

Supporting Information

Validating Free Spectral Range Tracking as a Robust Method for Mitigating Artifacts in VSC Kinetics

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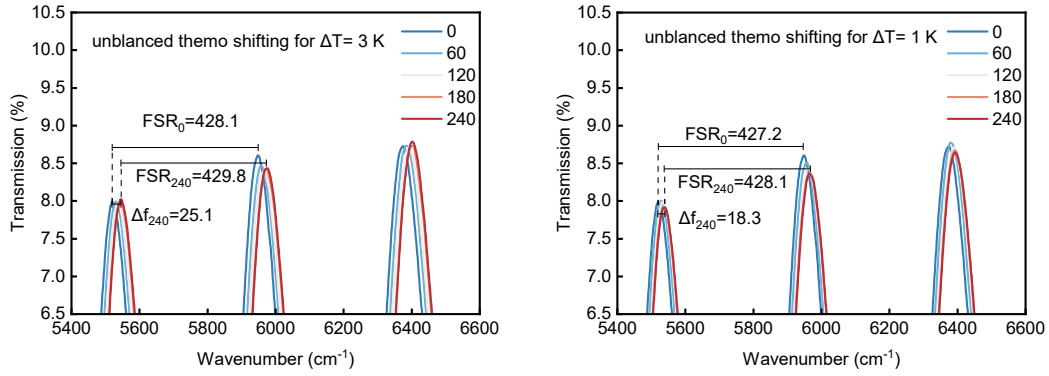


Fig. S1 Thermal relaxation-induced frequency drift of the $m = 10$ cavity mode under nonequilibrium conditions with $\Delta T = 3, 1$ K, monitored over 240 min.

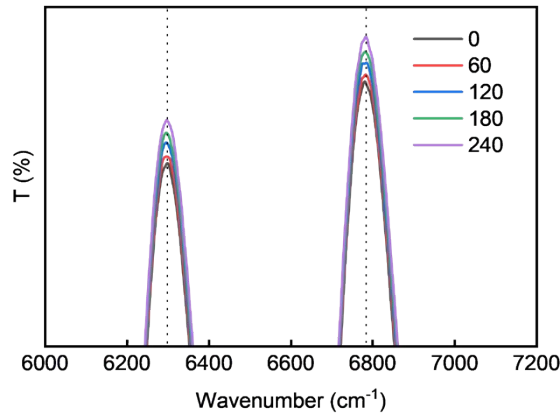


Fig. S2 The cavity filled with air over 240 min after reaching thermal equilibrium.

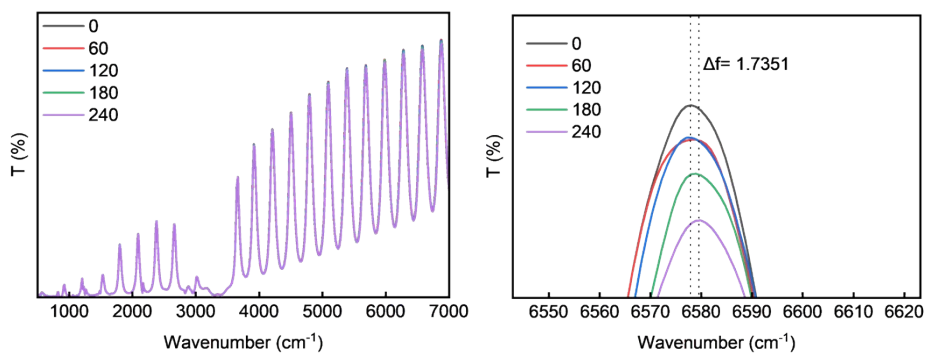


Fig. S3 The cavity filled with 3 M PTA over 240 min after reaching thermal equilibrium.

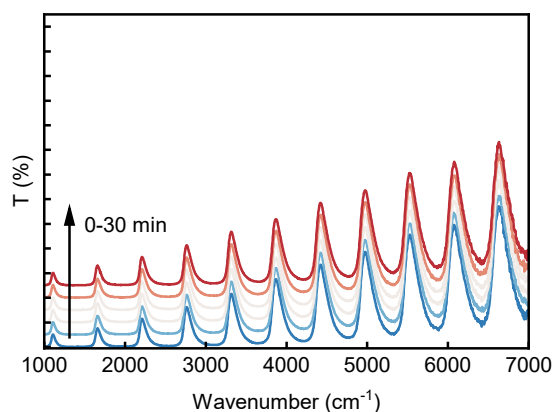


Fig. S4 Equilibrium of the cavity after pressure and thermal stabilization over 30 min (The timescale required for the reaction).

