PhD in Physics

Research Title: Innovative imaging and sensing techniques based on the quantum properties of light

Funded by
Istituto Nazionale di Ricerca Metrologica (INRIM)

Supervisor
Ivano Ruo Berchera (i.ruoberchera@inrim.it)
Francesco Raffa (francesco.raffa@polito.it)

Contact
http://quantumoptics.inrim.it/
m.genovese@inrim.it

Context of the research activity
The present PhD project aims at the realization, in equipped laboratories, of advanced research in the field of quantum optics applied to imaging and sensing.

The possibility of generating, manipulating and detecting quantum states of light and matter, developed in the last 30 years, has opened a completely new field named quantum technology. Counterintuitive principles of quantum mechanics such as the superposition principle, the uncertainty principle, the entanglement and more in general quantum correlations can be now tested in labs and can be used to devise new approach to secure communication, computation and measurement.

In particular, it has been shown that quantum states and quantum measurement techniques, allows to overcame classical precision limits in imaging and sensing, limits that has been long considered as fundamental bounds in conventional measurement methods.

More in detail, quantum correlations in optical fields allows to reduce the fluctuations or to gain information on the fluctuations of the field. When the light beam is used to probe a system under investigation, this translate in a better estimation of parameters of the system.

Noise can be also reduced by applying new paradigm of measurement such as the so called Zeno effect, where repeated measurements allow to freeze the evolution of quantum system.

Some of these approaches have been already demonstrated in experiments: for example, in imaging of weak absorbing object, in large scale interferometers, and in proof of principle experiments on magnetometry.
### Objectives

The objectives of the present PhD project:

- To further investigate in deep the problem of improving the signal to noise ratio and resolution in optical sensing and imaging by using quantum states of light and quantum measurements. Among the others, the project will focus on quantum resources such as sub-Poissonian light and quantum Zeno/anti-Zeno effect.
- To extend previous achievements in new directions. Among them: to explore quantum wide field imaging, obtained so far for a transmission profiles, to different parameters that involve also phase changes; Improving imaging resolution by exploiting single photon emitters and anti-bunching effects.
- Modeling and designing specific experiments to provide proof of principle demonstrations of the new approaches, taking into account experimental imperfections that could reduce the advantage of quantum techniques in realistic condition.
- Eventually, among the described areas, identifying promising techniques that have the potentialities to overtake the proof of principle and bring them towards a technological prototype.

### Skills and competencies for the development of the activity

Required competencies for the success of the project:

- Knowledge of the basis of quantum mechanics proven by the pass of the specific university exams.

Preferred skills and competences:

- Experience in modelling quantum optics experiments
- Knowledge of the basic optical components used in quantum optics experiments, linear components and non-linear components used to generate quantum states of light.
- Knowledge of the basic quantum enhanced optical measurement techniques.
- Excellent knowledge of the English language.