Lumos Maxima Forcier:

Remote Detection of Miniscule Forces by Photon-Avalanche

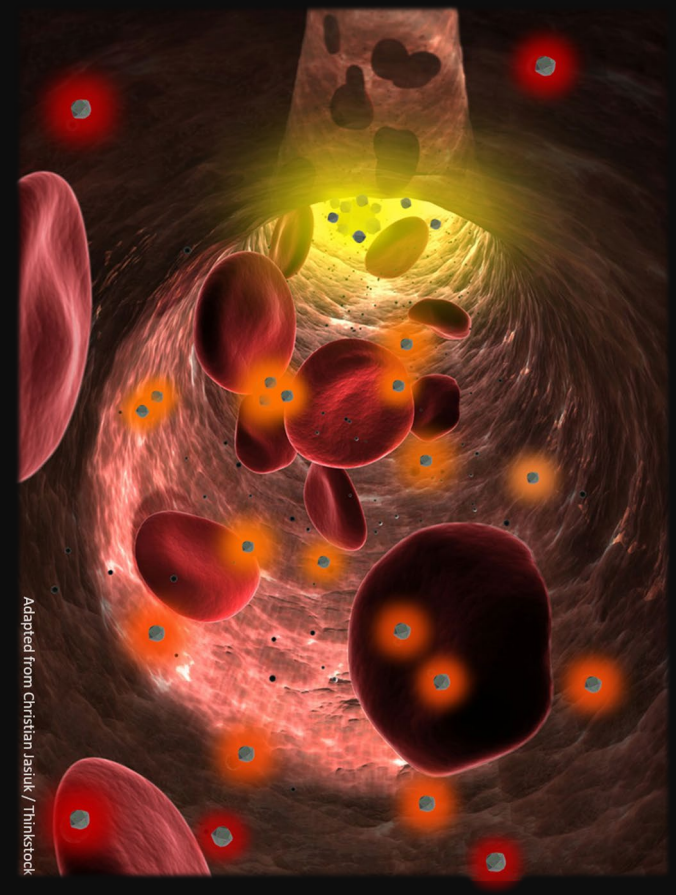
MSCA Postdoctoral Researcher: Natalie Fardian-Melamed

Perhaps ironically, the discovery of a nano-confined chain reaction coined “photon-avalanche” happened here at the Schuck Lab, right in the next-door building to that of Oppenheimer’s Manhattan Project. The major difference being that this chain reaction consists of photons – quanta of light, and not just any light – near-infrared light, which is biologically safe, and has many benefits that make it ideally suited for deep-tissue bio-imaging and medical diagnosis.

As a part of this EU Marie-Sklodowska Curie Action, we developed an advanced technique with the capability of optically imaging a single, isolated, photon-avalanching nanoparticle – while pressing upon it with a needle 10,000 thinner than a strand of human hair (an atomic force microscope tip). Using this capability, we isolated a single avalanching nanoparticle and pressed on it, ever-so-lightly, with the ultra-sharp tip – and discovered that the avalanche is extremely sensitive to miniscule mechanical forces. Tiny physical forces (imagine the weight of a grain of salt, divided by 1,000,000) lead to extreme changes in the optical signal we observe. Because the avalanche process is such a steeply nonlinear effect, small perturbations in the environment, such as the pressure felt by the nanoparticle, should lead to giant changes in response, explaining our observations.

Can we initiate a chain reaction with mechanical force? How small of a force can induce observable changes in emission? How large of a force can our nanoparticle bear? Can we induce different ‘colors’ of photon-avalanche with physical force? Can we ultimately use these nanoparticles for noninvasive detection and monitoring of the forces existing in nanoscale environments of real-world systems?

These – and more – are questions we’re addressing throughout this MSCA. Stay tuned!



Adapted from Christian Jasiuk / Thinkstock

N.F.-M. gratefully acknowledges support from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 893439.