THE UNIVERSITY OF WESTERN AUSTRALIA

Research Development & Innovation

Multi-post 3D Split Ring Cavity Lattice (Re-entrant Cavity):

a hybrid platform for integration of quantum systems

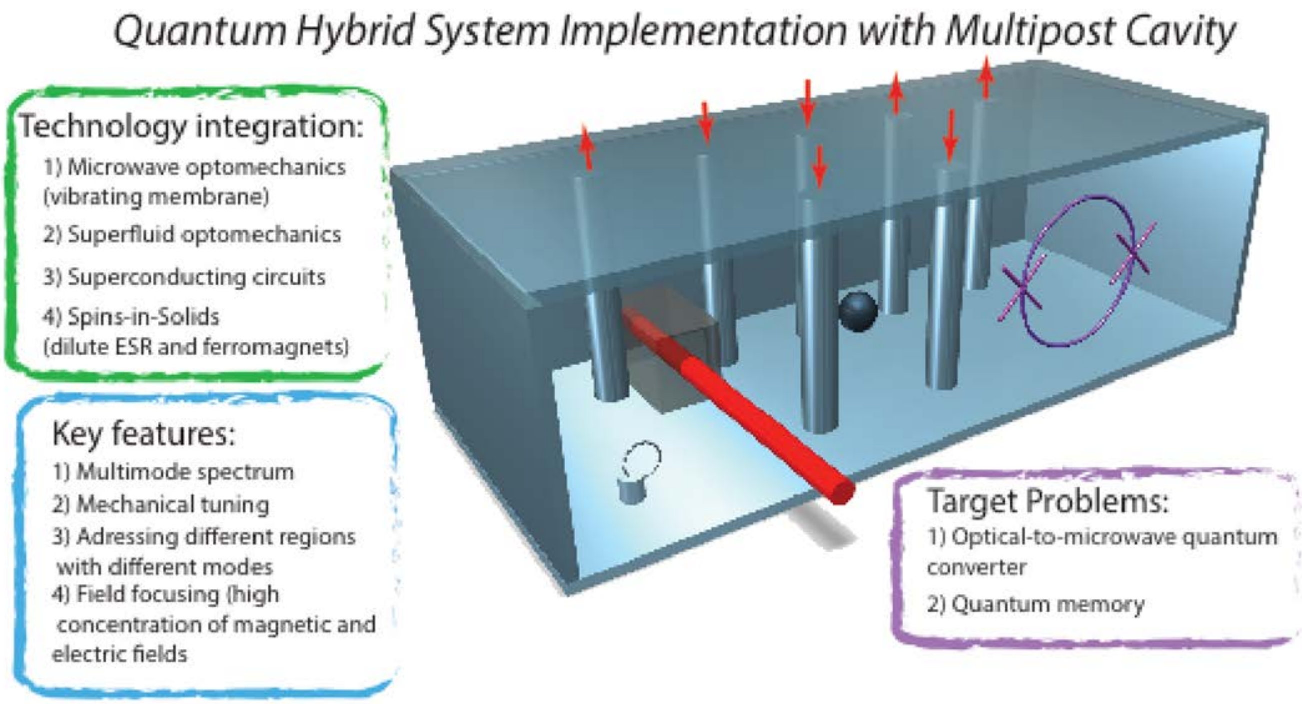
UWA technology licensing/ partnering opportunity

Towards applications for future quantum computing/ communication.

- **microwave-to-optics converter**
- **quantum memory**

Other Applications

- **multi-frequency sensing**
- **sensing gas/fluids**
- **probing magnetic and dielectric properties of solids/spectroscopy**
- **space-resolved pressure sensors**



