

HIGH COOPERATIVITY COUPLING OF ON-CHIP SUPERCONDUCTING RESONATORS TO NUCLEAR SPIN TRANSITIONS IN A Yb(trensal) MOLECULAR QUDIT

V. Rollano^{1,2}, M. C. de Ory^{3,4}, M. Rubin^{1,2}, D. Granados⁴, A. Gomez³, A. Chiesa⁵, D. Zueco^{1,2}, S. Piligkos⁶, S. Carretta⁵, F. Luis^{1,2}

¹ Instituto de Nanociencia y Materiales de Aragón (CSIC – UNIZAR), Zaragoza, 50009 Aragón, Spain.

² Departamento de Física de la Materia Condensada, Universidad de Zaragoza, Zaragoza, 50009 Aragón, Spain.

³ Centro de Astrobiología (CSIC – INTA), Torrejón de Ardoz, 28850 Madrid, Spain.

⁴ IMDEA Nanociencia, Cantoblanco, 28049 Madrid, Spain

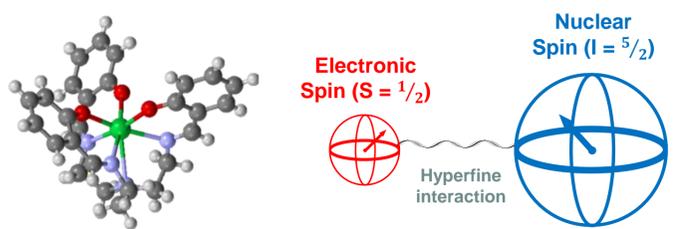
⁵ Dipartimento di Scienze Matematiche, Fisiche e Informatiche, Università di Parma, I-43124 Parma, Italy.

⁶ Department of Chemistry, University of Copenhagen, DK-2100 Copenhagen, Denmark.



DEVICE DESCRIPTION AND EXPERIMENTAL SETUP

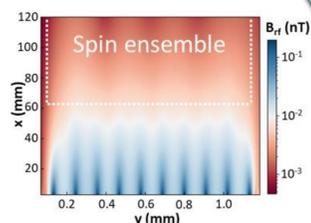
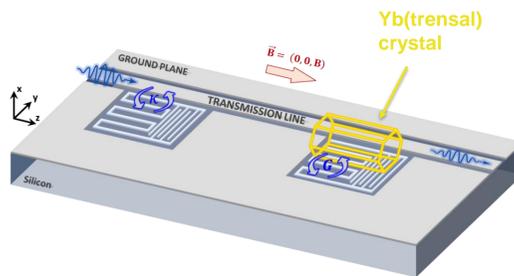
¹⁷³Yb(trensal) molecule¹



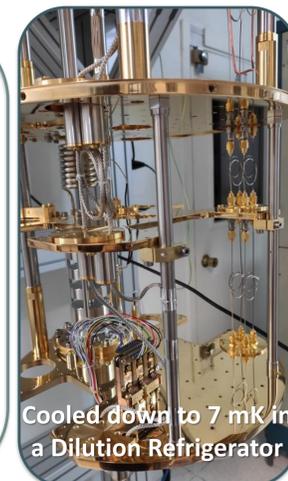
- Hyperfine interaction allows to initialize nuclear qubits through the electronic spin
- Effective Hamiltonian $H = \mu_B g \vec{B} \cdot \vec{S} + \mu_I g_I \vec{B} \cdot \vec{I} + A \vec{S} \cdot \vec{I} + p I_z^2$ allows to simulate molecule response

