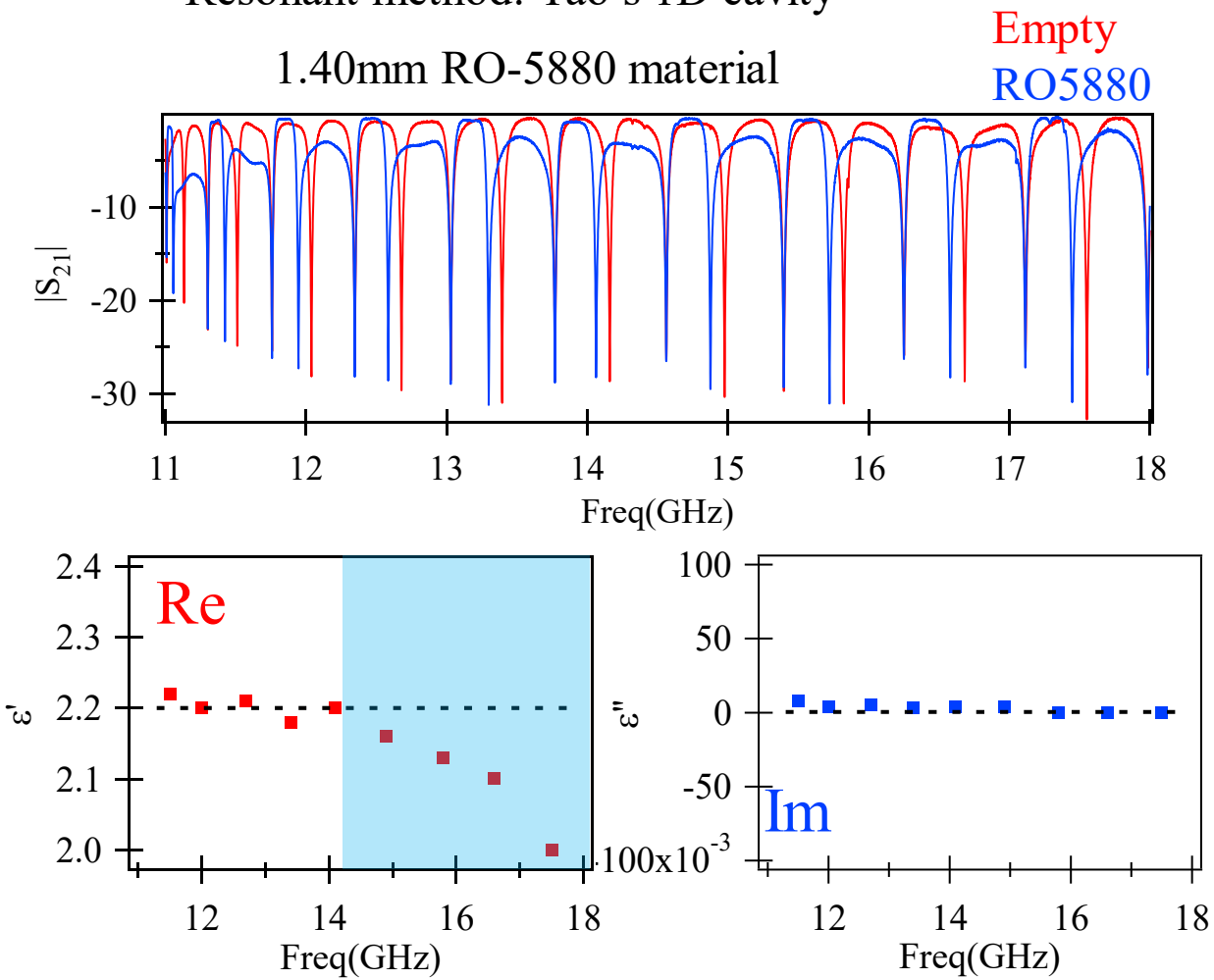