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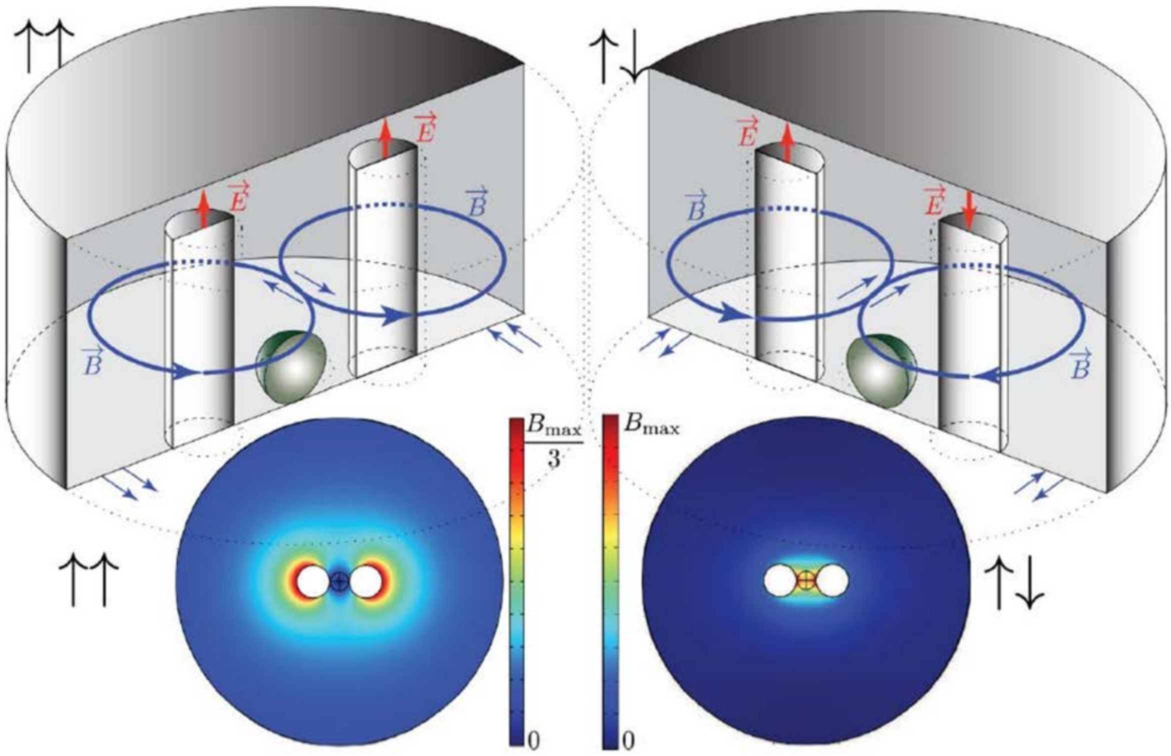

Left: Standard "Bright" mode Right: Ultrastrong coupled "Dark" mode

Example of a two-post version (basic building block of the 3D split-ring cavity lattice), implemented to create an ultrastrong hybrid quantum system between photons and magnons [3].

The Technology

Researchers at the University of Western Australia (UWA) have developed and patented a new type of electromagnetic metastructure consisting of an arrangement of conducting posts enclosed in a closed 3D cavity. The technology is based on known re-entrant (Klystron) cavities showing features of a lumped element system in the microwave region (1-30 GHz). Exhibiting all advantages of a closed cavity such as low resonance line widths, the system provides multifrequency option for testing matter and spectroscopy. Arranging the post structure, one can engineer the field structure for different modes allowing individual addressing of different parts of cavity space. On top of that, the system provides mechanical tunability that can be used on its own to implement space resolving pressure sensors. The system is scalable if a higher frequency range is required.

Benefits of the Technology

- A 3D cavity metastructure, closed cavity metamaterial, ensures ultimate coherence time for superconducting circuit/cavity applications [1]
- fast mechanical tuning in a wide frequency range [2] allows in-situ control over cavity frequencies
- magnetic field-focusing feature is ideal for achieving the strong coupling regimes with spins in complex-shape small crystals (sub-millimeter in the whole microwave region due to unique filling factors[3,4])
- spatial separation of magnetic and electric fields is required for some spectroscopy applications
- the system allows the engineering field structure in the cavity, with concentrated spots of magnetic field and dark field regions can be used for quantum system registers (addressing individual crystals/superconducting qubits from an array)
- high concentration of the electric field may be used for coupling to electrical dipoles in thin films
- high sensitivity to post gaps enables easy integration of optomechanics-type experiments including recent superfluid optomechanics due to the closed nature of the cavity
- 'four post structure may be utilised as a quadruple ion trap

State of Development

The system has been extensively simulated with commercial finite element method software [1]. A few prototypes have been physically built and tested [3-4]. The results are in good agreement with computer simulations. Some of the sample was used to achieve ultra-strong coupling with magnons in sub-millimeter crystals [3] and P1 centres in diamond [4] and higher order modes in such crystals. Several publications have been prepared. Further improvements in cavity performance (frequency range and size) can be achieved if better manufacturing capabilities are available. The system may be fabricated using the MEMS technology.

Commercial Opportunity

UWA is seeking expressions of interest from scientific instrument vendors to discuss commercial applications of the technology.

The Research Team

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The University of Western Australia

UWA is a research-intensive university ranked 96th in the world (Shanghai Jiao Tong University's internationally recognised Academic Ranking of World Universities – August 2016), and one of the internationally recognised Australian Group of Eight Universities.

References

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[5] "Superstrong Coupling of a Microwave Cavity to YIG Magnons", Applied Physics Letters, 2015, https://arxiv.org/abs/1508.04967v3

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