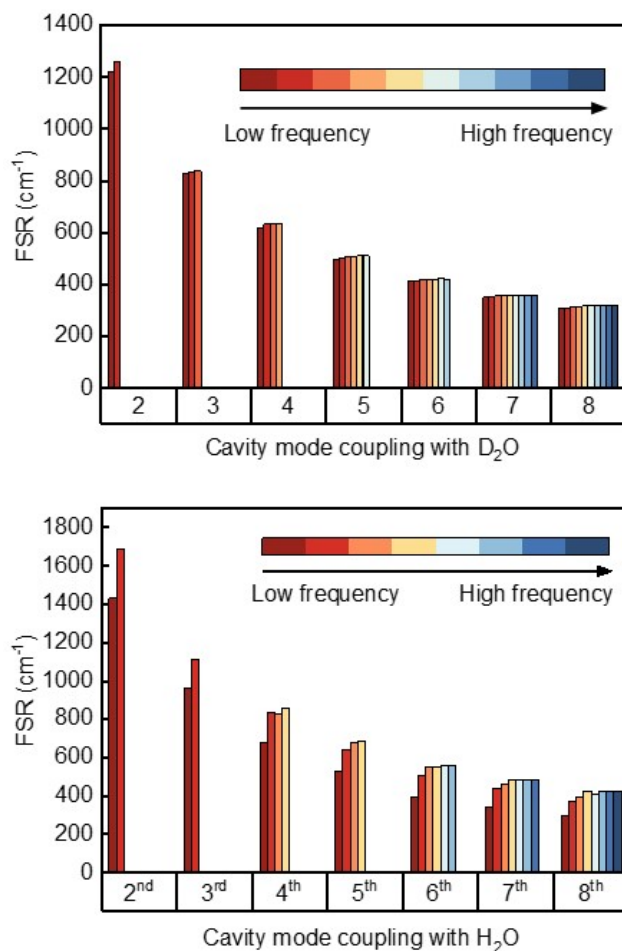


Fig. S5 Apparent refractive index changes of D₂O/H₂O stretching vibrations coupled with the 1st to 8th Fabry-Pérot (FP) cavity modes, extracted via Δ FSR. Different colors indicate apparent refractive indices extracted from the high-frequency region above 5000 cm⁻¹ for each coupling

order. In the bar chart, the color gradient from red to blue represents resonance peaks from low to high frequency.

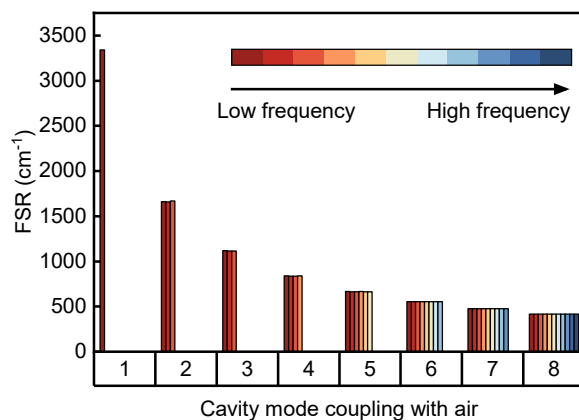


Fig. S6 Estimated FSR of air-filled empty cavities for achieving O–H vibrational strong coupling in H₂O-filled FP cavities. The FSR values correspond to the air-filled cavity states required before liquid injection, so that after filling the cavity with H₂O, the O–H stretching vibration is expected to couple with the 1st to 8th FP cavity modes. Different colors denote different target cavity-mode orders. the color gradient from red to blue represents resonance peaks from low to high frequency.

Table.S1 Drift analysis of the thermally equilibrated cavity over 240 min.

Contained	Time (min)	Frequency f (cm ⁻¹)	Frequency shifting Δf (cm ⁻¹)	
Cavity 1		0	6298.372	/
	Air	60	6298.5648	0.1928
		120	6298.372	0
		180	6298.7576	0.3856
		240	6298.7576	0.3856
		0	6578	/
	PTA	60	6579.1568	1.1567
		120	6579.5424	1.5423
		180	6579.5424	1.5423
		240	6579.7352	1.7351
Cavity 2			0	6300.301
	Air	60	6300.1082	-0.1928
		120	6300.1082	-0.1928
		180	6300.6866	0.3856
		240	6300.4938	0.1928
		0	6579.5424	/
	PTA	60	6580.892	1.3496
		120	6581.4704	1.928
		180	6581.6632	2.1208
		240	6581.6632	2.1208
Cavity 3			0	6301.0722
	Air	60	6301.265	0.1928
		120	6301.6506	0.5784
		180	6301.6506	0.5784
		240	6301.6506	0.5784
		0	6579.5424	/
	PTA	60	6580.5064	0.964
		120	6580.892	1.3496
		180	6581.4704	1.928
		240	6581.2776	1.7352