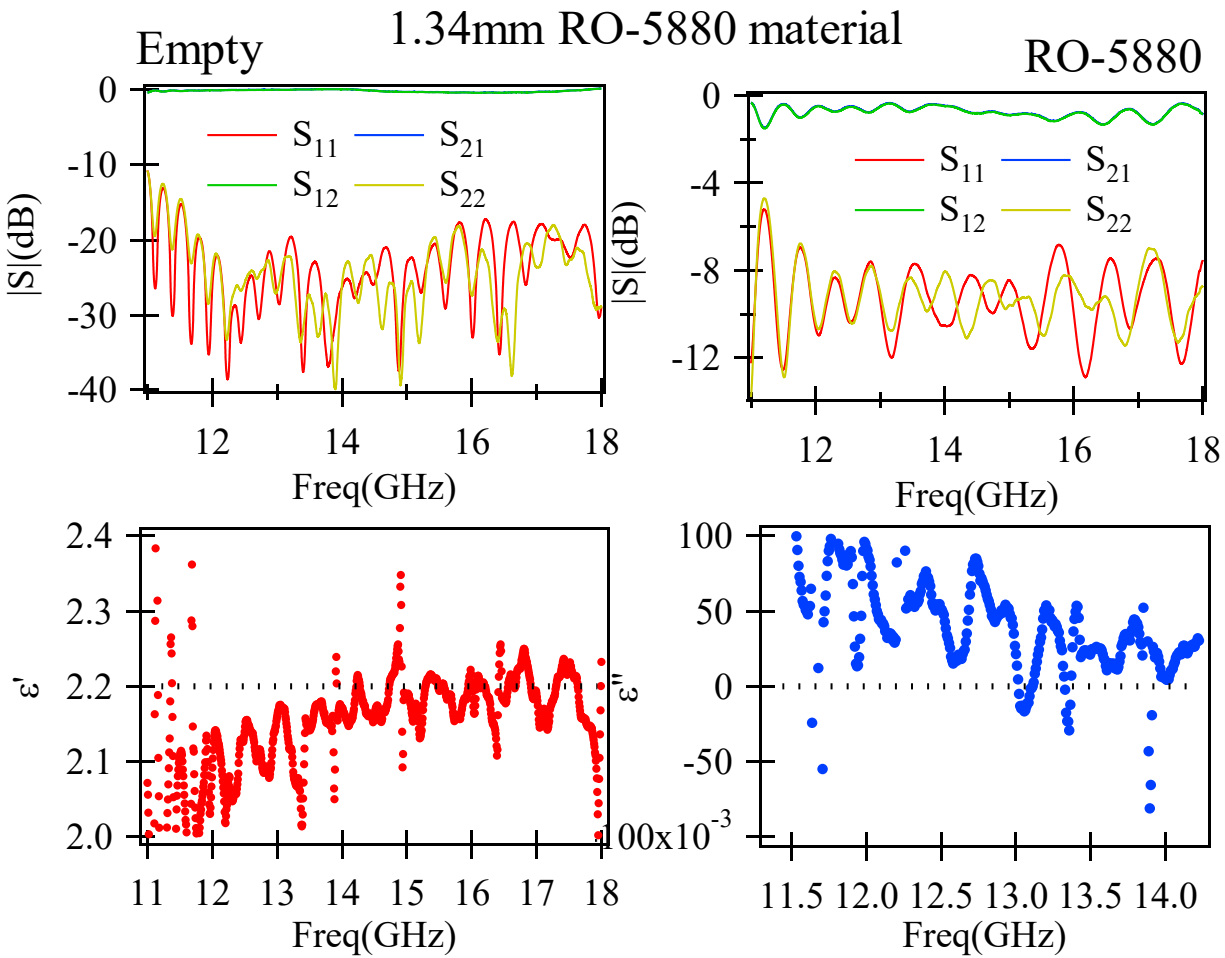
Yutong Zhao

