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hYbrid Quantum system: spin waves & microwave cAvities pRinted in 3D

PhD position
Microwave Department, Brest, France

KEYWORD
RF cavities, magnon photon coupling, YIG, 3D printing

CONTEXT AND OBJECTIVES
Over the past decade, quantum systems that provide new computing and detection capabilities have emerged [1]. One such promising hybrid system involves the coherent interaction between **microwave cavity photons** and **collective spin wave resonance** (quantised as the magnon), which provides a new route to transmit and process information [2, 3, 4, 5]. These systems possess tunability, long coherence times, large coupling, and the capacity to couple to a plethora of additional systems, including qubits. **The candidate will be focused on the construction of a completely controllable quantum hybrid system [6, 7] in which each degree of freedom can be manipulated externally and read-out electronically.** With this capability, a range of quantum technologies can be explored utilising efficient transduction for applications such as spin storage [4] and retrieval, and generation of non-classical states. As the majority of quantum applications must be conducted at cryogenic temperatures, one of the major engineering objective of the research will be to test the constructed hybrid systems within such an environment.

3D microwave resonant cavities are necessary tools for converting information from the building blocks of quantum information (qubits) into other energy forms for storage or transport [8, 9]. A **Hybrid system** - based on the integration of magnetic material (**magnons**) with cavities (**photons**) - will be tailored to reach a specific regime of coupling which generates bosonic particles called Cavity Magnon-Polaritons (CMP) associated with the hybridisation of a photon and a magnon. Cavity-mediated coupling [10] with a superconducting transmon qubit [11] introduces the requisite non-linearity (through the qubit's anharmonicity of energy states) into these systems for observation and exploitation of quantum mechanical phenomena, and this ambitious goal therefore defines the design parameter space we wish to explore.

- ✓ **Objectives 1:** Design and simulation of hybrid system (RF cavity + YIG spheres or slab). Extraction of the frequency response as function of an applied magnetic field (using COMSOL)
- ✓ **Objectives 2:** Investigation of tunable functions to precisely position the operating frequency of the cavities. The fabrication and metallization of 3D cavities will be performed by ELLIPTIKA (http://www.elliptika.com/)
- ✓ **Objectives 3:** Characterization: empty RF cavity, Hybrid system, magnon photon coupling strength, tunable operation, electrical read-out

INNOVATIVE NATURE OF THE PROJECT
- ✓ **3D printing prototyping** and industrial metallization process: This disruptive technology for cavity manufacturing will allow the production of cryogenic capable cavities; providing lighter weight, less cost and greater reproducibility than current implementations**.** Moreover, **it will**

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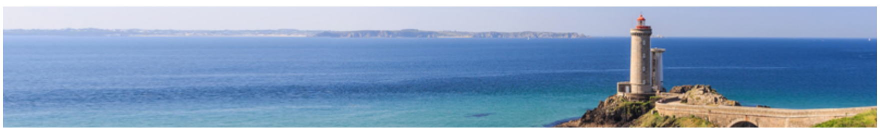

allow the exploration of novel and promising untested cavity designs that until now have been off-limits due to fabrication constraints.

- ✓ **Reaching Deep Strong Coupling** (DSC): With clever cavity engineering, achievable with 3D printing technology, there is nothing preventing the DSC regime being achieved in an RF cavity/YIG system [7]. For the optimal scenario of a filling factor $\eta=1$, a frequency of $\omega_c<1.72$ GHz would achieve DSC.
- ✓ **Cavity mediated coupling**: Achieve the fastest transfer of information between two indirectly coupled resonators by reaching GHz CMP coupling

PROFIL AND SKILLS REQUIRED

- ✓ PhD in Physics or RF engineering
- ✓ Experimental skills requested
- ✓ Ability to work with new equipment and simulation software
- ✓ Ability to communicate and disseminate his/her results
- ✓ Good social skills
- ✓ Good level in English

PRATICAL ASPECTS

- ✓ The PhD thesis will start on the 15/10/21 at IMT Atlantique, Brest
- ✓ The PhD position is funded by Brest Métropole

ADDITIONAL INFORMATION

CV and motivation letter to:

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DEADLINE FOR SUBMITTING AN APPLICATION 15/08/2021

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