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SUPERTWIN – the quantum microscope that will overcome the limits of classical optics

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The European project will be coordinated by Italy through Trento-based Fondazione Bruno Kessler

(v.l.) An Italian research center, Trento-based **Fondazione Bruno Kessler**, will lead the **SUPERTWIN** European Consortium that in the next three years will develop the first prototype of a quantum microscope in the world.

The objective of the SUPERTWIN project is to overcome the limits of classical optics to develop a super powerful microscope, able to exploit the properties of "twin" photons, the elementary particles of light theorized by quantum physics. This miscroscope would be able to reach a resolution of a few tens of billionths of a meter (nanometers), allowing to observe, for example, details of viruses or proteins.

“We are aware that the goals we have set are very ambitious"- explains **David Stoppa**, Head of the IRIS Research Unit at **Fondazione Bruno Kessler** and project coordinator - "But we are also aware of the quality of the SUPERTWIN Consortium and we are confident we will be able to repeat the achievements of previous European projects in which we participated. With this program we will have a significant opportunity to expand, in addition to spatial and biomedical sectors, the range of applications of our skills in the design of smart light sensors.”

Researchers at the Bruno Kessler Foundation, led by David Stoppa, will in particular develop an innovative optical sensor on which the operation of the microscope relies.

The project will end in 2018 and will receive an EU funding of **3,900,000 euros**. It is part of the **Horizon 2020 Program** and in particular of the research activities and innovation in science and technology that explore developing areas to date unknown and which will define future technologies.

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The SUPERTWIN Consortium comprises, besides Fondazione Bruno Kessler in Trento, A.P.E. Research srl (Italy), Centre Suisse d'Electronique et Microtechnique (Switzerland), III-V Lab (France), Single Quantum (The Netherlands), University of Bern (Switzerlans), École Polytechnique Fédérale de Lausanne (Switzerland), Institute of Physics, National Academy of Sciences of Belarus (Belarus), LFoundry S.r.l. (Italy).

More info at: https://iris.fbk.eu

Project Fact sheet by the SUPERTWIN Consortium

SUPERTWIN – "All Solid-State Super-Twinning Photon Microscope" – is a collaborative research project funded by the European Union within the Excellent Science - Future and Emerging Technologies section of the FETOPEN-2014-2015-RIA Horizon 2020 (H2020) Framework Programme, a programme that supports the early-stages of the science and technology research and innovation around new ideas towards radically new future technologies.

The project, launched on March 1st 2016, is coordinated by Fondazione Bruno Kessler (FBK) and it involves a highly multidisciplinary consortium of nine leading European experts in Quantum Physics, Photonics, CMOS Image Sensors manufacturing, Solid-state Photon Sensing and a potential industrial end-user of the SUPERTWIN technology**.** SUPERTWIN was granted 3,900,000 EUR of funding over a 36 month period. The SUPERTWIN consortium met on March 3rd 2016 for its general kick - off meeting.

SUPERTWIN project aims at developing a highly innovative microscopy technique that exploits the principles of quantum photonics to overcome the limitations of existing optical microscopes.

Nowadays, the resolution of an optical microscope is set by the Rayleigh limit at about half the photon wavelength. The modern development in the field that breaks this limit, the Scanning Near-field Optical Microscope (SNOM), requires a complex, high precision, time

consuming 2D scan of the sample under investigation to generate a full image. Other techniques exist, but they all exploit fluorescence. As typically the object under study is not fluorescent, the use of a specific preparation with fluorescent dyes is necessary.

SUPERTWIN's prime objective is to develop the prototype of a new microscope that exploits entangled photons to overcome the limits of classical optics, demonstrating a radically new line of technology for super-resolution imaging devices utilizing the principles of quantum optics. Entangled photons are elementary particles of light that share a certain property such that their states are strongly correlated as if they were *twins* connected by an invisible link. This counterintuitive effect was coined “spooky action at a distance” by Albert Einstein, before it was experimentally demonstrated in the 1980’s. The SUPERTWIN microscope comprises three main building blocks: (i) solid-state emitters based on advanced group-III nitride and III-V alloy epitaxial growths and wafer processing techniques to generate highly entangled photon states; (ii) single-photon detector arrays with data pre-processing capabilities manufactured in an optimized advanced CMOS technology node to record spatio-temporal multi-photon interference patterns; and (iii) dedicated data processing algorithms aimed at extracting the image of the illuminated object from the statistics of scattered entangled photons. This concept will pave the way for a new paradigm in optical imaging, triggering the development of novel microscopy systems that will surpass existing super-resolution microscopy techniques.

SUPERTWIN members:

- Fondazione Bruno Kessler (Italy, project coordinator)
- A.P.E. Research srl (Italy)
- Centre Suisse d'Electronique et Microtechnique (Switzerland)
- III-V Lab (France)
- Single Quantum (Netherlands)
- University of Bern (Switzerland)
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