

*Electronic Supplementary Information*

## Strong coupling between resonators and spin ensembles in the presence of exchange couplings†

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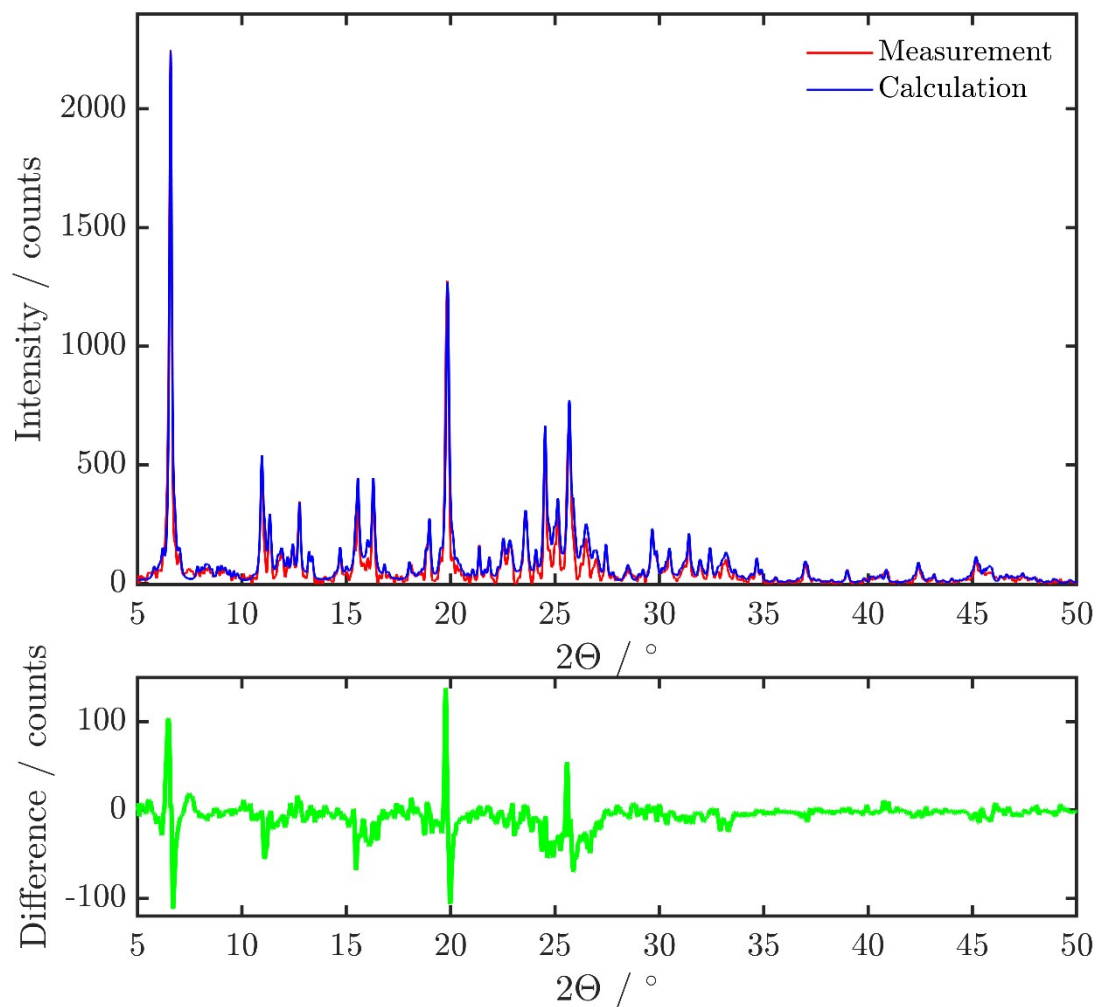


Figure S1. Measured powder diffractogram (red) on the commercial DPPH sample used in this investigation. The blue line is the calculated diffractogram assuming 87.1% solventless DPPH (CCDC 732147) and 12.9% DPPH benzene solvate (CCDC 1237782). The bottom panel is the difference between measured and calculated diffractograms.

Table S1. Measured dissipation rates, collective coupling constants and cooperativities of a 11.4 mg DPPH sample inside the copper Fabry-Pérot resonator at different temperatures.

$T$ (K)	$\gamma / 2\pi$ (MHz)	$\kappa_i / 2\pi$ (MHz)	$\kappa_e / 2\pi$ (MHz)	$\Omega_{\text{eff}} / 2\pi$ (MHz)	$C$
2.3	13(2)	2.0(5)	13.0(5)	98(3)	50(10)
3.0	12(2)	2.0(5)	13.0(5)	100(3)	60(10)
3.5	13(2)	2.0(5)	13.0(5)	101(3)	50(10)
4.1	10(2)	2.0(5)	13.0(5)	102(3)	70(20)
5.0	5.0(5)	2.0(5)	13.0(5)	105(2)	150(20)
7.0	3.0(5)	2.0(5)	13.0(5)	106(2)	250(60)
9.0	3.0(5)	2.0(5)	13.0(5)	107(2)	250(60)
9.5	3.0(5)	2.0(5)	13.0(5)	107(2)	250(60)
10.0	3.0(5)	2.0(5)	13.0(5)	107(2)	250(60)
10.5	3.0(5)	2.0(5)	13.0(5)	108(2)	250(60)
11.0	3.0(5)	2.0(5)	13.0(5)	106(2)	250(60)
13.0	3.0(5)	2.0(5)	13.0(5)	102(2)	230(50)
15.0	3.0(5)	2.0(5)	13.0(5)	100(2)	220(50)
20	3.0(5)	2.0(5)	13.0(5)	91(2)	180(40)
25	3.0(5)	2.0(5)	13.0(5)	87(2)	170(40)
30	3.0(5)	2.0(5)	13.0(5)	80(2)	140(30)
50	3.0(5)	2.0(5)	13.0(5)	69(2)	100(20)
70	3.0(5)	2.0(5)	13.0(5)	57(2)	70(20)
90	3.0(5)	2.5(5)	13.0(5)	52(2)	60(10)
110	3.0(5)	2.5(5)	13.0(5)	48(2)	50(10)
150	3.0(5)	3.0(5)	13.0(5)	42(2)	40(10)
180	3.0(5)	3.0(5)	13.0(5)	36(2)	30(10)
210	3.0(5)	3.5(5)	13.0(5)	34(2)	23(5)
240	3.0(5)	4.5(5)	13.0(5)	32(2)	20(4)
282	3.0(5)	4.5(5)	13.0(5)	30(2)	17(4)
294	3.0(5)	5.0(5)	13.0(5)	30(2)	17(4)