Interacting with spin transitions in a cQED scheme²

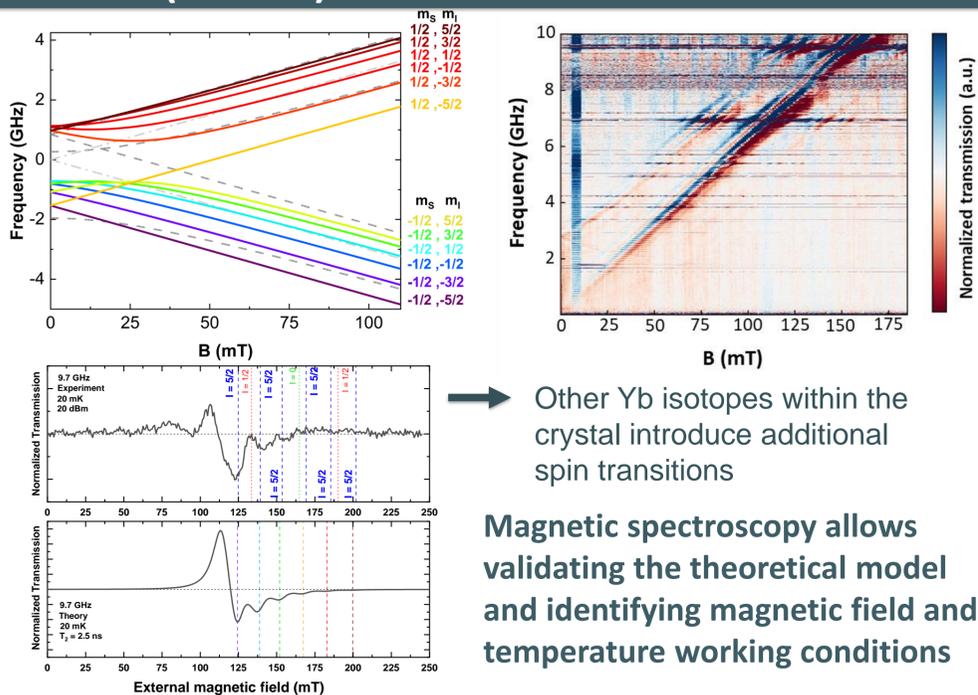
¹⁷³Yb(trensal) crystals on superconducting LC resonators



Design optimization through electromagnetic simulations



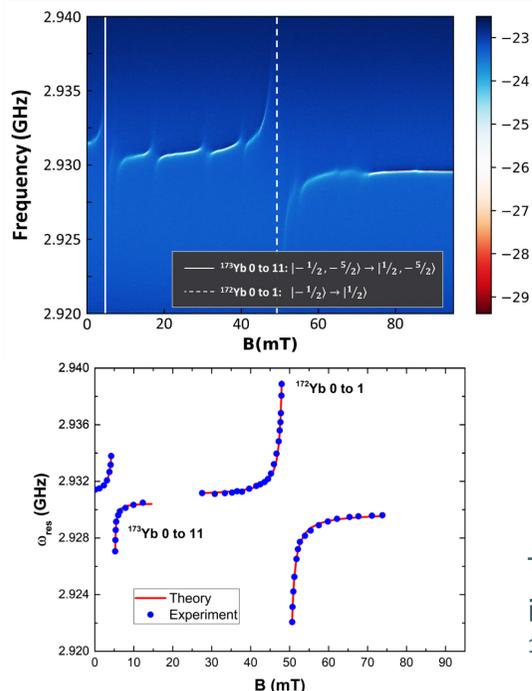
Yb(trensal) MAGNETIC SPECTROSCOPY



Other Yb isotopes within the crystal introduce additional spin transitions

Magnetic spectroscopy allows validating the theoretical model and identifying magnetic field and temperature working conditions