Resonant method: Yao's 1D cavity

1.40mm RO-5880 material



Non-Resonant method: rectangular waveguide



Cutoff frequencies

$(f_c)_{TE_{11}} = 10.92\ GHz$

$(f_c)_{TM_{01}} = 14.26 GHz$

The shift may caused by the existence of TM_{01} mode

More noisy and not accurate than resonant method

The dielectric relaxation of water between 0°C and 35°C

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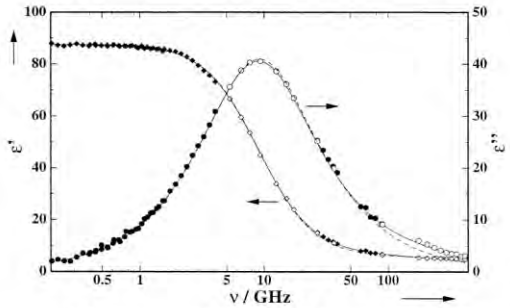


Fig. 1. Dielectric dispersion, $\varepsilon'(\nu)$, and loss spectrum, $\varepsilon''(\nu)$, of water at 0.2°C. Experimental data from our laboratory (closed symbols) and from the literature [10,11] (open symbols) fitted to a single (broken lines) and to a superposition of two Debye equations (solid lines).

