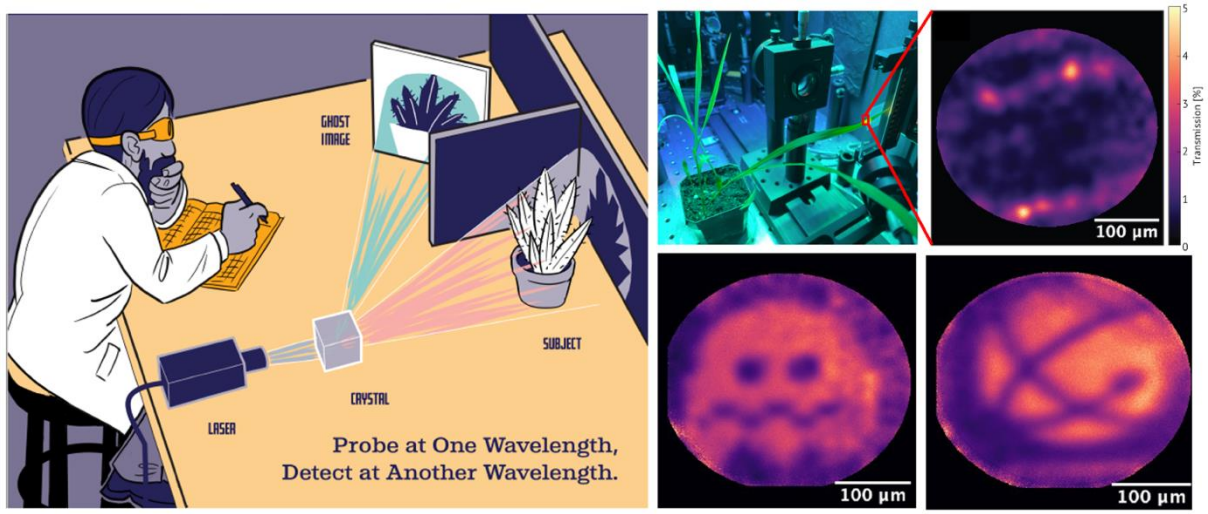
Infrared Quantum Ghost Imaging of Living and Undisturbed Plants

Scientific Achievement

Clear images of living plants with illumination light far dimmer than starlight, enabling imaging of delicate, light-sensitive samples, such as biofuel crops, without perturbation or damage. Demonstrated live plant imaging of several representative plant samples, including the biofuel crop sorghum.

Significance and Impact

This ultra-sensitive Quantum Ghost Imaging technique allows for detailed monitoring of plant health and growth without exposing crops to harmful light levels and causing stress or damage. Using label-free infrared imaging, researchers can gather critical information about important plant processes, including water content and photosynthetic activity, even in low-light conditions. This capability is particularly beneficial for studying biofuel crops, where optimizing growth and health is essential for maximizing yield and sustainability.



Left: Cartoon illustrating principles of quantum ghost imaging. Top Middle: Picture of sorghum plant in quantum ghost microscope. Top Right: Quantum ghost microscope transmission image of live sorghum leaf. Bright spots are rows of stomata.
Bottom: Quantum ghost images of binary test targets, including a ghost from Pac-Man (Bottom middle) and the Los Alamos National Laboratory logo (Bottom right).

Research Details

- Using NCam, a novel single-photon detector, demonstrated non-degenerate QGI with unprecedented sensitivity and contrast, obtaining images of living plants with less than 1% light transmission.
- Plants imaged with photon flux orders of magnitude below starlight.
- Realization of QGI expands the method to extremely low light bioimaging and imaging of light-sensitive samples, where minimizing illumination intensity is crucial to prevent phototoxicity or sample degradation.

Work was performed, in part, at the Center for Integrated Nanotechnologies.

Ryan, D.; Meier, K.; Seitz, K.; Hanson, K.; Morales, D.; Palmer, D.; Hanson, B.; Goodwin, P.; Newell, R.; Holmes, R.; Thompson, D,; Werner, J. “Infrared Quantum Ghost Imaging of Living and Undisturbed Plants.” *Optica*, 2024.