COUPLING TO ELECTRONIC TRANSITIONS

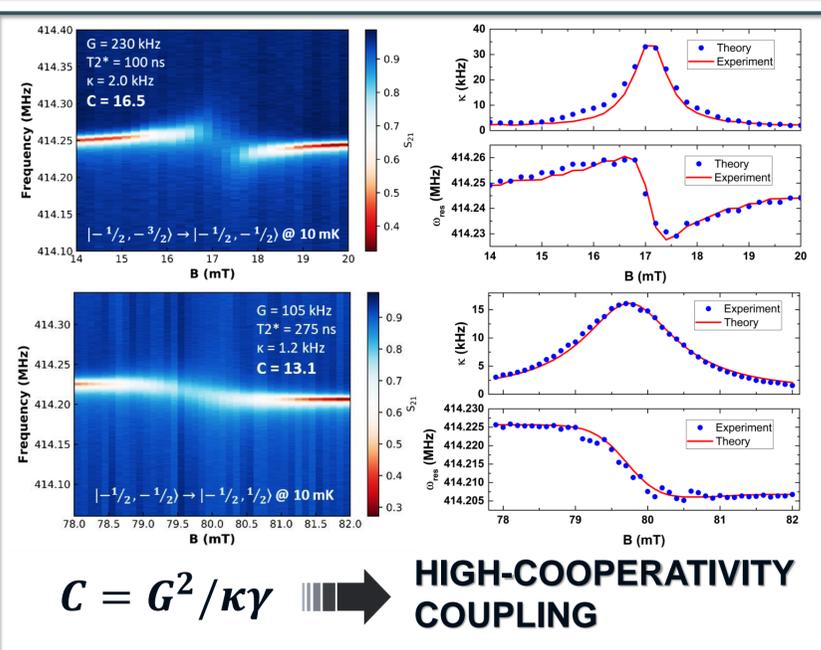


	¹⁷² Yb	¹⁷³ Yb
	0 to 1	0 to 11
G (MHz)	20.5	7.4
γ (MHz)	20.7	21.2

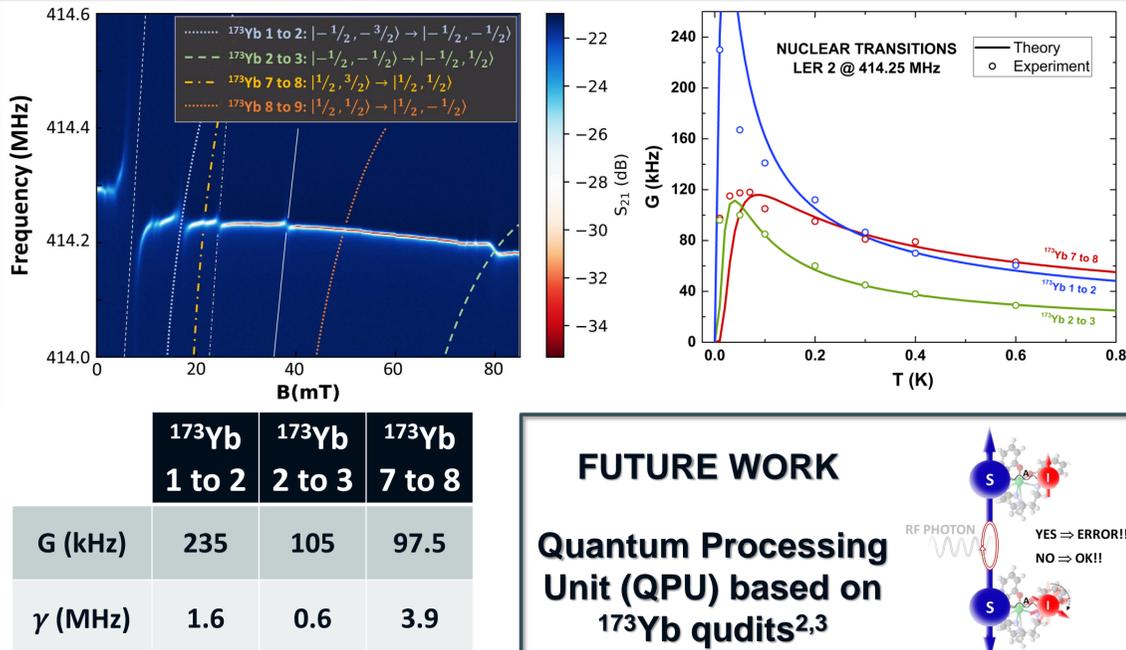
$G \sim \gamma$
STRONG COUPLING REGIME

The presence of other isotopic species precludes ¹⁷³Yb coupling rates

HIGH COOPERATIVITY COUPLING TO NUCLEAR TRANSITIONS



$$C = G^2 / \kappa \gamma \Rightarrow \text{HIGH-COOPERATIVITY COUPLING}$$



	¹⁷³ Yb	¹⁷³ Yb	¹⁷³ Yb
	1 to 2	2 to 3	7 to 8
G (kHz)	235	105	97.5
γ (MHz)	1.6	0.6	3.9

FUTURE WORK

Quantum Processing Unit (QPU) based on ¹⁷³Yb qudits^{2,3}

CONCLUSIONS

- Robust theoretical model make solid predictions and improve future designs
- Nuclear spin transitions traced in magnetic spectroscopy measurements
- High-cooperativity coupling to ¹⁷³Yb nuclear spin transitions in a cQED scheme
- Isotopically pure ¹⁷³Yb crystals needed for a QPU implementation

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SUPERMAN-QUTE (MICIN)

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