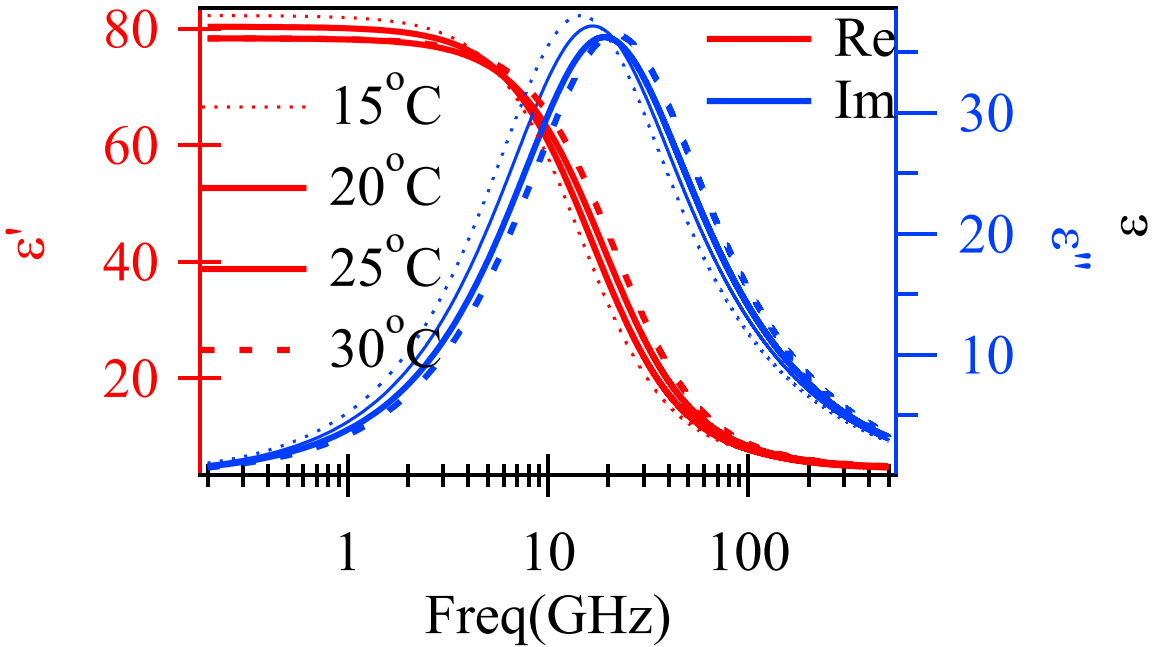
Measured Temperature

$T = (19 \pm 1)°C$

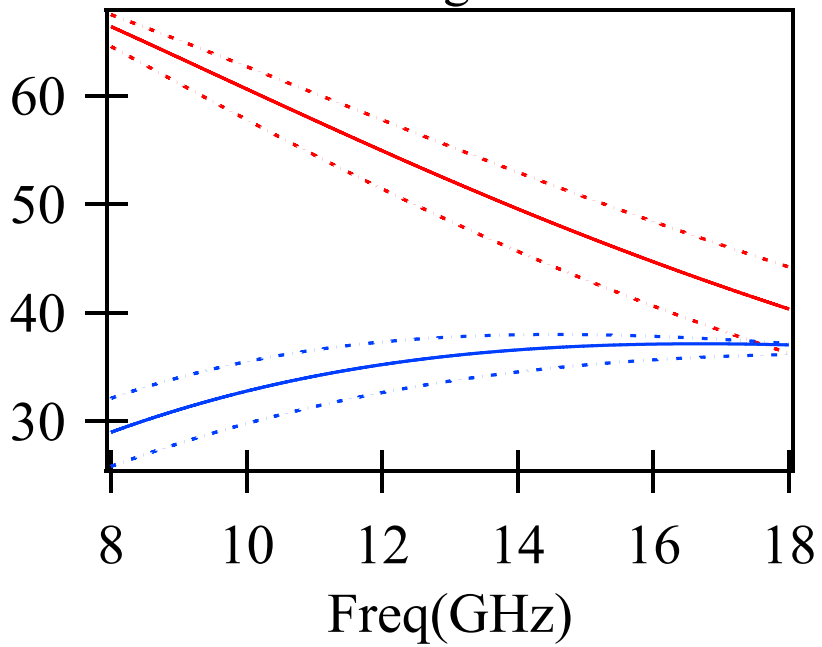
Purity of the de-ionized water:

$> 99.9\%$

Debye model of water
at different temperatures

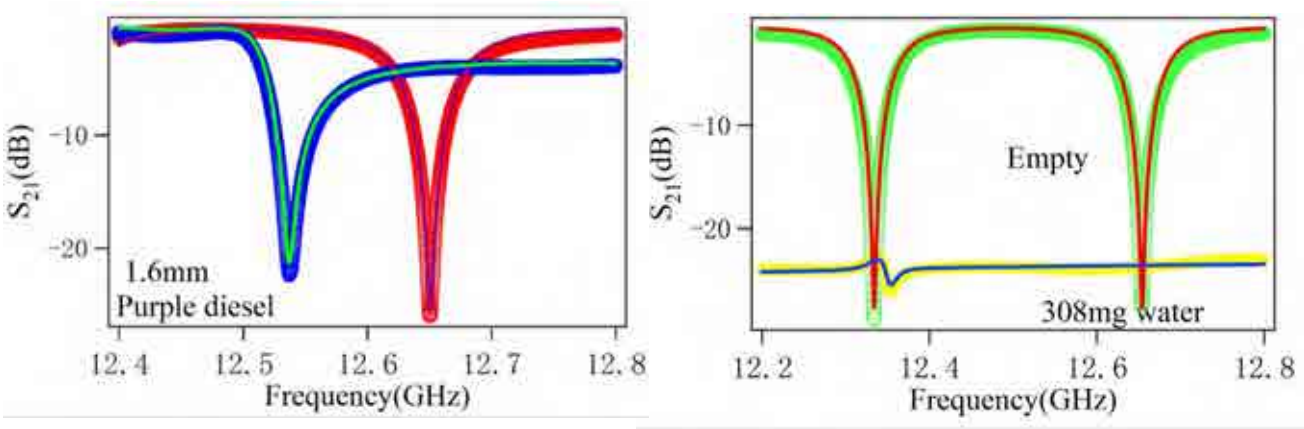


Debye model of water
according to our lab



$20°C \pm 5°C$

Resonant method

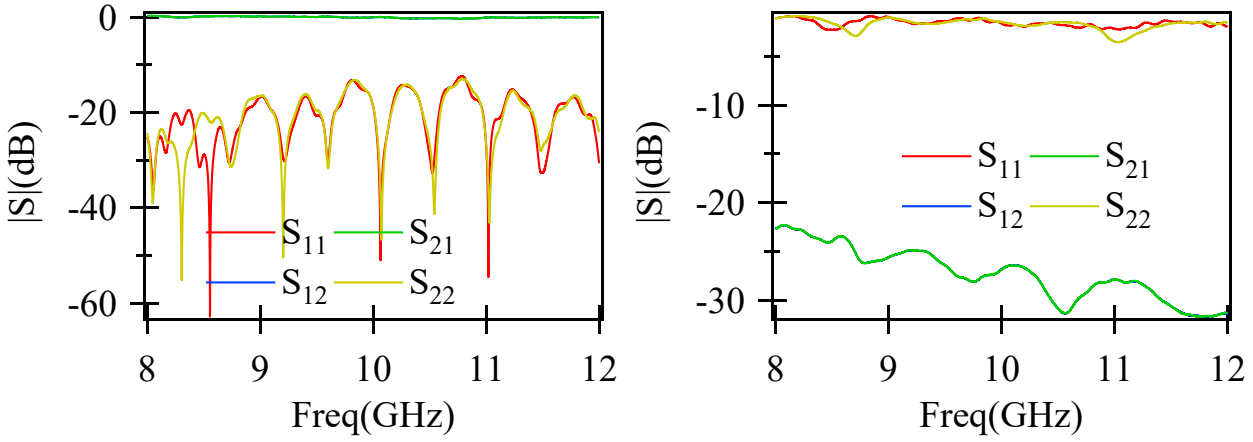


Water problem:

Due to the large absorption, the shifted peak is hard to find.

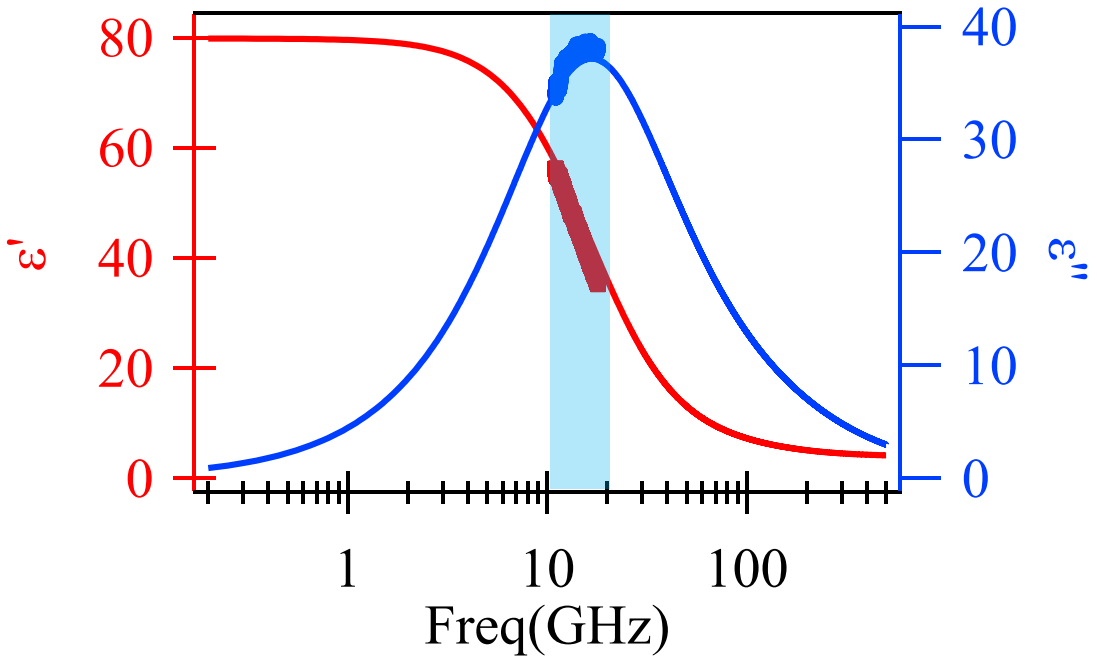
This method is inaccurate for large ϵ'' material.

Non-Resonant method



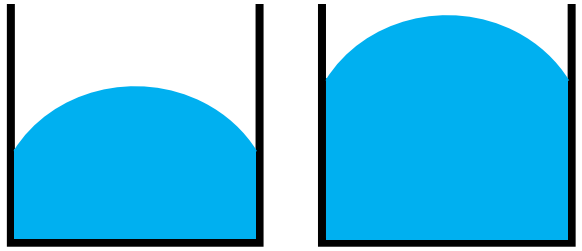
Broadband measurement can determine the dielectric constant of water.

Debye model of water at $20°C$ and measured data of water



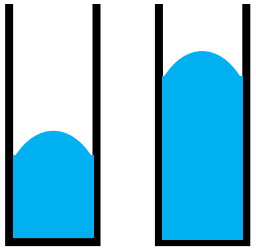
8 – 12GHz

X band: 1.450 mL and 1.153 mL



12 – 18GHz

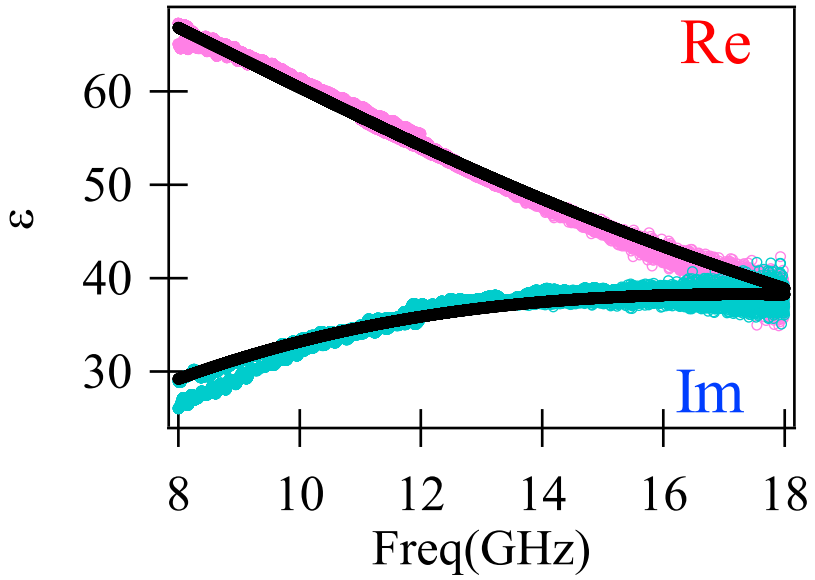
Ku band: 0.485 mL and 0.982 mL



Debye relaxation for water [1]:

$$\epsilon(\omega) = \epsilon_\infty + \frac{\epsilon - \epsilon_2}{1 + i\omega\tau_1} + \frac{\epsilon_2 - \epsilon_\infty}{1 + i\omega\tau_2}$$

ϵ_∞ , ϵ, ϵ_2, τ_1 , τ_2 --- fitting parameters



Fitting results

$\epsilon_\infty = 4.42$ (Fixed)

$\epsilon = 80.89$

$\epsilon_2 = 6.53$ (Fixed)

$\tau_{1=}$ 9.26 ps

$\tau_2 = 1.2$ ps (Fixed)

Fixed at $20°C$

[1] The dielectric relaxation of water between 0°C and 35°C

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